INVESTIGATING THE DETERMINANT OF ACTIVE TUBERCULOSIS (TB) EPIDEMIC ACROSS EASTERN AFRICA COUNTRIES

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DECLARATION

I, **Wanjiru Martin Nyamu**, do hereby declare that the presented research project is my own work and it has not been presented to any institution of higher learning for academic award.

Sign Date**: 10/21/2020**

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This research project has been submitted to the University of Nairobi School of health sciences with my approval as the university supervisor. The supervisors assisted me in defining the research topic, identifying the relevant research literature, and reliable data sources. Moreover, the supervisors will also provide guidelines in the framing of my research project.

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DEDICATION

This work is dedicated to my family for the immerse support and understanding throughout this study. You are my inspiration and the reason for my hard work.

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It has been an honour gaining knowledge and sharing experiences with all my lecturers and fellow students in the Master of Science Medical Statistics. You have enriched my experiences during this period, Thank You.

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LIST OF ABBREVIATIONS

AIDS:	Acquired Immunodeficiency Syndrome
AMR:	Antimicrobial-Resistant
DOTS:	Stop Tuberculosis Strategy
EEA:	European Economic Area
EU:	European Union
HIV:	Human Immunodeficiency Virus
MDR:	Multidrug-Resistant
TB:	Tuberculosis
WHO:	World Health Organization
XDR:	Extensively Drug-Resistant
XDR-TB	Extensively Drug-Resistant TB

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OPERATIONAL DEFINITIONS

I. Tuberculosis Best Estimate

Tuberculosis best estimate is the measure of tuberculosis burden for each country in 2018 tuberculosis cases. It gives the annual aggregate of tuberculosis incidence across the East Africa region. In this study, we used the TB best estimate as the response variable to indicate the incidence rate of tuberculosis infection for 2018 data across the Eastern Africa Countries.

II. Age

Age is the length of time that an individual has lived on earth. In this study, age was used as a predictor variable measured in years. It wsd grouped into different categories, representing those between 0-14 years, 15-24 years, 25-34 years, …, and 65-74 years. Different age groups are differently affected by Tuberculosis infection. The variable was coded for ease of analysis. The majority of the people in the Eastern Africa region are young, with a median age of about 18.7 years, according to World-o-meter (2020).

III. Gender

Gender is made up of two sexes (female and male) based on social and cultural differences but not biological differences. In this study, gender represented male and female and was a binary predictor variable. It was coded with 0 for females and 1 for males. The cultural and social difference between males and females constitute their differences in the outcome of interest.

IV. Active TB Risk Factors

A risk factor is something that raises the chances of an individual developing a disease. For instance, smoking of cigarettes, HIV infection, alcohol use, diabetes, and undernourishment are considered as the risk factors influencing the development of active TB across the Eastern Africa region. The risk factors influencing the development of diseases are believed to lower the immunity of the patient. The current study compared the impact of each TB risk factor with a reference factor to identify the most impactful risk factor to the development of active TB.

Smoking was measured by the number of cigarettes an individual smoked per day, while alcohol was measured by the number of milliliters or grams a person drank per day. Moreover, undernourishment also considered as malnutrition, which is the inability to acquire enough balance-diet food or the inability to meet dietary needs to provide energy.

V. Countries

This variable is the list of all the nineteen countries in the Eastern Africa region. The study explored countries with a high active TB burden. For instance, the study identified the top five most affected countries by TB infection in 2018 across the Eastern Africa region and the most affected region in the Eastern Africa region.

ABSTRACT

Background: Tuberculosis is an infectious disease that mainly infects the lungs, kidney, spine, brain, and intestines. It is a chronic infection that has been threatening the lives of humankind for more than four millenniums spreading through the air from one person to another.

Objective: The main objective of the study is to investigate the determinants of active Tuberculosis and determine the variation of the TB incidences with gender, age-groups, and countries in Eastern Africa region.

Methods: The study used a descriptive correlational research design under the positivist paradigm. Secondary data of aggregated Tuberculosis cases from the WHO database was used to address the research questions. A sample size of 656 aggregated tuberculosis cases across East African region was used.

Results: The result findings revealed that people at the age of 65 years and more are the most critical group of individuals susceptible to tuberculosis infection. The findings discovered that HIV patients have weaker immune system to fight diseases, seemingly, they are highly vulnerable to TB infection. Similarly, diabetic patients have a higher risk of developing tuberculosis more than smoking individual but not more than HIV patients. People who smoke are twice more likely to develop tuberculosis than undernourished individuals. However, alcohol was discovered to be less likely to expose individual to a risk of developing TB than undernourished individuals. According to the analysis Mozambique, Ethiopia, Kenya, Tanzania, and Uganda were the five leading countries with tuberculosis burden in East Africa in 2018. East Africa Community was the most affected region by tuberculosis, but Indian Ocean island region was least affected within East Africa region.

Conclusions: The current study's findings will add knowledge to the body of literature and provide insight into the East African governments to scale up and take concrete steps to control, prevent, diagnose, and treat the Tuberculosis epidemics.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Tuberculosis is an unrealized life-and-death contagious disease that primarily infects the lungs. However, it can also affect other parts of the body like the spine, kidney, brain, and intestines. It is a chronic infection that has been a peril to humankind for more than 4000 years spreading through the air from one individual to another (Zaman, 2010). Recent studies posit that despite efforts to mollify TB infection, the disease remains the top cause of morbidity and deaths in developing countries (Floyd et al., 2018; Lytras and Kalkouni, 2018; Zaman, 2010).

The World Health Organization (2013) discovered that approximately 10% of the latent infections result to be active Tuberculosis and, if not treated on time, cause death to almost half of those infected. Individuals with active TB in their lungs can spread the disease to healthy people through the air when they cough, spit, speak, or sneeze. However, individuals with latent TB can't cover the infection to healthy individuals.

Among the eight most affected countries with high TB burden, India was the leading with new TB cases, followed by China, then Indonesia, and lastly, South Africa (WHO, 2019). Since 1997, WHO has been publishing global TB report every year to provide a comprehensive and updated TB epidemic assessment to help in diagnosis, prevention and treatment of the disease at global, regional, and country-level. According to the World Health Organization (2013), adults in productive years are the most affected by Tuberculosis. Nonetheless, all individuals of all ages are at risk of being affected by Tuberculosis, with the majority of cases recorded in developing countries.

TB burden in most of the developing countries like Kenya is massive among the poor and vulnerable people aggravating social and economic inequality. Due to the lack of relevant surveillance mechanisms and proper monitoring of TB prevalence among the population at risk, data on vital and vulnerable people is limited. According to the Kenya Ministry of Health (2014), Kenya is among the top High TB Burden countries in the world. According to a Tuberculosis prevalence survey conducted in 2016 by the Ministry of Health in Kenya, the TB cases increased from 233 per 100,000 in 2015 to 558 cases per 100,000 population. In most developing countries with a weak surveillance system, not all TB cases are detected and more than 40% goes undetected and untreated (Ministry of Health, 2016). A recent study indicates that young adults aged between 15-34 years are most affected by TB infection, and about 83% of the patients were HIV negative (Philippe et al., 2016).

1.2 Problem Statement

Tuberculosis (TB) is an infectious disease resulting from a bacterium called Mycobacterium Tuberculosis. The bacterium disease mostly attacks the lungs but can also affect other body parts. According to the World Health Organization (2013), most of the tuberculosis infections are latent Tuberculosis since they do not have indicative symptoms. Several studies indicate that people with HIV/AIDS, and individuals with diabetes are more vulnerable to active Tuberculosis (Berkowitz, 2017; Narasimhan et al., 2013). Besides, other risk factors that accelerate influences the progress of Tuberculosis outbreak include smoking, malnutrition, use of alcohol, and indoor air pollution (Human, Smith, and Tshabalala, 2010; Lönnroth et al., 2008; Kigozi et al., 2017; Shamboze et al., 1999).

According to the World Health Organization (2019), the TB epidemic wiped out about 1.5 million people, where 16.7% of them were HIV positive individuals. World Health Organization (2019) report indicated that TB is a top 10 cause of death globally, killing more than HIV/AIDS from a single infectious agent. Also, the report stated that above 10 million people had active Tuberculosis in 2018 worldwide. The majority of those infected with TB were men (57%), then women (32%), and the lEastern affected were children (1.1%).

In 2018 TB killed more than 205 000 children, including those with HIV infection. In 2018, WHO discovered that five thousand people die every day due to active Tuberculosis worldwide. According to several studies, there exist significant gaps in TB diagnosis, proper notification and treatment, substantial financial support for tuberculosis prevention, and patient care in low and middle-income countries (Caminero et al., 2010; Turner et al., 2017; Yuko and Abdisalam, 2015). According to Lystras and Kalkouni (2018), reducing tuberculosis incidence and fighting the peril of drug resistance to Tuberculosis, requires an invention of new effective treatments, and new diagnostic measures to prevent inducement of active Tuberculosis in people with latent TB infection. The current study will help the world's governments particularly countries with high tuberculosis burden to scale up and take concrete steps in the control, diagnosis, prevention and treatment processes to end Tuberculosis epidemic.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This section provides a review of the tuberculosis infection and epidemics across the world. The review will help to shape research questions and contribute to the arguments about the requirement for the current study. Moreover, the review gives a background for understanding current knowledge about tuberculosis infection and find specific gaps in a body of research. This chapter will also help in interpreting the findings of this study by comparing and contrasting the results of other recent studies.

2.1 Empirical Review

According to Lytras and Kalkouni (2018), the tuberculosis scourge has plagued humankind for millenniums. Although tuberculosis is regarded as a disease of the old, it is global peril as it is the number one cause infectious disease that causes mortality today (Lytras and Kalkouni, 2018; Basu and Rao, 2017). Recent studies identified that among the contagious diseases, including HIV/AIDS, tuberculosis is at the pinnacle in death rate (Lytras and Kalkouni, 2018; Barberis et al., 2017; WHO, 2019). Lystras and Kalkouni (2018) discovered that tuberculosis resistant to drug account for a significant percentage of perils due to antimicrobial-resistant (AMR). In their study, they predicted that drug-resistant tuberculosis accounts for 25% of AMR-related deaths. In the invention of technology in the health sector and the development of socioeconomic status, there is an increase in applying effective and efficient treatments to drug, preventive, and control measures. Nevertheless, all these efforts have not mitigated tuberculosis jeopardy globally, and therefore, tuberculosis remains a public health threat worldwide.

Global challenges have aggravated the progress in mitigating deaths due to active tuberculosis. These global challenges include migration, war, inequality, deprivation, and social turmoil, and the invention of multidrug-resistant (MDR) and extensively drug-resistant (XDR) tuberculosis (Lytras and Kalkouni, 2018). Furthermore, MDR and XDR tuberculosis are believed to cause more deaths due to their high mortality rates when used in the wrong combination (Caminero et al., 2010). Nonetheless, the tuberculosis drug regime recommended that patients with MDR and XDR tuberculosis should receive the combination of at Eastern four drugs. According to Caminero et al. (2010), the pathogenic bacteria that cause disease (Mycobacterium tuberculosis) is highly likely to be susceptible if the drug is given to the patient in the combination of four or more groups of medicines selected based on safety, efficacy, and cost.

The tuberculosis epidemic became life-threatening worldwide, and the World Health Organization (WHO) declared it a global health emergency. In the process to fight the spreading and effects brought about by tuberculosis infection, WHO came up with three specific control strategies together with aspiring goals which included: the DOTS, which ended in 2005, the Stop Tuberculosis strategy, which started in 2006 to 2015, and lastly the End Tuberculosis strategy that began in 2016 until 2035 (Lytras and Kalkouni, 2018). Among the three strategies endorsed by WHO in 2014, the End Tuberculosis strategy has the most appealing goals that seek to mollify tuberculosis incidence by 90% and 95% attenuation of tuberculosis deaths by 2035 relative to 2015. To Achieve the stipulated goals, the WHO incepted a pillar of the overall strategy by supporting political commitment and encouraged government supervision.

The study conducted by Lystras and Kalkouni (2018) indicated that WHO's dedicated effort to reduce tuberculosis incidence and mortality due to TB infection bared fruits from 2000 to 2016. Between 2015 and 2016, the mortality rate declined by 4% annually, and tuberculosis incidence decreased by 1.9% per year. Nevertheless, the number of patients diagnosed with active tuberculosis and receiving medication increases every year. It was anticipated that to fulfill the ambitious targets of reducing global tuberculosis incidence and mortality rate, the current declining rate in global TB incidence needs to be hastened to a remarkable rate of about 5% annually in 2020 and 10% by 2025. According to recent studies, only a few nations and regions recorded a significant decline of more than 5% annually, mainly European countries. Consequently, countries with the highest tuberculosis burden did not show a higher substantial decrease in tuberculosis incidence.

The 10% decline in tuberculosis incidence in 2025 can be achieved by implementing novel drug therapies, highly sensitive diagnosis measures, and comprehensive organized TB control measures. Nevertheless, in their 2018 report, WHO approximated that among the 10.4 million new tuberculosis cases per year, only about 61% of them get diagnosed and receive treatment, and 22% of which are drug-resistant TB. Besides, the majority of tuberculosis patients do not get proper medication. Thus, the conditions make the spread of TB infections exacerbate, increasing the TB incidence in some regions in developing countries with weak public health care.

Due to lack of sufficient knowledge about the new drugs and how to use them alongside other standard treatments has led to high mortality among the active TB patients. Besides, the new drugs' high cost and adverse side effects make them unaffordable for many of the active TB patients. According to the 2018 WHO data, the global TB treatment success rate for all the cases was about 83%, and those who had drug-resistant tuberculosis were about 54%, with only 30% having XDR-TB (WHO, 2019).

According to (Quaife et al., 2020), deaths due to tuberculosis infection have declined significantly over the last two decades. They also articulated that over 54 million people have survived from tuberculosis infection from 2000. Recent studies indicate that there have been increasing efforts to reveal tuberculosis infection and mortality (Allwood et al., 2019; Yuko Oso and Abdisalam, 2015; Quaife et al., 2020). Besides, a developing body of research indicates that there is still no permanent solution to end the ill-health conditions despite many efforts to reduce tuberculosis infection. Recent studies articulate that a prolonged period of TB infections and morbidity results in frequent death (Allwood et al., 2019; Quaife et al., 2020)

A study conducted to investigate the factors facilitating the interruption of tuberculosis patients' treatment in South Africa identified socioeconomically (*Socioeconomic factors influencing tuberculosis treatment*, 2013), TB policy, and health care as significant factors (Human, Smith, and Tshabalala, 2010). The study findings discovered that tuberculosis management requires a multi-sectoral method and combined efforts to control and prevent the curable disease that continues to kill many people globally. Furthermore, (Narasimhan et al., 2013; *Socioeconomic factors influencing tuberculosis treatment*, 2013) further realized that socioeconomic and behavioral factors also increase the patients' risk by making them more susceptible to mycobacterium infection. Narisimhan et al. (2013) articulated that the TB mortality rate increases due to the effects of delay in diagnosing TB infection and the transmission of the bacilli. According to Turner et al. (2017), the transmission of tuberculosis infection from one person to another is complex. For that reason, several factors provide favorable conditions that are involved. The disease caused by mycobacterium is induced in the airways through coughing, sneezing, laughing, shouting, and other means, and then the active bacilli are released to the respiratory tract of the source host as an aerosol (Turner et al., 2017; (Caminero et al., 2010).

According to a study conducted by (Narasimhan et al., 2013), endogenous factors enhance the progression of active TB from bacterial infection. In their research, they discovered that HIV infection, malnutrition, diabetes, alcohol use, age, and use of immunosuppressive medication, and smoking play a vital role in facilitating the development of tuberculosis at both individual and population level.

2.1.1 HIV Infection

Human immunodeficiency virus (HIV) direct attacks people's immune system and makes them highly venerable to other infections. HIV invades the white blood cells that fight diseases. The virus replicates and produces more viruses, and the cycle can continue destroying an individual immune system badly if no treatment is provided to the patient (Liu et al., 2006). In this regard, HIV patients are highly vulnerable to TB infection since the virus compromises their immune system. Most of the high burden countries in Eastern Africa have high HIV prevalence leading to increased spread of TB infection (WHO, 2018). Several studies (Ravikumar and Varadaraja, 2017; Berkowitz, 2017) discovered that people infected with HIV and diabetes are significantly susceptible to developing active tuberculosis. The researchers suggested that efficient and effective diagnostic techniques and tools are vital for early discovering and treating disease; thus, mitigating unexpected morbidity and mortality. A study conducted by Govender (2017) pointed TB disease as the leading cause of death in South Africa despite all the efforts undertaken to improve diagnosis measures and treatments to international standards.

2.1.2 Diabetes

Diabetes is a metabolic disease that induces the production of blood sugar to higher levels than normal. People with diabetes have weak immunity to withstand other infections like TB and other viruses and bacterial infections. In this regard, diabetes is considered a significant contributing factor to the burden of TB infection in Eastern Africa (Stevenson *et al.*, 2007). Researchers argued that the emergence of diabetes mellitus in developed and developing countries had posed health threats (Dooley *et al.*, 2009). Dooley et al. (2009) revealed that people with diabetes were at a higher risk of developing active TB, and they had twice higher odds of deaths than those with no diabetes.

Adjusting for human immunodeficiency virus (HIV), age, weight, and foreign birth, the odds of death were 6.5 times higher in patients with diabetes than patients.

2.1.3 Alcohol Consumption

Consistent use of excessive alcohol is associated with serious health hazards. Research indicates that excessive alcohol use can develop chronic diseases and other serious health problems such as cardiovascular diseases, liver problems, high blood pressure, and other alcohol-associated diseases (Mukamal and Rimm, 2008). This weakens the health of the patients, making them vulnerable to other infections such as TB**.** Lönnroth et al. (2008) conducted a study on how alcohol impacts tuberculosis and revealed that people who drink more than 40 grams of alcohol per day and are addicted to alcohol use are highly at risk of active disease. Imtiaz et al. (2017) conducted a meta-analysis of alcohol consumption as a risk factor for TB. They revealed that alcohol consumption increases the risk of tuberculosis development by 35% compared to no alcohol use. They also discovered that past alcohol consumption had no significant association with a higher risk of TB compared to no alcohol use. Researchers argued that most of Eastern Africa countries with high TB burden are heavy alcohol users among diverse groups of young people (Francis et al., 2014). Rehm et al. (2009) revealed a strong relationship between heavy alcohol consumption and TB development in their systematic review. The researcher argued that alcohol has a pathogenic influence on heavy drinkers' immune systems, making them susceptible to active TB development.

2.1.4 Smoking

Evidence of an association between smoking and tuberculosis has been increasing in recent years. Smoking destroys the lungs and aggravates smokers' immune systems, making them more susceptible to TB infection (Leung et al., 2010). A study conducted by Alavi-Naini, Sharifi-Mood, and Metanat (2012) postulated that smokers are three times more likely to develop tuberculosis than non-smokers. Research indicates that smoking is significantly associated with lung cancer; hence smokers are highly vulnerable to active TB infection (Leung et al., 2010). Alavi-Naini, Sharifi-Mood, and Metanat (2012) recommended that smoking cessation intervention is required in the current TB control measures.

2.1.5 Undernourishment

Undernourishment is an inability to acquire enough balanced food or the level of food intake, unable to meet an individual's nutritional and energy requirement (Sinha *et al.*, 2019). Using both observations in a human and experimental animal model (Cegielski and McMurray 2004) revealed that undernourishment is a vital risk factor for TB infection. They discovered that undernourishment has significantly higher risks for the development of tuberculosis than HIV infection. In their study, Farre *et al.* (2014) discovered that being undernourished has a higher significant risk of developing TB than well-nourished individuals. Another study by Seid, G., and Ayele (2020) agreed with Fare et al. (2014) that undernourished individuals are venerable to TB infection than well-nourished individuals. Moreover, Sinha *et al.* (2019) argued that, given its influence on TB, addressing the undernourished will be a critical element of the WHO End TB Strategy.

2.1.6 Gender Difference

Govender (2017) revealed that patient vulnerability and complexity of the outcome differed between males and females. Recent studies indicate that males have a higher tuberculosis disease prevalence globally (Murphy et al., 2018; Marçôa et al., 2018; Nhamoyebonde and Leslie, 2014). Researchers argued that given the ratio of TB cases between male and female as 1.7:1 worldwide, little information could be deduced about the potential impact of an individual's sex on TB infection (Fernandes et al., 2018; Horton et al., 2016; World Health Organization, 2016). However, in some other countries like Vietnam, males pronounce higher TB cases where the male to female ratio is 3.1:1. The reasons why men record more top TB cases include the following: Men have greater exposure to infectious tuberculosis cases; they have a higher prevalence of TB predisposing factors (e.g., smoking and alcohol use); and women under-detection due to challenges they face in access to care (Fernandes et al., 2018). Over the past two decades, tuberculosis (TB) case notifications have been higher in men than women in most settings (Horton et al., 2016). According to Horton et al. (2016), men have more tuberculosis notification than women due to the barrier's women encounter in seeking medical care and TB diagnosis. Nevertheless, evidence on whether men have more cases than women cannot be based on notification data alone. In their study that involved 5414 pulmonary TB patients, Lin et al. (2013) found that women had a higher likelihood than men of having concurrent excess pulmonary TB cases.

2.1.7 Age-Sex Difference

Several studies indicate that tuberculosis prevalence of infection in males is not different from that in females at a young age, but around the puberty stage, the prevalence in males starts to exceed that of females (Fernandes et al., 2018; Zaman, 2010). This pattern of age-sex difference in TB prevalence of infection has been discovered in recent years in India, Korea, and most of the African countries with high TB burden (Kyu et al., 2018). According to a study by Marçôa et al. (2018), tuberculosis notification cases among men are higher than that among women after the second decade of life. Moreover, Lin et al. (2018) discovered no significant pulmonary tuberculosis difference between men and women below 45 years of age. However, among the patients 45 years and older, women recorded an extra-pulmonary TB compared to men.

2.1.8 Tuberculosis infection Across Different Countries

The tuberculosis incident cases relative to the country's population size vastly varies among countries. High-income countries, including most western European countries, records the lowest incidence of tuberculosis cases in the world (WHO, 2019). Moreover, Canada, the US, Australia, and New Zealand were identified as among tuberculosis's lowest rate countries. According to WHO (2018), India, China, Indonesia, Philippines, Pakistan, Nigeria, Bangladesh, and South Africa are the eight most affected countries with a high TB burden in the world. Moreover, the world health organization 2018 report indicated that Mozambique, Zambia, Kenya, Ethiopia, Uganda, Tanzania, Zimbabwe, and Ethiopia are the eight most affected countries with a high TB burden in the Eastern Africa region (WHO, 2018). Most of the countries in Eastern Africa with a high tuberculosis burden had a high HIV prevalence, which could be the most significant factor influencing TB's development among individuals (WHO, 2018).

Furthermore, according to Dye et al. (2006), more than a third of Sub-Saharan Africa people have tuberculosis infection. The researchers argued that tuberculosis was raised due to increased HIV infection among the people in Southern and Eastern Africa. This is the case because HIV infection aggravates patients' immunity, making them highly susceptible to tuberculosis infection. In more than one decade, the incidence rate of tuberculosis in the Eastern Africa region was estimated to grow at more than three percent annually, compared to other parts of the world (Dye et al., 2006). According to Zumla et al. (2015), the Eastern Africa region records the highest tuberculosis burden of patients with HIV globally. It is argued that countries with low tuberculosis incident rates like Comoros, Mauritius, and Seychelles, tend to possess different aims concerning the tuberculosis epidemic, as compared to countries with a high tuberculosis burden. Nonetheless, high income and low TB incidence countries should be on the front line in helping low income and high TB burden countries eradicate tuberculosis infection. The current study will focus on the difference in tuberculosis infection across the 20 countries in the Eastern Africa region.

2.3 Research gap

Although various research studies have been done to explore TB's prevalence globally, there is a shortage of evidence of the disease prevalence and incidence in the African context, especially Eastern Africa. Specifically, despite the available few explorations focusing on TB incidences, none of the studies compares TB infection between males and females across the Eastern Africa countries. Besides, there is limited knowledge of the most significant contributing factor of active tuberculosis and the most affected age group across Eastern Africa countries. This research study seeks to add a new knowledge gap to address the identified literature gaps by exploring the relationship between tuberculosis incidence and age, gender, and the TB risk factors (HIV infection, diabetes, alcohol, smoking, and malnourishment) across the Eastern Africa region. Additionally, the research evaluated the determinants of active Tuberculosis and determine the variation of the TB incidences with gender, age-groups, and countries in Eastern Africa region.

2.4 Conceptual Framework

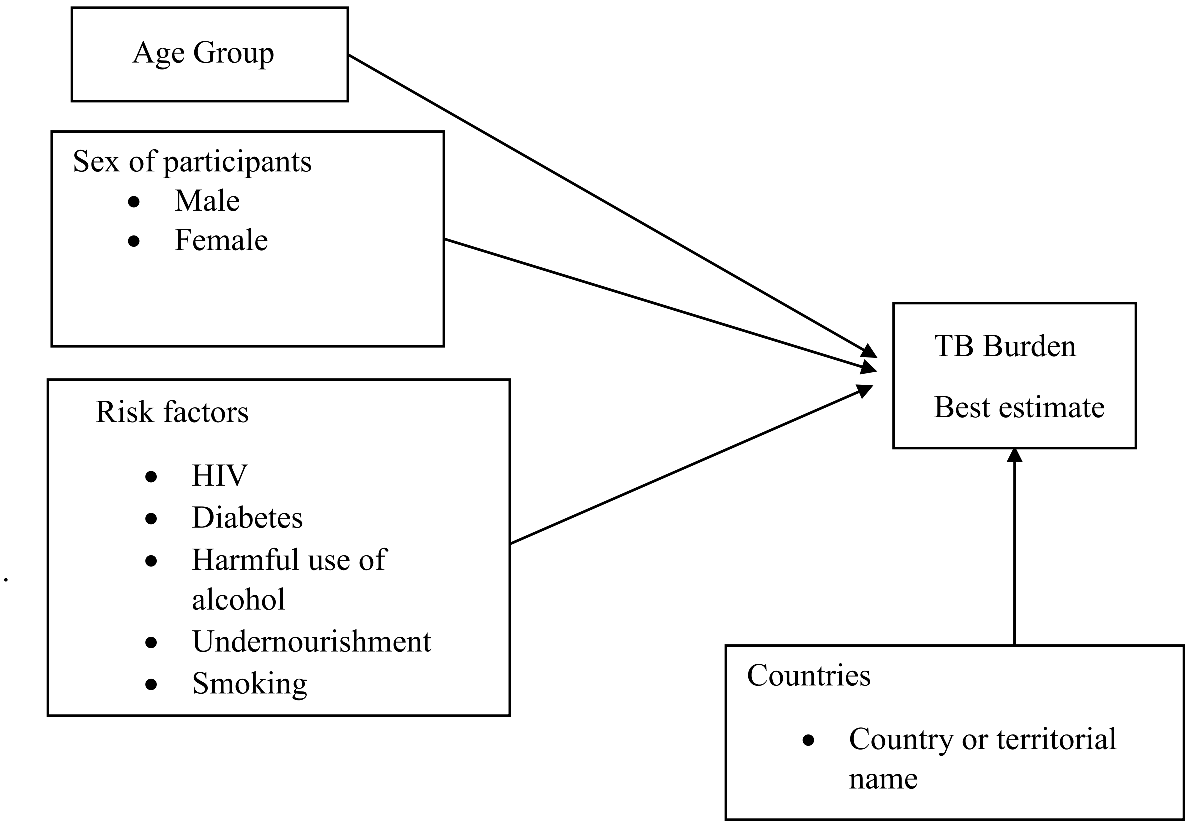

Figure 1: Conceptual Framework

2.5 Justification of the Study

The main purpose of this research study is to investigate the most significant contributing factors to active Tuberculosis and examine how Tuberculosis differs between gender, age group, and countries across the Eastern Africa Region. While TB influencing factors such as HIV, Diabetes, Smoking, Alcohol, and Undernourishment (Narasimhan et al., 2013) have been examined and studied in previous research, there is a lack of knowledge about their impact differ in influencing TB infection. Most of the research studies have focused on the global impact of TB influencing factors but have not explored these factors' impact across the Eastern Africa region.

In this regard, this paper aimed to articulate the risk factors contributing to TB outbreak at both personal and population levels within a country and across the Eastern Africa region. Furthermore, the study investigated whether there was an association between tuberculosis incidence and prominent risk factors such as HIV/AIDS infection, smoking, alcohol, diabetes, and undernourishment. The study also determined the difference in the rate of TB infection between gender, age, and countries in the Eastern Africa region.

The results of this research will provide insight into health workers and public health professionals on the kind of interventions to include in TB control practices. Exposure to smoking and excessive alcohol consumption aggravates a TB patient (Thomas et al., 2019). The research study findings have the potential to be used to raise awareness of health care workers on how to include effective interventions in TB control practices. Besides, the current study's findings will provide insight into the East African governments to scale up and take concrete steps to control, prevent, diagnose, and treat the Tuberculosis epidemics.

2.6 Research Questions

The research paper addressed the following research questions:

i) What is the incidence rate of tuberculosis infection between gender across the Eastern Africa Region?

ii) Which is the most affected age-group by TB infection across Eastern Africa Region?

iii) Across the Eastern Africa region, which countries have a high TB burden?

iv) What is the relationship between the TB risk factors (HIV, diabetes, alcohol, smoking, and malnourishment) and the estimated cases of TB across the East Africa Region?

The research questions were addressed the following hypotheses:

2.7 Research Hypotheses

H1: Males have a significantly higher tuberculosis incidence than female across the Eastern Africa region.

H2: The elderly above 65 years old have a significantly higher tuberculosis burden across Eastern Africa Region.

H3: There is a significant association between the TB risk factors (HIV, diabetes, alcohol, smoking, and malnourishment) and the estimated cases of TB across the East Africa Region.

2.8 Objectives the Study

The main objective of the study was to investigate the determinants of active Tuberculosis and determine the variation of the TB incidences with gender, age-groups, and countries in Eastern Africa region.

2.8.1 Specific Objectives

The specific objectives are:

i) To assess the incidence of tuberculosis between gender across the Eastern Africa Region

ii) To establish the most affected age-group by tuberculosis infection the Eastern Africa Region

iii) To determine the countries with high TB burden across the Eastern Africa region.

iv) To establish the relationship between the TB risk factors (HIV, diabetes, alcohol, smoking, and malnourishment) and the estimated cases of TB across the East Africa Region

CHAPTER THREE

METHODOLOGY

3.0 Introduction

The chapter articulates the felicitous procedures to be used in attaining the main objective of the study. This is explored under Research design, Target Population, study area, sample size determination, Sampling design, recruitment and consenting procedures, variables, data collection procedures, and materials. This was aimed to address the main objective of the study, which was to investigate the determinants of active Tuberculosis and determine the variation of the TB incidences with gender, age-groups, and countries in Eastern Africa region.

3.1 Research Design

The current study employed a descriptive correlational research design linked to a positivist paradigm. Choosing an appropriate research design helps in minimizing research bias and enhance the interpretability of the results (Polit and Beck, 2009). It is argued that research design is the architectural backbone of the research study. Moreover, the current study sought to describe the relationships between the response variable (tuberculosis best estimate) and TB risk factors controlling for age and gender without intending to infer causal connection.

3.2 Study Area

The study was conducted in the Eastern Africa region, which comprises of twenty territories, but only 19 countries was involved in the study. Annual aggregate for 2018 tuberculosis data for each country was combined to form a combined dataset in addressing the research questions. This region is considered as an eastern subregion of the African continent. It is made up of five regions that includes: East African Community (Tanzania, Kenya, Uganda, Rwanda, and Burundi), Horn of Africa (Djibouti, Eritrea, Ethiopia, and Somalia), Indian Ocean island (Madagascar, Mauritius, Comoros, and Seychelles), Central African Federation (Mozambique, Malawi, Zambia, and Zimbabwe), and Nile Valley (Sudan and South Sudan).

According to World-meter (2020), the Eastern Africa region is populated with 448,739,379 people, equivalent to 5.71% of the world's total population. It is ranked the highly populated subregion in Africa, with most people living in rural areas (69.2%) and with a median age of 18.7 years. Ethiopia has the highest population density, almost twice as Tanzania's population, which is more populated than Kenya.

3.3 Target Population

Populations are not only human subjects but may also consist of items, objects, or events. It comprises the entire aggregation of elements of interest to the research questions regardless of the basic unit. In this study, the target population comprised of active tuberculosis patients aged from day one to 74 years old across the Eastern Africa region.

3.3.1 Inclusion Criteria

The study used secondary data retrieved from the WHO database. The study included tuberculosis datasets obtained from the nineteen countries across Eastern Africa region. Only incidence estimates disaggregated by age, sex, and risk factors was considered for this analysis. Tuberculosis patients' young children and the elderly from year zero to 74 years of age was included in this study. Only the variables relevant to the study was included in the dataset that consisted of aggregated tuberculosis best estimates, TB risk factors (HIV, diabetes, smoking, alcohol, and undernourishment), age-group, gender, countries, and year.

3.3.2 Exclusion criteria

Any other variable not of interest to the study was not included in the dataset. Data from other countries apart from the Eastern Africa region was excluded from the analysis. Besides, data on prevalence and estimated burden of tuberculosis was not considered.

3.4 Variables

The study used 2018 annual aggregated tuberculosis cases (best estimate) as a continuous response variable. The outcome variable was tuberculosis's best estimate cases for 2018 for each country in the Eastern Africa region. The predictor variables had a categorical scale of measurement. The predictor variable included age, gender, active TB risk factors, and countries. Age was grouped into age groups, and TB risk factors were HIV, diabetes, alcohol, smoking, and undernourishment.

3.5 Data Collection Procedures

A sample is the subset of the population, and investigators collected data from the target population using a random or non-random sample. The study used secondary quantitative data with a sample of 656 annual aggregated cases retrieved from the World Health Organization (WHO) database. The data is the combination of TB annual aggregated cases for each country from the TB surveillance system in the Eastern Africa region. The information was electronically submitted to WHO Regional offices for EU/EEA and non-EU/EEA countries for 2018 from national surveillance institutes in those countries to estimate the global TB burden. This study's data was retrieved from the WHO database to consist of 2018 TB estimated cases for countries in the Eastern Africa region. Estimates of TB burden were measured in terms of incidence, prevalence, and mortality recorded every year by WHO. The information was gathered through surveillance systems, special studies, mortality surveys, surveys of under-reporting of detected TB, in-depth analysis of surveillance, expert opinion, other data (World Health Organization., 2013). The surveillance systems get TB data from case notifications and death registrations in each country across the world. In this study, the TB incidence are disaggregated by HIV status, gender, and age.

Since population-based surveys at the national level are not sufficient for estimating TB incidence globally, TB notifications provide the best proxy estimate of TB incidence in most countries. Countries having high-performance surveillance systems still have little under-reporting of diagnosed cases, and therefore, other sources of TB data were considered (Philippe et al., 2016). Moreover, in countries where access to and quality of health care is sound has few cases that remain undiagnosed. In a large number of developing countries where the mentioned criteria of estimating TB incidence are not possible, inventory study provides the best estimate of TB incidence

3.6 Sampling procedure

The study used a purposive sampling technique, a non-sampling method, to select only the Eastern Africa countries, and only the variables relevant in answering the study questions. The researcher retrieved the dataset for this study by purposively selecting only 19 countries in the Eastern Africa region. The researcher excluded data from any other country and excluded variables that were not relevant in answering the research questions. The sample size was obtained based on the number of annual aggregated tuberculosis cases across the nineteen Eastern Africa countries. A sample size of 656 annual aggregated tuberculosis cases was retrieved from global annually aggregated tuberculosis cases obtained from WHO database.

3.7 Ethical Consideration

Ethics was involved in what was done during the research. In research, investigators should ensure no harm to human subjects. According to WHO (2017), new tuberculosis (TB), ethical guidance provides that countries implementing the End TB Strategy cling to sound ethical standards that protect patients' rights. The researcher ensured the data was anonymous. The data did not contain participants identifying information. Nevertheless, if the data contained participants identifying information, it could be de-identified to ensure the participants' privacy and confidentiality. Since the data was freely available on the WHO online database, it was obtained following the WHO's data sharing policy and subject to WHO's copyright notice and permissions and licensing rules. Moreover, the researcher ensured the WHO database's tuberculosis data was kept safe from unauthorized access or accidental loss or corruption and made sure that the TB data's softcopies were encrypted in a computer as files.

The new ethics guidance takes care of contentious issues that include the isolation of contagious patients, the rights of TB patients in prison, prejudicial policies against migrants with TB, among others (WHO, 2017). The World Health Organization (WHO) stipulated that governments, health workers, care providers, researchers, non-governmental organizations, and other stakeholders should provide TB patients with the following services:

I. Social support
II. Isolate of TB patients after fulfilling all options that enable treatment adherence under specific conditions.
III. Ensure that all TB patients access the same standard of care offered to other citizens.
IV. Provide safe environment for all health workers and share gathered evidence from research swiftly to inform national and global TB policy updates.

It is argued that the WHO's End TB is reinforced by ethics, equity, and human rights protection (WHO, 2017).

3.8 Data management

3.8.1 Preparing the Data for Analysis

The data collected for most quantitative studies are hardly amenable to direct analysis. The data obtained was edited for accuracy, completeness, and consistency. Categorical variables were coded for ease of interpretation and analysis; for example, gender was coded such that male was given the value one, and female the value 2. Inconsistencies in the data were removed during data cleaning to validate the data for reliable findings. The data was cleaned for analysis using the R programming software version 3.6.3 and Excel spreadsheets.

3.8.2 Data Analysis

Addressing the research questions and test formulated hypotheses, the investigator analyzed the data in an orderly and coherent way.

Table 1: Data Analysis Plan

Objectives	Data required	Data analysis Plan	Data presentation plan
1	Tuberculosis incidence for male and female	Proportion of TB patients based on gender. Descriptive statistics (mean, maximum, minimum, standard deviation, median) Difference between TB average TB incidence using one sample independent sample t-test.	The proportion between male and female TB patients was presentenced inform of a pie chart. Descriptive statistics was presented in form of a table. Independent t-statistics and p-value was presented in a table for testing the hypothesis.
2	Tuberculosis incidence estimates across all the age-groups	The proportions of age-groups were determined. Descriptive statistics based on age-group was also calculated. The difference in tuberculosis infection	The proportion of age-groups was presented using a bar chart. Descriptive statistics and the inferential statistics was presented using tables.

		across age-groups using one-way ANOVA	
3	Tuberculosis incidence across all the Eastern Africa Countries	Descriptive statistics of TB incidence across all the 19 countries in the Eastern Africa region	Descriptive statistics was presented using a table.
4	Estimated TB incidence TB risk factors (HIV, diabetes, alcohol, smoking, and malnourishment) Age-groups Gender NB gender and age-groups were used as confounding variables.	Negative binomial regression analysis was used to identify the impact of TB risk factors on Estimated TB incidence	The results were presented in form of a table with regression estimates, risk ratios, standard errors of the estimates, and p-values of the regression estimates.

3.9 Study Limitation

It is impossible to infer causal relationships between the response and predictor variables in correlational research. Because it lacks control over the extraneous variables and lacks an exemplary counterfactual. Furthermore, correlational studies are highly susceptible to fallacious interpretation due to selection bias. The study did not investigate the number of patients who died of tuberculosis infections; therefore, we could not determine the percentage of those who do not recover from TB infections. Due to limited time, the researcher decided to use secondary data from the WHO database to address the research questions. Although secondary data saves time and is economical, the information used might not be accurate to guarantee a valid conclusion. Moreover, secondary data may be out of data based on the spread of TB infections between individuals, and the sample used from different countries in estimating the TB burden might not be a good representative of the target population.

CHAPTER FOUR

RESULTS AND DISCUSSION OF THE FINDINGS

4.1 Introduction

This chapter presents the results and discussion based on analysis of the research data. The results were presented in form of tables displaying descriptive statistics and relationship between variables and visual representation using graphical methods for categorical variables.

4.1.1 Respondents Demographics Information

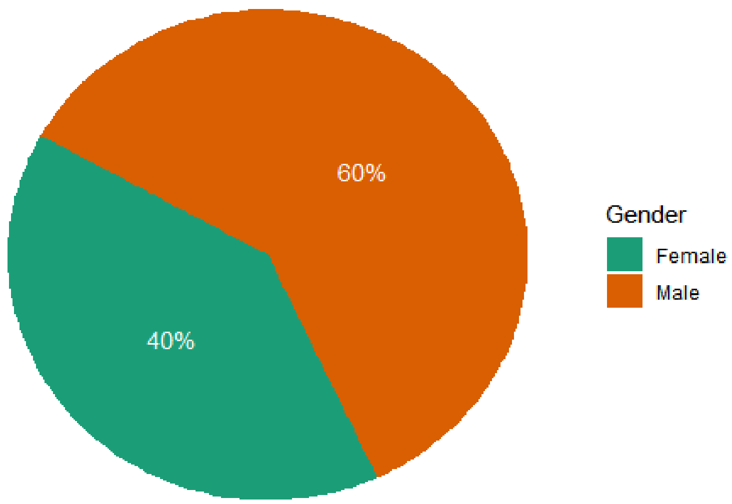

Figure 2: TB Patients by Gender

Figure 1 above indicates that there were more male (60%) TB patients than female (40%) TB patients. This suggested that men are the most affected individuals by TB infection than women in East Africa Region.

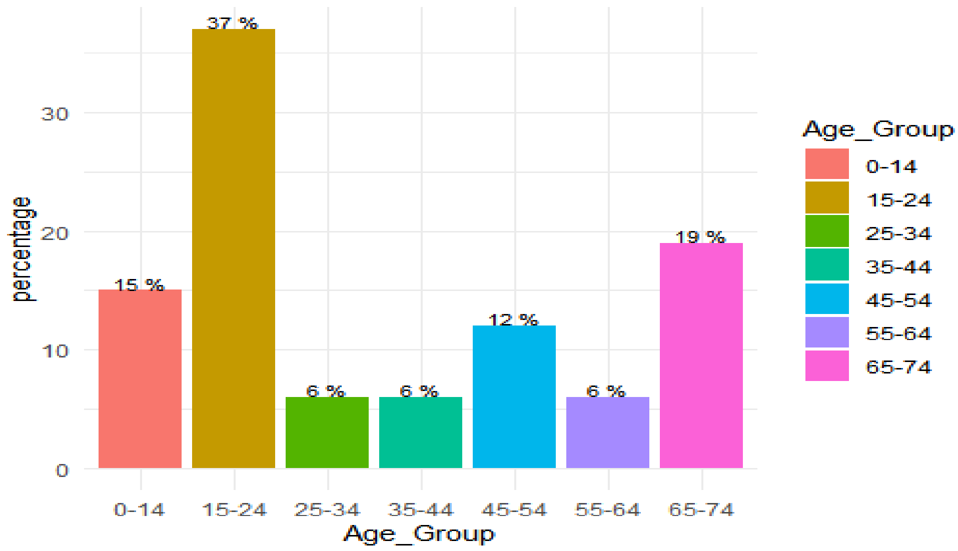

Figure 3: TB Patients by Age Group

According to the analysis displayed in figure 2 above, most TB patients in the East Africa region were young people aged between 15 to 24 years (37%). Nineteen percent of the TB patients were adults over 65 years, and 15% of the TB patients in the sample were below 14 years of age. Moreover, middle-aged individuals (25 to 44 years) and those between 55 to 64 years of age recorded the least percentage (6%) among those with TB infection in the East Africa region.

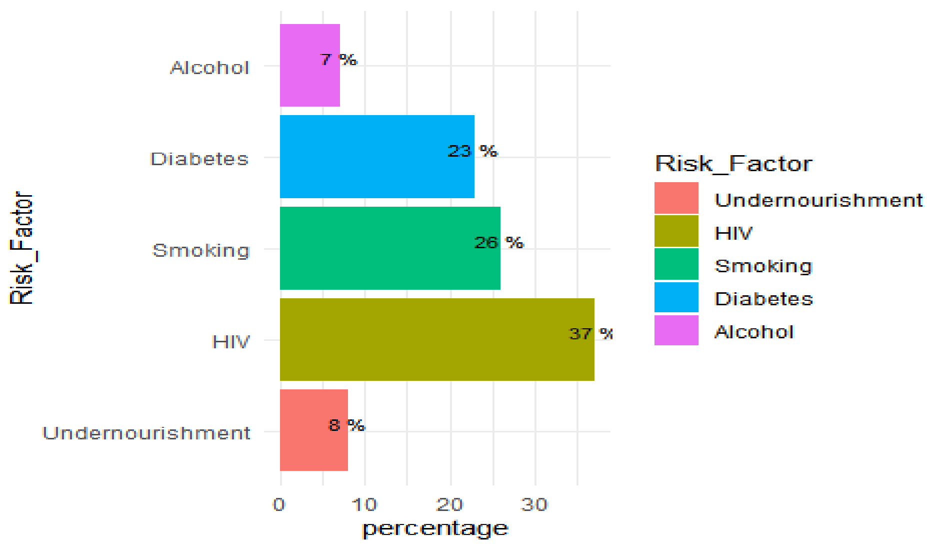

Figure 4: TB infection by Risk Factors

The analysis depicted in figure 3 indicates that most TB patients were HIV patients (37%). Twenty-six percent of the TB patients were smokers, and 23% of the patients were diabetic patients. Those who had undernourishment were only 8%, and the least number of patients were alcohol addicts. This suggested that individuals with HIV were more likely to be infected by Tuberculosis. Moreover, smoking was postulated to be a substantial risk factor to Tuberculosis, and alcohol is the least influencing factor to tuberculosis infection since only a few TB patients were alcohol drinkers.

4.2 To assess the incidence of tuberculosis between gender across the Eastern Africa region

Table 2: Descriptive Statistics by Gender

Gender	Mean	SD	Median	Min	Max
Female	6412.93	13950.22	1500	0	99000
Male	10781.98	24689.67	1900	0	165000

The analysis displayed in table 2 above indicates that males (M=10781.98, SD=24689.67) are the most affected individuals by tuberculosis infection than females (M=6412.93, SD=13950.22). Besides, the maximum number of TB cases for males (165,000) in the East Africa region is almost twice that of females (99,000). The analysis suggested that males are highly susceptible to tuberculosis infection across East African Regions than females, which may be accelerated by several factors such as diabetes, alcohol, and smoking status.

H1: **Males have a significantly higher tuberculosis incidence than female across the Eastern Africa region.**

The two-sample independence t-test in table 3 (**see appendix 2**) indicates that there is enough evidence to reject the null hypothesis that there is no difference in tuberculosis incidence between males and females at a 0.05 level of significance. We conclude that males have a significantly higher tuberculosis incidence than females across the Eastern Africa region (t = -2.89, p = 0.002).

4.3 To establish the most affected age-group by tuberculosis infection the Eastern Africa Region

Table 3: Descriptive Statistics by Age-Group

Age Group	Mean	SD	Median	Min	Max
65-74	19249.09	32252.61	3400	0	165000
15-24	8120.57	20197.04	1000	0	146000
25-34	5086.14	6538.09	2550	2	26000
35-44	4306.94	5136.44	2650	0	19000
0-14	3558.60	6076.59	1450	0	41000
45-54	2280.54	2922.43	1250	0	12000
55-64	1919.75	2184.81	1300	0	7300

The analysis depicted in table 4 above suggests that individuals above 64 years are the most affected age group by tuberculosis infection, recording the highest average number of cases across the East Africa region (M=19249, SD=32,252.61). This age group recorded the highest maximum number of tuberculosis cases (165,000) in 2018 in the East Africa region. Surprisingly, young individuals between the ages of 15 to 24 years were examined as the second group at risk of tuberculosis infection in 2018 (M=8121, SD=20197.04) with a maximum number of infections reaching 146,000 TB cases. Individuals aged between 55 to 64 years were identified as people at the lowest risk of tuberculosis infection in the East Africa region. They recorded the lowest average number of TB cases (M=1919.8, SD=2184.8) and shown the lowest maximum number (7300) of TB cases.

H2: The elderly above 65 years old have a significantly higher tuberculosis burden across Eastern Africa Region.

Table 4: One-Way ANOVA

	Sum Sq	Df	F value	Pr(>F)
(Intercept)	21353981155	1	52.053	0.000
Age Group	27531007632	6	11.185	0.000
Residuals	266241536959	649		

The analysis displayed in table 5 above suggests that the overall at least one age group is significant at 0.05 level of significance ($F(649) = 11.185$, $p < 0.001$). Further analysis is needed to determine which pair of age groups are significantly different at a 0.05 level of significance. A pairwise comparison sing TurkeyHSD was conducted, as shown below.

Post Hoc Test: Turkey HSD

Table 5: Pairwise Comparison

Age Groups	diff	Lower Bound	Upper Bound	p-value
15-24-0-14	4561.967	-2449.619	11573.554	0.465
25-34-0-14	1527.539	-9600.120	12655.197	1.000
35-44-0-14	748.344	-10379.314	11876.003	1.000
45-54-0-14	-1278.058	-10200.034	7643.917	1.000
55-64-0-14	-1638.850	-12766.508	9488.808	0.999
65-74-0-14	15690.492	7807.894	23573.091	0.000
25-34-15-24	-3034.428	-13145.319	7076.462	0.974
35-44-15-24	-3813.623	-13924.513	6297.268	0.923
45-54-15-24	-5840.025	-13456.256	1776.205	0.261
55-64-15-24	-6200.817	-16311.708	3910.073	0.539
65-74-15-24	11128.525	4761.368	17495.683	0.000
35-44-25-34	-779.194	-14079.290	12520.901	1.000
45-54-25-34	-2805.597	-14323.818	8712.624	0.991
55-64-25-34	-3166.389	-16466.485	10133.707	0.992
65-74-25-34	14162.954	3429.681	24896.226	0.002
45-54-35-44	-2026.403	-13544.624	9491.818	0.999
55-64-35-44	-2387.194	-15687.290	10912.901	0.998
65-74-35-44	14942.148	4208.876	25675.420	0.001
55-64-45-54	-360.792	-11879.012	11157.429	1.000
65-74-45-54	16968.551	8543.588	25393.513	0.000
65-74-55-64	17329.342	6596.070	28062.614	0.000

The analysis results in table 6 above revealed that patients between the ages of 65 and 74 had a significantly higher tuberculosis incidence than all the other groups at a 0.05 level of significance ($p < 0.05$). Therefore, based on the analysis, individuals above 64 years of age have a significantly higher tuberculosis burden across Eastern Africa region. This suggests that much emphasis should be given to care for the elderly since they are highly susceptible to tuberculosis infection.

4.3.1 Age-Sex Difference in Active Tuberculosis Infection

Table 6: Age-Sex Difference in Tuberculosis Infection

Sum of Best Estimate	**Sex**		
Age Group	Female	Male	Grand Total
0-14	2.6%	3.7%	6.3%
15-24	9.2%	27.9%	37.1%
25-34	0.9%	2.7%	3.6%
35-44	1.2%	1.8%	3.1%
45-54	1.4%	1.8%	3.2%
55-64	0.6%	0.8%	1.4%
65-74	13.8%	31.5%	45.3%
Grand Total	29.8%	70.2%	100.0%

According to the analysis male recorded a higher prevalence of tuberculosis than female across all the age groups. The analysis depicted in table 7 above suggested old individuals above 64 years were the most susceptible group for active tuberculosis infection, recording the highest prevalence where men (31.5%) recorded more than twice that of women (13.8%). The second affected group was between 15 to 24 years, where tuberculosis prevalence in men (27.9%) was three times that in women (9.2%). Children under the age of 15 years for both men and women were more vulnerable to active tuberculosis than individuals aged above 24 years and below 65. According to the analysis, males recorded a higher prevalence of tuberculosis than females across all age groups.

4.4 To determine the countries with high TB burden across the Eastern Africa region.

Table 7: Descriptive Statistics by Country

Country	Mean	SD	Median	Min	Max
Mozambique	27183.89	36924.47	10500.0	720	162000
Ethiopia	25497.50	39858.30	8100.0	150	165000
Kenya	24779.44	36633.85	9300.0	290	150000
Tanzania	24289.72	34044.55	10000.0	730	142000
Uganda	15044.17	21843.59	4950.0	390	86000
Zambia	10845.00	15405.06	4250.0	350	60000
Madagascar	10512.42	15574.31	3800.0	240	61000
Somalia	6232.47	9420.34	2350.0	29	39000
Malawi	5580.28	7753.01	2050.0	190	33000
Zimbabwe	5523.86	7828.98	2250.0	99	30000
Sudan	5029.36	7458.78	2000.0	69	30000
South Sudan	3145.00	4155.66	1300.0	480	16000
Burundi	2072.06	3077.13	870.0	86	12000
Rwanda	1241.64	1839.54	490.0	41	7300
Eritrea	463.34	731.11	190.0	1	3100
Djibouti	388.61	624.66	115.0	3	2500
Comoros	43.54	74.13	16.0	0	290
Mauritius	26.72	41.05	11.5	0	160
Seychelles	2.74	4.94	0.5	0	17

According to the analysis depicted in table 8 above, Mozambique was discovered as the country with the highest TB burden in the East Africa Region (M=27183.9, SD=36924.5) with 720 minimum and a maximum of 162,000 aggregated TB cases in 2018. Moreover, Ethiopia was the second affected developing country with tuberculosis burden (M=25,497.5, SD=39,858.3), recording 150 minimum TB cases and a maximum of 165,000 annually aggregated TB cases in 2018. Kenya was recorded as the third affected country by tuberculosis burden (M=24,779.4, SD=36,633.9), having 290 minimum and a maximum of 150,000 annually aggregated TB cases in 2018. Tanzania followed with a slightly lower TB burden than Kenya (M=24,289.72, SD=34,044.55) with a minimum of 730 and a maximum of 142,000 annually aggregated TB cases. Uganda recorded the fifth country in tuberculosis burden (M=15,044.77, SD=21,843.59), having a minimum of 390 and a maximum of 86,000 annually aggregated TB cases. Moreover, Seychelles is the only country that recorded the least average amount of tuberculosis burden in East Africa (M = 2.74, SD=4.94) with 17 maximum TB cases in 2018.

Table 8: Average TB incidence in the Eastern Africa Regions

Eastern Africa Regions	Female	Male	Total Frequency
East Africa Community	20.70%	22.39%	43.09%
Central African Federation	14.49%	18.01%	32.50%
Nile Valley	3.60%	8.93%	12.52%
Horn of Africa	3.11%	8.70%	11.81%
Indian Ocean Island	0.05%	0.04%	0.09%

The analysis results portrayed in table 9 revealed that males recorded a higher incidence than females across all the Eastern Africa regions suggesting that men are more susceptible to tuberculosis than women in the Eastern Africa region. The analysis revealed that tuberculosis incidence in Eastern Africa Regions was higher in countries falling within East Africa Community (Tanzania, Kenya, Uganda, Burundi, and Rwanda) (43.1%) followed by those countries in the Central African Federation (Mozambique, Malawi, Zambia, and Zimbabwe)

(32.1%). Countries falling under Indian Ocean island (Madagascar, Mauritius, Comoros, and Seychelles) had the lowest tuberculosis incidence (0.09%). The results suggested that countries in the East Africa community had the highest tuberculosis burden in the East African Region. Those in the Indian Ocean island were the least affected by tuberculosis infection.

4.5 To establish the relationship between the TB risk factors (HIV, diabetes, alcohol, smoking, and malnourishment) and the estimated cases of TB across the East Africa Region

4.5.1 Test for Over-Dispersion of the Outcome Variable

There is evidence of overdispersion in the data at 0.05 level of significance ($p < 0.001$) see table 13 in Appendix 2. Therefore, poison regression was not appropriate to model this count data because the outcome variable is over-dispersed. Seemingly, negative binomial regression is the most appropriate statistical technique used for over-dispersed count data. It is a generalization of Poisson regression as it has a similar mean structure with Poisson regression. Besides, negative binomial regression is robust than Poisson regression for over-dispersed count data since it possesses an extra parameter that models overdispersion. Besides, if the response variable's conditional distribution is over-dispersed, negative binomial regression gives a narrower confidence interval compared to a Poisson regression model.

4.5.2 Test for The Fitness of Negative Binomial Regression Model

Table 9: Model fit using Deviance Method

Residual Deviance	Critical Value
823.32	666.47

According to the analysis in table 10 above, residual deviance (823.32) was more significant than Chi-square critical value (666.47) for the residual deviance. Thus, there was enough evidence to reject the null hypothesis that the negative binomial regression model does not fit the data well. We concluded that the negative binomial regression model fits the data well.

H3: There is a significant association between the TB risk factors (HIV, diabetes, alcohol, smoking, and malnourishment) and the estimated cases of TB across the East Africa Region.

Table 10: Negative Binomial Model Coefficients and Rate Ratios

	Estimate	Rate Ratio	std-error	p-value
(Intercept)	7.266	1430.217	23.175	0.000
15-24	0.701	2.017	3.215	0.001
25-34	0.259	1.296	0.748	0.454
35-44	0.237	1.267	0.685	0.494
45-54	-0.166	0.847	-0.594	0.553
55-64	-0.428	0.652	-1.239	0.215
65-74	1.648	5.196	6.715	0.000
Male	0.317	1.373	2.191	0.028
HIV	0.889	2.432	3.137	0.002
Smoking	0.868	2.383	2.972	0.003
Diabetes	0.652	1.919	2.180	0.029
Alcohol	-0.513	0.599	-1.374	0.169

According to the analysis depicted in table 12 in Appendix 2, risk factors predictor variable has a significant contribution to the predicting power of the model at 0.05 level of significance controlling for age groups and gender ($p = 0.0164$).

Controlling for gender and age group levels, individuals with HIV infection are 2.43 times more likely to be infected by tuberculosis than undernourished individuals. Similarly, smoking individuals are 2.38 times more likely to be infected by tuberculosis than undernourished individuals. Also, people with diabetes are twice more vulnerable to tuberculosis than people who are undernourished. Nevertheless, people who are alcoholic drinkers are 40% less likely to get infected by tuberculosis compared to undernourished people. Based on the analysis, it is surmised that HIV infection, smoking, and diabetes are the most significant factors influencing tuberculosis infection.

4.6 Discussion of the Findings

This study's main objective was to investigate the determinants of active Tuberculosis and determine the variation of the TB incidences with gender, age-groups, and countries in Eastern Africa region. The results findings addressed the three formulated hypotheses in this study. The analysis revealed that males are highly susceptible to active tuberculosis infection than females. Moreover, this study's findings discovered people over 64 years are highly vulnerable to active tuberculosis infection compared to other age groups. Furthermore, the findings revealed that the rate of tuberculosis infection significantly differs across different influencing factors. The analysis discovered that HIV patients and diabetes patients are almost two and a half times more likely to be infected by active tuberculosis than those in undernourishment. Moreover, smokers were discovered to be twice more likely to be affected by active tuberculosis than those in undernourishment. The analysis revealed that Mozambique, Ethiopia, Kenya, Tanzania, and Uganda are the top five countries with the highest active tuberculosis burden in the East Africa region. Besides, East African Community is the most affected region while Indian Ocean island was the least affected region in Eastern Africa Countries.

This research study's finding agreed with Ravikumar and Varadaraja (2017) and Berkowitz's (2017) findings, who discovered that people infected with HIV and those who have diabetes are significantly susceptible to develop active tuberculosis. This study's findings supported Narasimhan et al. (2013) that discovered that HIV infection, diabetes, age, smoking, and malnutrition facilitate the progression of the rate of active TB infection. However, this study's findings disagreed with Lönnroth et al. (2008) and Narasimhan et al. (2013) that discovered alcohol use to impact the rate of active TB infection. The current study revealed that alcohol had no significant impact on active TB infection rates compared to undernourishment. In their findings, Cegielski and McMurray (2004) discovered that malnutrition has a significantly higher risk of developing tuberculosis than HIV infection. Their findings were in disagreement with the current study that revealed that HIV infection has 2.4 times the risk of TB infection than malnutrition.

The current study agreed with Govender's (2017) findings, who discovered that patient vulnerability and complexity of TB outcomes significantly differed between males and females. The current findings were in substantial agreement with recent studies (Murphy et al., 2018; Marçôa et al., 2018; Nhamoyebonde and Leslie, 2014) that revealed that males have a higher tuberculosis disease prevalence globally compared to female. Also, the current findings supported (Fernandes et al., 2018; Horton et al., 2016; World Health Organization, 2016) findings that argued that males have a higher likelihood of active TB infection compared to females. Fernandes et al. (2018) argued that in some countries like Vietnam, TB infection prevalence in males is three times that of females. They postulated that men have a greater exposure to active TB infection than women because they have highly exposed to smoking and alcohol use, which are risk factors facilitating the progression of TB infection.

Moreover, they added that TB in women under detected due to the challenges they face to access health care. The current findings also supported Horton et al. (2016), who discovered that TB cases notification is higher in men than in most settings. They argued that men have more TB notification than women because of the barrier's women encounter while seeking medical care and TB diagnosis. Nevertheless, we cannot base the evidence on whether men are at a higher risk of active tuberculosis than when using notification data alone. Contrary to the current study and several other past research, Lin et al. (2013), in their findings, argued that women had a higher likelihood of having concurrent excess active TB cases than men. Besides, their findings did not give concrete evidence on why they considered women to be at a higher risk of TB infection than men.

The current study findings differed with that of Fernandes et al. (2018) and Zaman (2010) that argued that tuberculosis prevalence at a young age is the same for males and females. Still, the prevalence in males starts to exceed that of females at around the puberty stage. According to the current study findings, male records the highest tuberculosis prevalence at all stages of life. The current study findings disagreed with Kyu et al. (2018), who discovered a pattern of age-sex difference in TB prevalence of infection. Moreover, this study's findings opposed Marcoa et al. (2018) and that of Lin et al. (2018) findings who argued that tuberculosis prevalence between males and females was the same in some stages but differed at other life stages. According to Marcoa et al. (2018), tuberculosis notification cases among men are higher than that among women after the second decade of life. However, contrary to the current study, Lin et al. (2018) argued that below 45 years of age, tuberculosis prevalence between males and females is not different, but, at 45 years and older, women recorded a higher prevalence of TB than men. Other researchers' findings (Narasimhan et al., 2013; *Socioeconomic factors influencing tuberculosis treatment*, 2013) added that socioeconomic and behavioral factors also increase the patients' risk by making them more susceptible to mycobacterium infection. For instance, Narisimhan et al. (2013) articulated that the TB mortality rate escalates due to the effects of delay in diagnosing TB infection and the transmission of the bacilli.

Dye et al. (2006) argued that due to the high increase in HIV infection among the people in East Africa, tuberculosis was raised. The current study supported their findings as they argued that people with HIV are highly vulnerable to TB infection since they have weak immunity to fight any infection. The current study discovered that Mozambique, Ethiopia, Kenya, Tanzania, and Uganda are the top five countries with the highest tuberculosis burden across the East Africa region. However, little has been done on the current infection rate across the East Africa region. The findings of this study will add knowledge to the body of literature and help governments and decision-makers across the East Africa region, including Kenya, make the right policies and decisions in fighting the progression of TB infection.

CHAPTER FIVE

CONCLUSION

5.1 Introduction

This chapter gives the summary of the current findings and the contribution of the to the body of knowledge. The conclusion articulates the implications of the findings and the weakness of the research study. Moreover, this chapter gives suggestions for future research.

5.2 Summary of the Findings

This study's main objective was to investigate the determinants of active Tuberculosis and determine the variation of the TB incidences with gender, age-groups, and countries in Eastern Africa region. The study addressed the four specific objects, and the result supported the three formulated hypotheses. According to the result findings, people at the age of 65 and more are the most critical group of individuals susceptible to tuberculosis infection. Community health workers and public health practitioners should make more effort and care for the elderly to prevent active tuberculosis infection progression. HIV patients have a weaker immune system to fight diseases; seemingly, they are highly vulnerable to TB infection. The study discovered that patients with HIV are about 2.43 times more likely to develop TB than undernourished individuals.

Moreover, the findings revealed that diabetic patients have 2.38 times more likely to develop active TB than undernourished individuals. It was discovered that diabetic patients have a higher risk of developing tuberculosis than smoking individuals but not more than HIV patients. People who smoke are twice more likely to develop tuberculosis than undernourished individuals. However, alcohol was discovered to be less likely to expose an individual to a risk of developing TB than undernourished individuals.

Based on the findings, the ministry of health should devise control and prevention measures to reduce the spread of active TB across East Africa. Moreover, efficient and effective diagnostic techniques and tools are vital for early discovering and treating disease; thus, mitigating unexpected morbidity and mortality. The current study's findings will provide insight into the East African governments to scale up and take concrete steps to control, prevent, diagnose, and treat the Tuberculosis epidemics.

5.3 Suggestion for Further Study

Therefore, a future study is needed that will use primary data to examine the current trend and spread of TB infection across different countries. A future study is needed to determine which factors facilitate the high burden of TB infections in the most affected countries like Mozambique, Ethiopia, Kenya, Tanzania, and Uganda and what should be done to reduce the TB burden in those countries. Further research is needed to determine how TB infection differs for HIV and diabetes patients and those without, for smokers and non-smokers, for alcoholic and non-alcoholic individuals.

Work Plan

	January 2020	July 2020	October 2020
Concept Paper Development Proposal Review, Presentation, Submission and Pretest	■	■	
Data Collection, Coding, Entry and Analysis		■	
Report Writing and Report Submission			■

List of References

Alavi-Naini, R., Sharifi-Mood, B. and Metanat, M., 2012 'Association Between Tuberculosis and Smoking', *International Journal of High-Risk Behaviors and Addiction*, 1(2), pp. 71–74. doi: 10.5812/ijhrba.5215

Allwood, B., Zalm, M. van der, Makanda, G., Mortimer, K., F.s, A. A., Uzochukwu, E., Denise, E., Diane, G., Graeme, H., Olena, I., Rupert, J., M, M. F., Jamilah, M., Stellah, M., Sanne, van K., Andrea, R., Ingrid, S., Cari, S., Dalene, von D., … Robert, W., 2019. The long shadow post-tuberculosis. *The Lancet Infectious Diseases*, *19*(11), 1170–1171. https://doi.org/10.1016/S1473-3099(19)30564-X

Barberis, I., Bragazzi, N. L., Galluzzo, L., and Martini, M., 2017. The history of tuberculosis: from the first historical records to the isolation of Koch's bacillus. *Journal of preventive medicine and hygiene*, *58*(1), E9.

Basu, S., and Rao, N. A., 2017. *Tuberculosis*.

Berkowitz, N., 2017. *Effect of diabetes and HIV on radiographic manifestations of pulmonary tuberculosis*. University of Cape Town Faculty of Health Sciences Centre for Infectious Disease Epidemiology and Research (CIDER). http://hdl.handle.net/11427/25250

Caminero, J. A., Sotgiu, G., Zumla, A., and Migliori, G. B., 2010. Best drug treatment for multidrug-resistant and extensively drug-resistant tuberculosis. *The Lancet Infectious Diseases*, *10*(9), 621–629. https://doi.org/10.1016/S1473-3099(10)70139-0

Davies, P.D.O., Yew, W.W., Ganguly, D., Davidow, A.L., Reichman, L.B., Dheda, K. and Rook, G.A., 2006. Smoking and tuberculosis: the epidemiological association and immunopathogenesis. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, *100*(4), pp.291-298.

Dooley, K.E., Tang, T., Golub, J.E., Dorman, S.E. and Cronin, W., 2009. Impact of diabetes mellitus on treatment outcomes of patients with active tuberculosis. *The American journal of tropical medicine and hygiene*, *80*(4), pp.634-639.

Dye, C., Harries, A. D., Maher, D., Hosseini, S. M., Nkhoma, W., and Salaniponi, F. M., 2006. Tuberculosis. In D. T. Jamison, R. G. Feachem, M. W. Makgoba, E. R. Bos, F. K. Baingana, K. J. Hofman, and K. O. Rogo (Eds.), *Disease and Mortality in Sub-Saharan Africa* (2nd ed.). World Bank. http://www.ncbi.nlm.nih.gov/books/NBK2285/

Govender, V., 2017. *The role of gender in patient-provider trust for tuberculosis treatment* (Doctoral dissertation, University of Cape Town).

Human, S.P., Smith, J.E. and Tshabalala, D.L., 2010. Factors influencing tuberculosis treatment interruptions. *Africa Journal of Nursing and Midwifery*, *12*(2), pp.48-57.

Farre, T.B., Formiga, F., Ferrer, A., Plana- Ripoll, O., Almeda, J. and Pujol, R., 2014. Risk of being undernourished in a cohort of community- dwelling 85- year- olds: The O ctabaix study. *Geriatrics and gerontology international*, *14*(3), pp.702-709.

Fernandes, P., Ma, Y., Gaeddert, M., Tsacogianis, T., Marques-Rodrigues, P., Fregona, G., Loomans, A., Jones-López, E. C., Dietze, R., Ellner, J. J., White, L. F., and Hochberg, N. S., 2018. Sex and age differences in Mycobacterium tuberculosis infection in Brazil. *Epidemiology and Infection*, *146*(12), 1503–1510. https://doi.org/10.1017/S0950268818001450

Floyd, K., Glaziou, P., Zumla, A., and Raviglione, M., 2018. The global tuberculosis epidemic and progress in care, prevention, and research: An overview in year 3 of the End TB era. *The Lancet Respiratory Medicine*, *6*(4), 299–314. https://doi.org/10.1016/S2213-2600(18)30057-2

Horton, K. C., MacPherson, P., Houben, R. M. G. J., White, R. G., and Corbett, E. L., 2016. Sex Differences in Tuberculosis Burden and Notifications in Low- and Middle-Income Countries: A Systematic Review and Meta-analysis. *PLoS Medicine*, *13*(9). https://doi.org/10.1371/journal.pmed.1002119

Kenya Ministry of Health., 2014. Transforming Health: Accelerating Attainment of Universal Health Coverage. Kenya Health Sector Strategic and Investment Plan (Khsspi), July 2013- June 2017.

Kigozi, G., Heunis, C., Chikobvu, P., Botha, S., and van Rensburg, D., 2017. Factors influencing treatment default among tuberculosis patients in a high burden province of South Africa. *International Journal of Infectious Diseases International Journal of Infectious Diseases*, *54*, 95–102.

Kyu, H. H., Maddison, E. R., Henry, N. J., Ledesma, J. R., Wiens, K. E., Reiner, R., Biehl, M. H., Shields, C., Osgood-Zimmerman, A., Ross, J. M., Carter, A., Frank, T. D., Wang, H., Srinivasan, V., Agarwal, S. K., Alahdab, F., Alene, K. A., Ali, B. A., Alvis-Guzman, N., … Murray, C. J. L., 2018. Global, regional, and national burden of tuberculosis, 1990–2016: Results from the Global Burden of Diseases, Injuries, and Risk Factors 2016 Study. *The Lancet Infectious Diseases*, *18*(12), 1329–1349. https://doi.org/10.1016/S1473-3099(18)30625-X

Lin, C.-Y., Chen, T.-C., Lu, P.-L., Lai, C.-C., Yang, Y.-H., Lin, W.-R., Huang, P.-M., and Chen, Y.-H., 2013. Effects of Gender and Age on Development of Concurrent Extrapulmonary Tuberculosis in Patients with Pulmonary Tuberculosis: A Population Based Study. *PLOS ONE*, *8*(5), e63936. https://doi.org/10.1371/journal.pone.0063936

Liu, T.F. and Shafer, R.W., 2006. Web resources for HIV type 1 genotypic-resistance test interpretation. *Clinical infectious diseases*, *42*(11), pp.1608-1618.

Lytras, T., and Kalkouni, O., 2018. The global tuberculosis epidemic: turning political will into concrete action. *Journal of thoracic disease*, *10*(Suppl 26), S3149.

Lönnroth, K., Williams, B. G., Stadlin, S., Jaramillo, E., and Dye, C., 2008. Alcohol use as a risk factor for tuberculosis – a systematic review. *BMC Public Health*, *8*(1), 289. https://doi.org/10.1186/1471-2458-8-289

Marçôa, R., Ribeiro, A. I., Zão, I., and Duarte, R., 2018. Tuberculosis and gender – Factors influencing the risk of tuberculosis among men and women by age group. *Pulmonology*, *24*(3), 199–202. https://doi.org/10.1016/j.pulmoe.2018.03.004

Ministry of Health., 2016. *Kenya Tuberculosis Prevalence Survey 2016*, *ibid.*

Murphy, M. E., Wills, G. H., Murthy, S., Louw, C., Bateson, A. L. C., Hunt, R. D., McHugh, T. D., Nunn, A. J., Meredith, S. K., Mendel, C. M., Spigelman, M., Crook, A. M., Gillespie, S. H., Diacon, A., Hanekom, M., Venter, A., Dawson, R., Narunsky, K., Mtafya, B., … for the REMoxTB consortium., 2018. Gender differences in tuberculosis treatment outcomes: A post hoc analysis of the REMoxTB study. *BMC Medicine*, *16*(1), 189. https://doi.org/10.1186/s12916-018-1169-5

Narasimhan, P., Wood, J., MacIntyre, C. R., and Mathai, D., 2013. *Risk Factors for Tuberculosis* [Review Article]. Pulmonary Medicine. https://doi.org/10.1155/2013/828939

Nhamoyebonde, S., and Leslie, A., 2014. Biological Differences Between the Sexes and Susceptibility to Tuberculosis. *The Journal of Infectious Diseases*, *209*(suppl_3), S100–S106. https://doi.org/10.1093/infdis/jiu147

Polit, D. F., and Beck, C. T., 2009. *Essentials of Nursing Research: Appraising Evidence for Nursing Practice*. Lippincott Williams and Wilkins.

Philippe, G., Charalambos, S., Carel, P., and Katherine, F., 2016. Methods used by WHO to estimate the Global burden of TB disease. *arXiv preprint arXiv:1603.00278*.

Quaife, M., Houben, R. M. G. J., Allwood, B., Cohen, T., Coussens, A. K., Harries, A. D., Kampen, S. van, Marx, F. M., Sweeney, S., Wallis, R. S., and Menzies, N. A., 2020. Post-tuberculosis mortality and morbidity: Valuing the hidden epidemic. *The Lancet Respiratory Medicine*, *0*(0). https://doi.org/10.1016/S2213-2600(20)30039-4

Seid, G. and Ayele, M., 2020. Undernutrition and Mortality among Adult Tuberculosis Patients in Addis Ababa, Ethiopia. *Advances in Preventive Medicine*, *2020*

Shamboze, V. P., Pan African Institute for Development, and East and Southern Africa., 1999. *A study on factors influencing increased deaths of tuberculosis patients among 15-55 years age group in Mpongwe District*. Pan African Institute for Development, East and Southern Africa.

Sinha, P., Davis, J., Saag, L., Wanke, C., Salgame, P., Mesick, J., Horsburgh Jr, C.R. and Hochberg, N.S., 2019. Undernutrition and tuberculosis: public health implications. *The Journal of infectious diseases*, *219*(9), pp.1356-1363.

Socio-economic factors influencing tuberculosis treatment., 2013. http://hdl.handle.net/11070.1/4111

Sousa, V. D., Driessnack, M., and Mendes, I. A. C., 2007. An overview of research designs relevant to nursing: Part 1: quantitative research designs. *Revista Latino-Americana de Enfermagem*, *15*(3), 502–507. https://doi.org/10.1590/S0104-11692007000300022

Stevenson, C.R., Forouhi, N.G., Roglic, G., Williams, B.G., Lauer, J.A., Dye, C. and Unwin, N., 2007. Diabetes and tuberculosis: the impact of the diabetes epidemic on tuberculosis incidence. *BMC public health*, *7*(1), p.234.

Zumla, A., Petersen, E., Nyirenda, T. and Chakaya, J., 2015. Tackling the tuberculosis epidemic in sub-Saharan Africa–unique opportunities arising from the second

European Developing Countries Clinical Trials Partnership (EDCTP) programme 2015-2024. *International Journal of Infectious Diseases*, *32*, pp.46-49.

Taherdoost, H., 2016. *Sampling Methods in Research Methodology; How to Choose a Sampling Technique for Research* (SSRN Scholarly Paper ID 3205035). Social Science Research Network. https://papers.ssrn.com/abstract=3205035

Thomas, B.E., Thiruvengadam, K., Kadam, D., Ovung, S., Sivakumar, S., Bala Yogendra Shivakumar, S.V., Paradkar, M., Gupte, N., Suryavanshi, N., Dolla, C.K. and Gupte, A.N., 2019. Smoking, alcohol use disorder and tuberculosis treatment outcomes: A dual co-morbidity burden that cannot be ignored. *PLoS One*, *14*(7), p.e0220507.

Turner, R. D., Chiu, C., Churchyard, G. J., Esmail, H., Lewinsohn, D. M., Gandhi, N. R., and Fennelly, K. P., 2017. *Tuberculosis Infectiousness and Host Susceptibility.* https://nls.ldls.org.uk/welcome.html?lsidyva2ce4ffa

World Health Organization., 2017. *Ethics guidance for the implementation of the End TB strategy* (No. WHO/HTM/TB/2017.07). World Health Organization.

World Health Organization. 2016. Global Tuberculosis Report 2016. Switzerland: World Health Organization.

World Health Organization., 2013. *Global tuberculosis report 2013*. World Health Organization

World Health Organization., 2019. *Global tuberculosis report 2019*. World Health Organization

Yuko Oso, W., and Abdisalam, I. J., 2015. *Delayed Tuberculosis Treatment in Somaliland Factors Influencing Delayed Treatment of Tuberculosis in Borama District, Somaliland*. LAP LAMBERT Academic Publishing. http://nbn-resolving.de/urn:nbn:de:101:1-2015020914354

Zaman, K., 2010. Tuberculosis: A Global Health Problem. *Journal of Health, Population, and Nutrition*, *28*(2), 111–113.

Zumla, A., Petersen, E., Nyirenda, T., and Chakaya, J., 2015. Tackling the tuberculosis epidemic in sub-Saharan Africa–unique opportunities arising from the second European Developing Countries Clinical Trials Partnership (EDCTP) programme 2015-2024. *International Journal of Infectious Diseases*, *32*, 46-49.

APPENDICES

Appendix1: Budget

PROPOSAL			
ITEM	QUANTITY	PRICE/UNIT	TOTAL(Kshs)
Stationery	10	100	1000
Flash disk	1	1500	1500
Typing	1	1000	3000
Printing	3	400	1200
Internet	30 Gb	1000	3000
Binding	3	150	450
		Sub Total	Kshs 8,150
PROJECT			
Data analysis	-	-	-
Printing	3	800	2400
Binding	3	200	600
		Sub Total	Kshs 3000
Contingency	-	-	Kshs 2000
Publishing		-	-
		Grand Total	Kshs 13150

Appendix 2: R-Output

Table 11: One Sample Independent t-test

```
##  Welch Two Sample t-test
##
## data:  Best_Estimate by Gender
## t = -2.8879, df = 640.22, p-value = 0.002005
## alternative hypothesis: true difference in means is less than 0
## 95 percent confidence interval:
##      -Inf -1876.94
## sample estimates:
## mean in group Female   mean in group Male
##             6412.935            10781.980
```

Table 12: Test of Significance of Risk Factor Variable

```
m1 <- glm.nb(Best_Estimate~Risk_Factor, data=data)
m2 <- glm.nb(Best_Estimate~ 1, data=data)

anova(m1, m2)

## Likelihood ratio tests of Negative Binomial Models
##
## Response: Best_Estimate
##         Model     theta Resid. df    2 x log-lik.   Test    df LR stat.
## 1           1 0.2918317       655       -12151.96
## 2 Risk_Factor 0.2953852       651       -12139.83 1 vs 2     4 12.12626
##      Pr(Chi)
## 1
## 2 0.01643666
```

Table 13: Test for over-dispersion of count data

```
##
##  DHARMa nonparametric dispersion test via sd of residuals fitted vs.
##  simulated
##
## data:  simulationOutput
## ratioObsSim = 206.66, p-value < 2.2e-16
## alternative hypothesis: two.sided
```

Appendix 3: Dataset

Table 14: Sample Dataset

Country	year	measure	unit	age_group	gender	risk_factor	Best_Estimate
Burundi	2018	inc	num	0-14	Male	HIV	1300
Burundi	2018	inc	num	0-14	Male	HIV	610
Burundi	2018	inc	num	0-14	Male	HIV	670
Burundi	2018	inc	num	0-14	Male	HIV	320
Burundi	2018	inc	num	0-14	Male	Undernourishment	380
Burundi	2018	inc	num	15-24	Male	Alcohol	800
Burundi	2018	inc	num	15-24	Male	Smoking	1100
Burundi	2018	inc	num	15-24	Male	HIV	11000
Burundi	2018	inc	num	15-24	Male	HIV	1600
Burundi	2018	inc	num	15-24	Female	HIV	230
Burundi	2018	inc	num	15-24	Female	Alcohol	210
Burundi	2018	inc	num	15-24	Male	HIV	86
Burundi	2018	inc	num	15-24	Male	Smoking	4200
Burundi	2018	inc	num	15-24	Male	Smoking	6900
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
Zimbabwe	2018	inc	num	65-74	Male	HIV	30000
Zimbabwe	2018	inc	num	65-74	Female	Diabetes	18000
Zimbabwe	2018	inc	num	65-74	Male	HIV	15000
Zimbabwe	2018	inc	num	65-74	Female	Diabetes	12000
Zimbabwe	2018	inc	num	65-74	Male	Alcohol	18000

Source of the dataset: https://www.who.int/tb/country/data/download/en/ : » Download WHO TB incidence estimates disaggregated by age, sex and risk factor [0.6Mb]