Challenges of Tuberculosis Control Program Performance in Jimma Zone, Southwest Ethiopia

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Summary

Background: Tuberculosis (TB) is a global public health threat. The World Health Organization has developed the End TB Strategy to end the global TB epidemic by 2035. The strategy aims to reach at least 90% of all people with TB and treat all of them with the standard anti-TB treatment regimen. Countries around the world have been implementing the End TB Strategy for the past eight years. Achieving the End TB targets among others require establishing an efficient and well-resourced tuberculosis control program in member states. Ethiopia is one of the high tuberculosis burden countries. In Jimma Zone, Ethiopia where this study was conducted, low TB case notification rate and suboptimal TB treatment outcomes have been challenges to the performance of the TB control program. Addressing these challenges is crucial for the success of the End TB Strategy targets at local and national levels.

Aims: The aim of this PhD project was to assess the challenges and associated factors of TB control program performance. The specific objectives were 1) to identify barriers to TB case finding and explore its associated factors, 2) to compare TB treatment outcomes and associated factors among patients treated with community-based directly observed treatment, short-course (CB-DOTS) versus facility-based directly observed treatment, short-course (FB-DOTS), 3) to determine the length and factors associated with total delay, and 4) to assess TB treatment outcomes and determinants of an unfavorable treatment outcome.

Methods: The studies were carried out in Jimma Zone, Southwest Ethiopia. Several study designs including qualitative, cohort, and cross-sectional study designs were used to answer the research questions. As there were four separate studies, the sample size was determined according to the study designs used. For the qualitative study (Paper I), we included 60 participants at various levels for in-depth interviews and 42 health facilities for resource availability assessment. In (Papers II, III, and IV), we included 1,161 TB patients who were recruited from eight randomly selected districts and one town administration in the study Zone. The patients were interviewed using a structured questionnaire that was pretested. Qualitative data were transcribed, coded, categorized, and thematized. For the quantitative data, a binary logistic regression analysis was employed to analyze the association between the independent and dependent variables. The crude odds ratio (COR), adjusted odds ratio (AOR), and 95% confidence intervals (CI) were calculated, with a p-value of 0.05 considered statistically significant. Furthermore, the study groups' relative risk (RR) and risk difference

(RD) were calculated. To compare group differences, chi-square (X^2) or Fisher's exact tests were used.

Results: the qualitative study result showed that inadequate resources, such as shortage of health care providers, insufficient basic infrastructure, and inadequate diagnostic equipment and supplies; and limited access to diagnostic services, such as lack of nearby health facilities offering TB diagnostic services and health system delays were identified as major challenges to TB case finding. Paper II showed that that community-based DOTS is more effective than facility-based DOTS in terms of increasing cure rate, sputum conversion and lowering treatment failure rate. While women and illiterate patients preferred CB-DOTS to FB-DOTS, TB patients co-infected with human immunodeficiency virus (HIV) opted for FB-DOTS. Paper III assessed the length and associated factors of total delay. The findings revealed that the median total delay was 35 days [interquartile range (IQR) 25, 67 days] and this delay was associated with poor knowledge of TB, swelling or wounds in the neck region, being woman, low level of education, and low household income. The result of our study from Paper IV showed that 86.9% of TB patients had a favorable treatment outcome and 5.7% had an unfavorable treatment outcome. Being a woman, low household income, stigma, and alcohol consumption were identified as determinants of unfavorable treatment outcome.

Conclusion: This thesis assesses the challenges to TB control program performance in Jimma Zone, Ethiopia. Our findings highlight the importance of early case detection and prompt treatment of TB to increase TB case notification and treatment success rates, thereby improving TB control program performance and ultimately achieving the goals of the End TB Strategy. In addition, our findings underscore the benefits of scaling up and increasing decentralization of the community-based DOTS approach to improve rural communities' access to TB treatment services. It is critical to improve TB control program performance by not only identifying the challenges, but also addressing the associated factors with targeted strategies or interventions related to economic, behavioral, and social factors.

Sammendrag

Bakgrunn: Tuberkulose (TB) utgjør en global trussel mot folkehelsen. Verdens helseorganisasjon har utviklet strategien "End TB" for å avslutte den globale TB-epidemien innen 2035. Strategien har som mål å finne minst 90% av alle personer med TB og behandle dem med standard anti-TB-behandling. Land over hele verden har implementert "End TB"-strategien de siste åtte årene. En forutsetning for å nå målene i strategien er at det finnes et velfungerende tuberkulosekontrollprogram. Etiopia er ett av landene med høy forekomst av tuberkulose. I Jimma Zone i Etiopia, der denne studien ble gjennomført, har det vært utfordringer knyttet til lav forekomst av registrerte TB-tilfeller og dårlige behandlingsresultater. Å takle disse utfordringene er avgjørende for suksessen til "End TB"-strategiens mål på lokalt og nasjonalt nivå.

Mål: Målet med dette doktorgradsprosjektet var å vurdere utfordringene og faktorene som påvirker ytelsen til TB-kontrollprogrammet. De spesifikke målene var 1) å identifisere barrierer for å oppdage TB-tilfeller og utforske tilhørende faktorer, 2) å sammenligne behandlingsresultater og tilknyttede faktorer blant pasienter behandlet med direkte observert behandling, kortere behandlingsregime, i primærhelsetjenesten (CB-DOTS), versus direkte observert behandling i sykehus (FB-DOTS), 3) å fastslå lengden og faktorene knyttet til total forsinkelse, og 4) å vurdere TB-behandlingsresultater og faktorer som påvirker ugunstige behandlingsresultater.

Metoder: Studiene ble utført i Jimma Zone, sørvest i Etiopia. Flere studiedesign, inkludert kvalitative, kohort- og tverrsnittsstudier, ble brukt for å besvare forskningsspørsmålene. Ettersom det var fire separate studier, ble utvalgsstørrelsen bestemt i henhold til de brukte studiedesignene. For den kvalitative studien (Artikkel I) inkluderte vi 60 deltakere på ulike nivåer for dybdeintervjuer, og 42 helseinstitusjoner ble vurdert i forhold til tilgjengeligheten av ressurser. I Artikkel II, III og IV inkluderte vi 1161 TB-pasienter som ble rekruttert fra åtte tilfeldig valgte distrikter og én byadministrasjon i studieområdet. Pasientene ble intervjuet ved hjelp av et strukturert spørreskjema som ble forhåndstestet. Kvalitative data ble transkribert, kodet, kategorisert og tematisert. For de kvantitative dataene ble det brukt binær logistisk regresjonsanalyse for å analysere sammenhengen mellom uavhengige og avhengige variabler. De ukorrigerte oddsratioene ($_{c}$OR), justerte oddsratioene ($_{a}$OR) og 95% konfidensintervaller (KI) ble beregnet, der en p-verdi på 0,05 ble ansett som statistisk signifikant. Videre ble den relative risikoen (RR) og risikoforskjellen (RD) for

studiegruppene beregnet. For å sammenligne forskjeller mellom gruppene ble det brukt kji-kvadrat (X^2) eller Fisher's eksakte tester.

Resultater: Resultatene fra den kvalitative studien viste at utilstrekkelige ressurser, som mangel på helsepersonell, utilstrekkelig grunnleggende infrastruktur og manglende diagnostisk utstyr og forsyninger, samt begrenset tilgang til diagnostiske tjenester, som mangel på nærliggende helsetjenester som tilbyr TB-diagnostiske tjenester og forsinkelser i helsesystemet, ble identifisert som betydelige utfordringer for å identifisere nye TB-tilfeller. Artikkel II viste at DOTS i primærhelsetjenesten er mer effektivt enn fasilitetsbasert DOTS når det gjelder å øke helbredelsesraten, sputumkonvertering og redusere behandlingssvikt. Mens kvinner og pasienter uten skolegang foretrakk CB-DOTS fremfor FB-DOTS, valgte TB-pasienter som var samtidig smittet med humant immunsviktvirus (HIV) FB-DOTS. Artikkel III vurderte lengden og faktorene knyttet til total forsinkelse. Funnene viste at median total forsinkelse var 35 dager [interkvartilrekkevidde (IQR) 25, 67 dager], og denne forsinkelsen var knyttet til manglende kunnskap om TB, hevelse eller sår i nakken, å være kvinne, lavt utdanningsnivå og lav husholdningsinntekt. Resultatene fra vår studie i Artikkel IV viste at 86,9% av TB-pasientene hadde et gunstig behandlingsresultat, mens 5,7% hadde et ugunstig behandlingsresultat. Å være kvinne, ha lav husholdningsinntekt, stigma og alkoholforbruk ble identifisert som faktorer som gav dårligere behandlingsresultater.

Konklusjon: Denne avhandlingen vurderer utfordringene knyttet til TB-programmets ytelse i Jimma Zone, Etiopia. Våre funn understreker viktigheten av tidlig påvisning av tilfeller og rask behandling av TB for å øke identifisering og rapportering av TB-tilfeller og suksessraten for behandlingen, og dermed forbedre ytelsen til TB-programmet og til slutt oppnå målene i End TB-strategien. I tillegg fremhever våre funn fordelene med å ytterligere utvide og desentralisere DOTS-tilnærmingen for å forbedre tilgangen til TB-behandlingstjenester i rurale områder. Det er avgjørende å forbedre ytelsen til TB-programmet ved å ikke bare identifisere utfordringene, men også adressere de tilknyttede faktorene med målrettede strategier eller tiltak knyttet til økonomiske, atferdsmessige og sosiale faktorer.

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Papers included in the thesis

Paper I: Barriers for tuberculosis case finding in Southwest Ethiopia: A qualitative study**.** 2020; PLoS ONE 15(1). Ereso BM, Yimer SA, Gradmann C, Sagbakken M

Paper II: Treatment outcomes of patients with drug sensitive tuberculosis under community-based versus facility-based directly observed treatment, short course strategy in Southwest Ethiopia: a prospective cohort study. BMJ Open 2021; 11. Ereso BM, Sagbakken M, Gradmann C, Yimer SA.

Paper III: Total delay and associated factors among tuberculosis patients in Jimma Zone, Southwest Ethiopia. 2023; PLoS ONE 18(2). Ereso BM, Sagbakken M, Gradmann C, Yimer SA.

Paper IV: Determinants of Unfavorable Treatment Outcome among Tuberculosis Patients in Jimma Zone, Southwest Ethiopia. Ereso BM, Sagbakken M, Gradmann C, Yimer SA. AJTMH-22-0648 – accepted manuscript

List of Abbreviations

AFB	acid-fast-bacilli
AIDS	acquired Immunodeficiency Syndrome
AOR	adjusted odds ratio
ART	antiretroviral therapy
BCC	behavioural change communication
BCG	Bacille Calmette-Guérin
BMI	body mass index
CB-DOTS	community-based directly observed treatment, short-course
CD4	cluster of differentiation 4
CHWs	community health workers
CI	confidence interval
COREQ	consolidated criteria for reporting qualitative research
COR	crude odds ratio
CPT	co-trimoxazole preventive therapy
DNA	deoxyribonucleic acid
DOTS	directly observed treatment, short course
DR	drug resistant
DST	drug sensitivity test
FB-DOTS	facility-based directly observed treatment, short-course
FM	fluorescent microscope
HEWs	health extension workers
HIV	human immunodeficiency virus
HPMZ	isoniazid, rifapentine, moxifloxacin, and pyrazinamide
HPs	Health posts
HSTP	Health Sector Transformation Plan
IEC	information education and communication
IQR	interquartile Range
LED	light-emitting diode
LPAs	line probe assays

LIC and LMIC	low-and lower-middle-income countries
LTFU	lost to follow-up
MDGs	Millennium Development Goals
MDR	multidrug-resistant
M. tuberculosis	*Mycobacterium tuberculosis*
MTB complex	*Mycobacterium tuberculosis* complex
NGOs	Non-governmental organizations
NTCP	National TB control program
NTLCP	National Tuberculosis and Leprosy Control Program
OI	opportunistic infection
OPD	outpatient department
RCTs	randomized control trials
RD	risk difference
RH	rifampicin and isoniazid
RHZE	rifampicin, isoniazid, pyrazinamide and ethambutol
RR	relative risk
RR-TB	rifampicin-resistant tuberculosis
SDG	Sustainable Development Goals
SMS	short messaging service
SPSS	statistical package for the social sciences
TB	tuberculosis
TSR	treatment success rate
UMIC	upper-middle-income countries
WHO	World Health Organization
XDR	extensively drug-resistant
ZN	Ziehl Neelsen

1. Introduction

This chapter provides an overview of tuberculosis (TB), including its history, etiology, transmission, pathogenesis, and latent TB, clinical features, diagnosis, treatment, and prevention. The chapter also covers risk factors for TB, factors contributing to the resurgence of TB, global TB burden and control strategies, practical challenges of TB control program, Ethiopian health system, and TB burden and control programs in Ethiopia, Oromia Region, and Jimma Zone (study area). In addition, the study rationale and conceptual framework are presented.

1.1. An overview of Tuberculosis

1.1.1. History of tuberculosis

TB is one of the oldest chronic infectious diseases mainly caused by a bacillus referred to as *Mycobacterium tuberculosis (M. tuberculosis).* It has existed for as long as human history can be traced (1). The *M. tuberculosis* is thought to have evolved around 3 million years ago and belongs to the genus *Mycobacterium*, which one believes to have originated around 150 million years ago. The famous scientist Robert Koch isolated the *M. tuberculosis* bacillus. He first identified, isolated, and cultured the bacillus in animal serum. He then reproduced the disease in laboratory animals by inoculating them with the bacillus. Robert Koch presented this remarkable result in 1882, marking a milestone in combating TB(1,2). The origin and history of TB can be divided into four time periods, which are as follows: 1) ancient archeological findings, some of which are based on modern scientific Deoxyribonucleic acid (DNA) methodology testing; 2) medical and non-medical literatures' documentation; 3) discovery of TB causation; and 4) subsequent TB treatment approaches (2,3). TB was first used as a medical term by a German professor of medicine Johann Schönlein in 1829 (4). Earlier to this, TB of the lungs was known as "Phthisis" (Greek word for "wasting away"), the "White plague," and "Consumption". The disease now known as TB has plagued humans throughout recorded history (3). It is astonishing that this disease has threatened public health since the 1800s, yet therapeutic progress has been very slow (5).

1.1.2. Etiology of Tuberculosis

TB is caused by Mycobacteria species from the *Mycobacterium tuberculosis* complex (MTB complex). *Mycobacterium africanum*, *M. bovis*, *M. canettii*, *M. caprae, M. microti, M. orygis, M. pinnipedii, M. suricattae, M. mungi, and M. tuberculosis* are all members of the MTB

complex. M. tuberculosis is the most common cause of TB in humans (2,6). M. tuberculosis is a pathogen that has evolved to survive within the host (6).

1.1.3. Transmission of Tuberculosis

TB transmission occurs to susceptible individuals who inhale air containing the bacilli spread as tiny particle (droplet nuclei). *M. tuberculosis* is carried in the air by droplet nuclei, which are 1-5 microns in diameter. Infectious droplet nuclei are produced when people with pulmonary or laryngeal TB cough, sneeze, shout, or sing. The tiny particles can endure in the air for numerous hours depending on the environment. *M. tuberculosis* is spread through the air when a person inhales the droplet nuclei comprising *M. tuberculosis*. The droplet nuclei travel through the mouth or nasal passages, upper respiratory tract, and bronchi to reach the lungs' alveoli (7–9).

There is a TB transmission cascade: 1) a case of TB as a source; 2) contagious particles are produced; 3) the particles live in the air; 4) a susceptible individual inhales the air; 5) a person becomes infected; and 6) a susceptible host (person) develops TB. Interrupting TB transmission requires interventions that target this chain (7).

Furthermore, the dynamics of TB transmission are dependent on the following factors: 1) host susceptibility; 2) degree of infectiousness of the source (case); 3) exposure level of the susceptible host such as closeness, duration, and frequency; and 4) environmental factors (commonly determined by poor ventilation and overcrowding). The risk of transmission and infection increases when a vulnerable person is exposed to an infectious type of TB for an extended period. TB transmission is also facilitated by inadequate ventilation and overcrowding (9,10).

TB can be transmitted in the home or in the community. Previous studies indicate that a person exposed to a TB patient in the household is approximately four times more likely to be infected with *M. tuberculosis* than a person exposed to a TB patient in the community. Thus, households denote areas of extensive *M. tuberculosis* transmission (10,11). Factors influencing TB transmission in the community include TB prevalence, individuals' (living, working, and interacting) habits, and health systems' ability to early identify and treat people with contagious forms of TB. While recent transmission accounts for a large proportion of TB cases in high-burden countries, remote transmission accounts for a larger proportion of

TB cases in low-burden countries. As a result, intensified research and innovation are required to stop the spread of TB (7,9,11).

1.1.4. Pathogenesis of TB and latent TB

TB infection process starts when an individual inhales droplet nucleus with tubercle bacilli and a multiplication of the bacilli (tubercle bacilli) occurs in the lungs' alveoli. Alveolar macrophages consume these tubercle bacilli, and many of them are engulfed or inhibited. Then, when macrophages die, a small number of them may multiply within the cell and be released. If these bacilli are alive, they can spread through lymphatic channels or the bloodstream to other tissues and organs such as apex of the lung, lymph nodes, kidneys, bone, and brain. Six to fourteen weeks later, the immunological response frequently stops the bacilli's rapid multiplication, preventing disease development and causing latent infection (latent TB). The lesions usually heal completely, but the bacilli may remain alive (dormant) in the lesion (8,12).

Persons with latent TB do not have TB symptoms because the bacilli cause no tissue damage and are not contagious. There is a continuing immune response due to bacilli antigen stimulation in latent TB infection, but there is no evidence of clinical features of active TB (12,13). In immune-competent people, only five to ten percent of infected people develop active TB over their lifetime. The lifetime risk is higher in children under the age of five and in people with compromised immune systems (12,13). Latent TB infection has been identified as a major source of new TB cases and is one of the major challenges to meet the End TB Strategy's target (14). It is difficult to distinguish between latent TB infection and active TB cases without proper screening and investigation (14,15).

1.1.5. Clinical features of TB

The clinical features or symptoms of TB vary depending on the organ involved, age, and immune status. Clinical features in immune competent persons are most commonly caused by lung involvement (more than 80% of cases). However, specific clinical manifestations may occur when extra-pulmonary organs such as lymph nodes, pleura, genito-urinary tract, abdomen, spine, joints, and nervous system are involved. Persistent cough for two or more weeks (any duration for HIV positives), fever for more than two weeks, night sweats, and unexplained weight loss (more than ten percent) are common clinical manifestations of pulmonary TB. Coughing may be uncommon in HIV patients, young children, and severely

malnourished people because of their weakened immune systems (12,16,17). Recognition of TB symptoms is essential to inform the community about the symptoms and to encourage early seeking of health care. It also helps inform health care providers to raise the index of suspicion to easily identify TB suspects and cases presenting to health facilities (10,11,16).

1.1.6. Diagnosis of TB

TB can be diagnosed using mycobacteriological and molecular tests, other tests that help the diagnosis include chest radiography, histopathological, or biochemical analysis of body parts or fluids. Mycobacterial culture is the gold standard investigation for absolute bacteriologic confirmation of TB (17,18). However, recent studies show that molecular diagnostic tests, such as GeneXpert and line probe assays (LPAs), are more effective than mycobacterial culture and acid-fast-bacilli(AFB) smear microscopy tests (19). AFB smear microscopy uses Ziehl Neelsen (ZN) staining of sputum smears under a light microscope for detecting the presence of AFB. AFB smear microscopy, which has been used for over a century, is still widely used for TB diagnosis in low and middle-income countries, including Ethiopia (18,20). It is quick, simple, cheap, and commonly used method. However, this method has low sensitivity and specificity for TB diagnosis. The two types of microscopes used are the conventional light microscope (ZN) and the fluorescent microscope (FM) (20,21). The fluorescent microscope was established to improve the sensitivity of conventional microscopes; light-emitting diode (LED)-based fluorescent microscopy has been used in many countries (22,23). LED is less expensive and is currently used as a substitute technique for ZN staining, as recommended by World Health Organization (WHO) (22). The GeneXpert test is a molecular test for TB diagnosis that detects the presence of M. tuberculosis as well as rifampicin resistance. It is a highly sensitive and specific test for TB diagnosis. It also identifies DNA sequences (genes) specific for rifampicin resistance (24). However, due to the high cost of the GeneXpert test, scaling up these technologies in high-TB burden countries including Ethiopia, where the majority of TB patients reside, is difficult (25,26). TB diagnosis in HIV-infected patients requires special attention because of the poor sensitivity of AFB smear microscopy test in those patients (27). To combat TB, it is crucial to use effective diagnostic tests for improving diagnosis and treatment of TB patients (24,28).

1.1.7. Treatment of TB

TB is preventable and curable. A majority (about 85%) of persons with active TB can successfully be treated with a short-term drug regimen (six months). The treatment has an

additional purpose in limiting transmission of the infection. Thus, universal health coverage (UHC) is essential to ensure that all patients with the disease or infection can access treatment (16,18). The regimen for treating patients with drug-susceptible TB encompasses an intensive phase of two months with rifampicin, isoniazid, pyrazinamide and ethambutol (2RHZE), followed by a continuation phase of four months with rifampicin and isoniazid (4RH). However, a prolonged continuation phase treatment for 10 months (2RHZE/10RH) is needed for patients with central nervous system and osteo-articular TB (16–18). WHO has added a new recommendation that those 12 years and older with drug-susceptible pulmonary TB can be treated with a 4-month regimen of rifapentine (P), H, Z, and moxifloxacin (M). WHO also recommends that children and adolescents (3 months to 16 years) with non-severe TB and without suspected R and H resistance can be treated with a 4-month regimen (2HRZ and occasionally E, and a continuation of 2 months of H and R)(29).

1.1.8. TB prevention

TB can be prevented using a variety of methods. The most common intervention available at the health-care level is TB preventive treatment with isoniazid, which reduces the risk of TB infection progressing to active TB disease. According to the WHO, TB prevention is recommended for people living with HIV, household contacts of pulmonary smear positive TB patients, and clinically risk groups such as those on dialysis (18,30).

Another strategy for TB prevention is TB infection prevention and control. Administrative control, environmental control, and respiratory protection are all part of this strategy. The administrative control aims at reducing M. tuberculosis transmission by limiting the risk or exposure to persons with infectious TB at health care settings. The activities among others includes, screening, patient identification, risk assessment, educating, training, and counseling health care personnel, patients, and visitors about TB infection etc. (30,31). With regards to environmental control, dilution, filtration, and disinfection measures are applied to reduce the concentration of contagious droplet nuclei in the air. The respiratory protection control is intended to reduce the risk of exposure to M. tuberculosis and is used in combination with other strategies to prevent the bacilli's spread (18,30,31). The Bacille Calmette-Guérin (BCG) vaccine for infants can help to protect against severe forms of TB in infants and young children. BCG is the only licensed vaccine for TB prevention. Preventive and therapeutic new TB vaccines are being developed, with approximately 20 new vaccines currently in various stages of clinical trials (32–34).

1.2. Risk factors for TB

A number of risk factors have been identified as increasing the risk of TB infection and development of active TB (35–44). The majority of known risk factors are linked with conditions that primarily compromise people's immune systems, such as Diabetes mellitus (DM), malnutrition, and chronic renal failure (35,36,38–40,44). Other risk factors of TB include household or close contacts of an infectious TB patient, alcohol consumption or alcoholism, illicit drug use, cigarette smoking, living in a poorly ventilated house or overcrowding, history of hospital admission, and previously treated TB (37,39,41,43,45,46). A meta-analysis of 14 studies from 14 high TB burden countries provided a random effects estimate of the relative risk (RR) of active TB with smoking, alcohol consumption, diabetes, and body mass index (BMI) less than 18.5 kg/m^2 for each sex. The result showed that, the risks of active TB were significantly higher among those who had diabetes and persons with a BMI of less than 18.5 kg/m^2 in both sexes. The risk was also higher among men who abused alcohol, and women who used to smoke cigarettes. The risks from combined exposures were statistically significant in men for diabetics with a BMI less than 18.5 kg/m^2 (RR = 6.4), people with diabetes who smoked (RR = 3.8), and people with diabetes who drank alcohol (RR = 3.2). The risks of combined risk factors were statistically significant in in women with diabetes with a BMI less than 18.5 kg/m^2 (RR = 10.0), people with diabetes who smoked (RR = 5.4), and women with a BMI less than 18.5 kg/m^2 who smoked (RR = 5.0). These risk factors accounted for 61% of the estimated TB cases in men and 34% in women. Tobacco smoking, alcohol consumption, diabetes, and low BMI are all individual risk factors that, when combined, triple or quadruple the risk of developing active TB (47). The various factors are discussed below.

1.2.1. Diabetes mellitus

Diabetes mellitus is one of the risk factors for TB. Diabetes compromises the immune system and imbalances the equilibrium, resulting in the reactivation of latent TB and development to active TB (44). Diabetes patients exposed to and infected with TB are more likely to develop active TB and become ill, with a relative risk (RR) of 3.11 with a 95% confidence interval (CI) of 2.27- 4.26 (39). Thus, a person with diabetes is more likely to develop active TB than a person without diabetes (48). Diabetes may increase susceptibility to TB through a variety of mechanisms. These are: 1) directly related to hyperglycemia and cellular insulinopenia; and 2) indirectly related to its effect on macrophage and lymphocyte function, resulting in a

reduced ability to contain TB. Diabetes is known to be associated with immune dysfunction and changes in immune system components, such as altered levels of specific cytokines and chemokines (proteins secreted by immune system cells that stimulate the movement of other cells) (49). Moreover, diabetes affects chemotaxis (the movement of a cell or organism in response to a chemical stimulus**)**, phagocytosis, activation and antigen presentation by phagocytes in reaction to TB. In this case, the chemotaxis of monocytes is compromised, and this deficiency does not improve with insulin. Previous studies have shown that diabetes predisposes a person to infections (such as TB), with cell-mediated immunity playing an important role (50,51).

1.2.2. Malnutrition

Malnutrition is one of the risk factors for TB (44,48,52). A previous study showed that there was a six- to tenfold increase in the RR of TB with mild to moderate and severe undernutrition, reflecting that malnutrition is a strong risk factor for TB (53). This is associated with protein and micronutrient deficiencies which impair both innate and adaptive immune function by affecting the hematopoietic and lymphoid organs (54). Furthermore, nutrients such as vitamins and minerals have been linked to increased immune responses against intracellular pathogens such as M. tuberculosis. Malnutrition, such as micronutrient deficiency causes immune-homeostasis alteration, which significantly increases person's susceptibility to TB infection or progression of the infection to active TB. As a result, malnutrition is the most common risk factor of immunodeficiency (53,55). Evidence from studies have shown that deficiency of macro-nutrient and micro-nutrient increases the risk of TB by impairing host immunity (53). Studies have shown that high level of dietary cholesterol is positively related with an increased risk of TB (35,56). The *M. tuberculosis* obtains and metabolizes host-derived lipids such as fatty acids and cholesterol, and uses these substrates to cause and maintain the disease (56). Furthermore, malnutrition not only increases the risk of developing active TB from latent TB, but it also contributes to increase TB incidence. It also leads to poor treatment adherence and outcomes due to decreased appetite, malabsorption, and under-nutrition, which increases the risk of drug toxicity (57,58). A systematic review reported that there is a bidirectional relationship between under-nutrition and TB. According to this review, under-nutrition increases the risk of TB, which then leads to malnutrition. Furthermore, malnutrition may increase the risk of latent TB progressing to active TB (57). This indicate that under-nutrition is a strong risk factor for TB at the individual and national level by decreasing the host's defense against TB infection (16).

1.2.3. Age

The risk of TB increases with age, and the incidence of TB is higher in adults than in children. According to a previous study, the estimated incidence of M. tuberculosis infection in adults was 1.5 to 6 times higher than in children (59). TB mainly affects the productive age group (15-49 years). However, older people are also at high risk of contracting TB (16,18,59,60). There is evidence that older people produce more interleukin (IL)-6 and reactive oxygen species in macrophages than younger people. M. tuberculosis replication is higher in older macrophages than in younger macrophages. This may explain why older people are more susceptible to TB disease (61). A study shows that although TB is more common in adults, children exposed to household TB patients are at a high risk of infection and disease development (36).

1.2.4. Gender

TB prevalence is higher in men than women (16,18). According to a systematic review and meta-analysis in low- and middle-income countries, the overall random-effects-weighted male-to-female prevalence ratios for bacteriologically positive and smear-positive TB were 2.21 and 2.51, respectively (62). Several studies, including a systematic review from low- and middle-income countries, found that that TB prevalence was significantly higher among men than women (60,62,63). According to a population-based cohort study from Ethiopia, the incidence of PTB among individuals with persistent cough was higher in men than in women. Men had a 62% higher risk of developing bacteriologically confirmed PTB than women [hazard ratio (HR) = 1.62], and men had a 56% higher risk of developing clinically diagnosed PTB than women (HR =1.56) (64). The risk differences could be explained by the fact that women have both maternal and paternal X chromosome, whereas men only have one. As a result, women have a stronger immune response than men, making them less susceptible to many infectious diseases (65). Several immune-related genes and immunoregulatory elements are found on the X chromosome. In addition, sex hormones may influence sex differences, leading to the conclusion that the X chromosome is likely to significantly influence immune response and sex differences in susceptibility to infection (65). Sex also influences the relationship between hemostasis and the extent of TB lung lesions; this may be a mechanism for sex differences in TB pathogenesis (66,67). A study stated that a majority (>50%) of TB infections were due to contact with adult men. As a result, TB treatment and control in men is crucial to prevent TB in the community (men, women, and children) (59).

One reason for the higher TB incidence in men could be that women delay seeking healthcare longer than men after the onset of TB symptoms. Women's ability to use available health services, including TB care, is also limited due to disparities in access to health care caused by economic constraints, and a lack of power or inability to make decisions (68).

1.2.5. Tobacco smoking

Tobacco smoking is one of the modifiable risk factors for TB. Several previous studies have found an association between tobacco smoking and an increased risk of TB (47,69–73). A study found that being a current or former smoker nearly tripled the risk of active TB (OR=2.8)(69). In another study, smoking was identified as a four-fold risk factor for developing TB (AOR = 4.43) (41). Another study found that men with HIV who smoke have a higher risk of developing TB than nonsmokers, with current smoking tripling the risk (AOR= 3.2) and former smoking nearly doubling the risk (AOR= 1.8) (70). According to one study's population attributable fraction estimates, tobacco was responsible for 18% of TB cases in this group (73). Tobacco use increases the risk of developing TB, increases the risk of TB relapse, and weakens the disease's response to treatment. It weakens the lung's defense mechanisms to infection, making the individual more sensitive to infection and development of the disease by the following mechanisms: 1) changed mucociliary clearance, 2) immune-depression of pulmonary lymphocytes, 3) decreased activity of alveolar macrophage, 4) changed pulmonary dendritic cell activity, and 5) decreased cytotoxic activity of natural killer cells (47,72–74). Tobacco smoke is a risk factor for both active and latent TB. It is associated with delayed diagnosis, increased disease severity and poor treatment outcomes. It is worse in densely populated areas where TB is prevalent due to overcrowding and high transmission (72,75). According to one study, current smokers have a higher risk of developing TB than never smokers, and the risk is more likely to increase with increasing dose and duration of smoking. In this study, individuals who ceased smoking and maintained their weight after baseline assessment had a lower risk of developing TB compared to those who continued smoking (76).

A systematic review and meta-analysis revealed that second-hand smoke (involuntary smoking or passive smoking) increases the risk of latent TB infection and active TB in both children and adult non-smokers. Because it affects both on the innate and adaptive immune systems of the lungs, it increases susceptibility to TB infection and development of active TB (71). Behavioral risk reduction strategies, such as tobacco smoking cessation, are effective for

TB prevention. A study found that tobacco smoking reduction strategy was effective and cost-effective, decreasing TB incidence by 5.5% over 20 years at an estimated cost of $95,835 per prevented TB case (77).

1.2.6. Alcohol consumption

Alcohol consumption is another modifiable risk factor for TB, and it is associated with increased incidence and poor treatment outcomes (47,73,78,79). According to a global meta-analysis of 36 cohort and case-control studies, alcohol consumption was related with a 35% increased risk of TB compared with non-drinkers (RR= 1.35). In addition, alcohol-related problems were linked with more than three times increased risk of TB compared to people without alcohol-related problems (RR= 3.33) (37). A meta-analysis from 14 high TB burden countries showed that heavy alcohol use (a woman who consumes 8 or more drinks per week or a man who consumes 15 or more drinks per week) is a risk factor for the development of new active TB. A significant dose-response relationship of increased TB risk with increasing alcohol consumption was observed in this meta-analysis (47). According to a systematic review, harmful alcohol use is one of the leading risk factors for diseases such as TB, disability, and death worldwide (39). Another systematic review of reviews reported that behavioral risk factors such as alcohol, smoking, and illicit drug use increase the risk of contracting and suffering from communicable diseases such as TB (80). The mechanisms by which alcohol consumption increases the risk of TB are more likely to be biological and behavioral in nature. Through a variety of immunological mechanisms, alcohol use increases susceptibility to TB. Chronic or irregular heavy drinking increases susceptibility to mycobacterial infection and reduces vaccination response. Chronic heavy drinking promotes inflammation while weakening neutrophil function in the innate immune response, and causing T and B cell loss in the adaptive response (81,82). In terms of behavioral mechanisms, most of the effects of alcohol on disease acquisition are due to impaired decision making or impaired control, and alcohol consumption leads to lost to follow-up and nonadherence for TB treatment (83–85). Prevention of communicable diseases is more successful when behavioral risk factors are prevented (80).

1.2.7. Air pollution

According to the WHO, more than 90% of people live in areas with hazardous levels of air pollution (86). Air pollution is one of the modifiable risk factors for TB. Studies have reported that there is an association between CO, NO2, SO2, and PM 2.5 exposure and the

risk of TB (87–89). The associations were stronger in male and elderly patients, and they changed with the seasons (88,89). Short-term exposure to low levels of SO2 and NO2 increased the risk of TB. On the other hand, only higher levels of CO and PM 2.5 exposure were linked to an increased risk of TB (87). The use of solid fuels for heating was found to be significantly related to active TB (90). When children are exposed to contaminated cooking fuel, they are at a higher risk of contracting TB. Moreover, the type of cooking fuel used (kerosene) and active PTB was positively associated (91).

Studies have been conducted to investigate the mechanisms by which air pollutants increases the risk of TB. Increased air pollutants such as PM2.5 exposure impairs respiratory system immunity by inducing oxidative stress and makes the host more susceptible to TB. Air pollutants can stimulate and interact with the immune system by stimulating inflammation. Air pollution seems to be able to cause extensive inflammatory responses, which can then lead to disease via chronic inflammation. When immune cells are exposed to diesel engine exhaust particles and then to *M. tuberculosis*, the cells exposed to the particles do not react normally to the *M. tuberculosis* (92–95). A systematic review found interventions to protect against air pollution. These interventions can be physical (for example, wearing a face mask), behavioral (for example, minimizing outdoor physical activity or selecting a less congested walk route), technological (for example, alerts on mobile phone applications to avoid outside walk when there is poor air quality), pharmacological (for example, utilization of proper inhalers), or a mix of the above (86).

1.2.8. Illicit drug use

One of the risk factors for TB is illicit drug use. According to a previous study, the risk of TB increases among illicit drug users (96). Another study found that drug misuse accounted for 15% of TB cases in this group, based on population attributable fraction estimates (73). According to a review of epidemiologic data, illicit drug use, such as cocaine use, was one of the risk factors associated with TB infection and active TB. The proportion of injection drug users who become infected and develop TB was eight percent. The presence of TB-infected illicit drug users in families and communities is critical to maintaining the TB transmission chain and increasing the risk of TB. Other factors that increase the risk of TB among illicit drug users include their risky lifestyle, overcrowding, indoor gatherings of users, sharing of materials for use, malnutrition and severe coughs that many users develop, the spread of HIV infection among such users, and the rise in the number of imprisonments (39).

1.2.9. Other risk factors

There are several other risk factors for contracting TB. A study showed that miners with silicosis have an increased risk of developing TB disease compared to those who do not work in mining areas (97). Type of human leukocyte antigens (HLA) is another risk factor for TB. Individuals with HLA types A11-B15 and DR2 have a higher risk of contracting TB than other HLA types. Type of blood group and hemophilia are liked with increased risk of TB. TB seems to be higher among persons with blood group AB or B compared to blood group O and A. Children with Hemophilia have an increased risk of TB compared to children with other diseases. Other medical conditions including malignancies (Hodgkin's lymphoma), vitamin D deficiency, patients on immunosuppressive drugs, chronic malabsorption syndrome, individuals with chronic renal failure who are on hemodialysis, patients who have undergone gastrectomy have a higher risk of developing TB (97).

1.3. Factors that contributed to TB resurgence

Factors contributing to the resurgence of TB include human immunodeficiency virus/acquired immunodeficiency syndrome (HIV/AIDS), poverty, population growth, migration, and drug-resistant TB (16,18,98).

1.3.1. HIV/AIDS

HIV/AIDS has contributed to the resurgence of TB and is associated with poor treatment outcomes (18). TB is an opportunistic infection (OI) that occurs more frequently and with greater severity among individuals with weakened immune systems than in individuals with normal immune systems. HIV depletes cluster of differentiation 4(CD4) T cells, which may compromise an individual's immune system (44,99,100). The risk of latent TB progressing to active TB is highest in HIV patients. Furthermore, the risk of developing active TB in HIV positive patients is about 20 times higher than in HIV-negative persons (31,44). If the latent TB is not treated, it can rapidly progress to active TB in persons living with HIV due to their weakened immune system. HIV also increases the probability of re-infections and relapses of TB (7,46). Furthermore, an increase in the number of immune-compromised persons living with HIV creates a large reservoir of persons susceptible to TB reactivation, resulting in an increase in active TB cases (101). Thus, HIV poses a risk for TB epidemics by increasing TB incidence and mortality rates in an immune-compromised population susceptible to primary and recurrent TB (7,102). Previous studies found that the risk of TB in HIV/AIDS patients

increased with WHO clinical stage III, a CD4 count < 200 cells/l, and poor adherence to antiretroviral therapy (ART) (103,104). According to the WHO recommendation, national HIV programs and TB-control programs should create linkages and partnerships with other stakeholders for implementation and monitoring of collaborative TB/HIV activities. To reduce the burden of HIV, the policy recommends routine HIV testing for presumptive or diagnosed TB patients and their spouses and family members. HIV-positive TB patients should receive co-trimoxazole preventive therapy (CPT). In addition, all HIV-positive TB patients, regardless of CD4 cell count, should start ART as soon as possible after starting anti-TB drugs. HIV-positive TB patients with severe immunosuppression (CD4 counts less than 50 cells/mm3) should begin ART within the first two weeks of starting treatment for TB. HIV prevention services should be provided to TB patients, their families, and community members (101,105).

1.3.2. Poverty

TB is considered as a disease of poverty. Poverty has contributed to the resurgence of TB through a variety of mechanisms, including a reduction in the prompt seeking of health care (16). A study stated that TB is significantly more likely to be reported among the multidimensional poor than among the multidimensional non-poor (106). Another study found a link between poverty and TB through the strong mediating effect of low body mass index (BMI) (107). Thus, poverty and TB are linked in a vicious circle. Poverty contributes to the spread of TB by affecting living conditions, such as individuals living in overcrowded and poorly ventilated households, increased susceptibility due to malnutrition and/or infections, and long diagnostic delays due to direct or indirect costs. Furthermore, an illness like TB has an economic impact because people with the disease are more likely to be less productive at work, lose their work, retire early, or die. All of this leads to lower household income and an increased risk of further impoverishment (108,109). Furthermore, those who are extremely poor, neglected, or marginalized are at a higher risk of TB transmission and susceptibility due to a combination of factors such as overcrowding, poor ventilation, and a delay in seeking health care (108–110).

The WHO developed a TB-Sustainable Development Goals (SDG) monitoring framework to monitor14 indicators that are strongly linked to TB incidence. Two of the 14 indicators are under SDG 1: End poverty in all its forms everywhere. These are as follows: 1) Proportion of population living below the international poverty line; 2) Proportion of population covered by

social protection systems (16,18). Thus, poverty reduction and social protection are included as part of the WHO End TB Strategy to implement and reinforce bold policies and supportive systems (18,111). In addition, reducing income inequality and economic growth have an impact on reducing the TB epidemic (16,18).

1.3.3. Migration

Migration has contributed to the resurgence of TB, increasing morbidity and mortality among migrants and their communities. A systematic review and meta-analysis reported that active and latent TB prevalence is high among refugees and asylum seekers (98). Another systematic review reported that a high TB burden in migrants are likely due to the recurrence of remotely acquired latent TB infection after migration from low or middle-income, high TB burden countries to high-income and low TB burden settings (112). In this review, reasons for the TB burden among migrants include migrants having active TB on arrival, migrants having previously acquired latent TB that reactivates after arrival, or migrants developing TB through local transmission after arrival (112). Evidence show that there are several risk factors for TB exposure, infection, and transmission, as well as poor treatment outcomes, throughout the migration process (112,113). These factors include: 1) individual factors such as overcrowding and poor living and working conditions, low socio-economic status, and substance abuse; and 2) social factors such as language barriers, cultural beliefs, immigration status, lack of knowledge about entitlement to health services, and low health-related spending capacity (112,114). A systematic review noted that healthcare providers faced numerous challenges in providing health care for migrants including language and cultural barriers, limited institutional capacity in relation to time or other resource limitations, and also conflicts between their professional ethics and laws that limits the right of migrants to get health care (115). Thus, it is crucial to perform tailored TB screening for early detection and treatment of latent and active TB targeted to migrants.

1.3.4. Population growth

Population growth has contributed to the resurgence of TB. TB is an old human disease that is thought to have evolved together with modern human populations over thousands of years. Infectious diseases, including TB, are favored by living in densely populated cities. The factors that increase TB transmission in communities are determined by how people live, work, and interact (116–118). Overcrowding, poor ventilation, close contacts, and exposure to air pollution may all contribute to an increase in TB transmission in the community as the

population grows. The burden primarily affects vulnerable groups such as those living with HIV, diabetes, malnutrition, and in urban slums, where the risk of developing TB is high (9,119,120).

1.3.5. Drug-resistant TB

Drug resistant (DR) TB contributes to increased TB incidence and adds significantly to the global TB burden. Drug-resistant TB can occur when anti-TB drugs are misused or not properly managed (121,122). Patient's delay in receiving early diagnosis and treatment, prior treatment with anti-TB drugs and primary infection with DR-TB strains all may cause DR-TB (122). Resistance to antibiotics occurs in *M. tuberculosis* strains because of spontaneous gene changes that reduce the bacterium's susceptibility to the most commonly used anti-TB drugs. These genes can encrypt drug targets or mechanisms of drug metabolism, thereby influencing the efficacy of anti-TB therapy. As a result, the drugs no longer kill the TB bacteria (122–124). Drug-resistant TB can be acquired as well as transmitted. Drug resistance in a patient who has not previously received anti-TB treatment is called primary drug resistance. Acquired drug resistance is resistance that develops in a patient who has previously received chemotherapy (121,125). Inadequate treatment, especially when standardized treatment is used in the absence of drug sensitivity test (DST) results, and poor adherence or interruption of treatment, are major causes of acquired drug resistance TB. Drug-resistant TB can be transmitted in communities or during hospital epidemics, primarily as a result of inadequate infection prevention measures (121,125). According to the WHO, DR-TB is classified into five groups: isoniazid-resistant TB, rifampicin-resistant TB, multidrug-resistant (MDR-TB), pre-extensively drug-resistant, and extensively drug-resistant (XDR-TB). MDR-TB is resistant to the two most potent TB drugs, rifampicin and isoniazid. Pre-XDR-TB is defined as TB that is resistant to rifampicin and any fluoroquinolone, whereas XDR-TB is defined as TB that is resistant to rifampicin, isoniazid, any fluoroquinolone, and at least one of the drugs bedaquiline or linezolid (18).

1.3.6. COVID-19 and TB

The problems of TB patients have been worsening as a result of COVID-19 pandemic. This is because the world's attention has been diverted from TB treatment to COVID-19 since 2020, TB and COVID-19 have similar clinical symptoms and manifestations such as cough, fever, and shortness of breath (126). COVID-19 infection develops faster than TB. Because both

COVID-19 and TB impair the host's immune response, it is realistic to consider that their fatal combination will have more severe consequences than either of them alone (126,127).

Since the emergence of COVID-19, the increased national governments efforts mostly geared towards combating COVID-19 have weakened the TB control efforts. As a result, progress in the fight against TB has slowed down (16). The TB burden may have increased during the COVID-19 pandemic for a variety of reasons (127) including :1) increased poverty (due to job loss, unemployment, and economic burdens) as a result of lockdowns; 2) reduction of access to health care services such as reduced screening, testing, treatment initiation, adherence, and follow up generally for the community and particularly for people at risk of TB (HIV, diabetes, previous TB); 3) redirection of resources and health care services, including laboratory services, from TB to COVID-19; 4) changed health-seeking behavior because of COVID-19 stigma; and 5) Reduced TB case finding due to overlapping symptoms and prioritization of COVID-19 (127,128).

1.4. Global Burden of Tuberculosis

Despite the availability of effective TB diagnostic and treatment strategies, the global TB burden persists. TB is a major cause of illness and one of the leading causes of death worldwide (16,18). TB was the top cause of mortality from a single infectious agent, ranking alongside HIV/AIDS until the pandemic of the coronavirus (COVID-19) emerged (16,127). In 1993, the WHO declared TB a global public health emergency (129). Since then, significant progress has been done to secure early diagnosis of TB, drug sensitivity test (DST) and in the expansion of new regimens of TB drugs (129). TB incidence had decreased by an average of 1.5% per year prior to the COVID-19 pandemic, while TB mortality decreased by about one-third (127). According to the WHO's 2022 update; there were an estimated 10.6 million TB cases and 1.6 million TB deaths. Likewise, the TB incidence rate per 100,000 population per year increased by 3.6% between 2020 and 2021 due to the COVID-19 pandemic, after declining by about two percent per year for most of the previous two decades (18).

Adult men bear the greatest burden, accounting for 56.5% of all TB cases in 2021; adult women accounted for 32.5%, and children accounted for 11% of cases (16,18). According to the WHO's 2022 report, the 30 countries with the highest TB burden accounted for 87% of all estimated global incident TB cases, with eight of these countries accounting for more than

two-thirds of the total (18). According to the WHO's 2021 report, about 85% of the TB deaths happened in the WHO African and South-East Asia regions. In most of the 30 high TB burden countries, the estimated number of TB deaths increased in 2021 (16,18). Generally, low- and lower-middle-income countries account for over 90% of TB cases and deaths (16).

TB is a global public health problem that poses new challenges for some patients, including those with HIV, multidrug-resistant (MDR), and extensively drug-resistant (XDR) TB (130). The burden of DR-TB raised between 2020 and 2021, with 450 000 new cases of rifampicin-resistant (RR-TB) in 2021 which increased by 3.1% from 437 000 in 2020 (18,130). In 2021, a total of 141 953 MDR/RR-TB cases and 25 038 pre-XDR-TB or XDR-TB cases were identified, of a total of 166 991 cases worldwide. This represents an increase of 6.4% from the total of 156 982 in 2020 (18).

The COVID-19 pandemic is a significant threat for global TB control, pushing it back by about ten years (127). Because of the pandemic, the positive trend was shortly reversed, years of improvement in providing necessary TB services were changed, and the TB disease burden increased (127,128). A significant reduction in TB case notifications, increased TB deaths, a reduction in essential TB services, and funding by less than 50% of target were the most influential effects of the COVID-19 pandemic in 2020 (16,127). According to TB/COVID-19 Global study group, the co-infection of COVID-19 and TB increases the complexity of clinical patient management (such as a demand for extra oxygen, mechanical ventilation and skilled staff), thereby negatively impacting health care services. They concluded that co-infection with TB and COVID-19 is a " cursed pair " that requires immediate attention (128).

1.5. Global Tuberculosis control strategies

TB control efforts started before the development of anti-TB drugs. TB control was practiced by strengthening the patient's immunity to resist TB. The patient’s resistance was strengthened through different mechanisms such as special balanced diets and bed rest in health institution (131). Management of TB in a health institution was expensive and only accessible to a limited number of TB patients worldwide. On the other hand, at least 50% of TB patients died as a result of the disease (128). Prior to the introduction of chemotherapy, the WHO estimated that on average one contagious TB patient (source) would spread M. Tuberculosis to 20 other people over a two-year period, either before death or self-cure (132). In the 1950s, combination drugs that kill TB bacilli and cure TB were developed and

transformed TB treatment, resulting in a significant decrease of TB case fatality to ≤ 5 percent (131). In the late 1960s, rifampicin was introduced as part of a combination of anti-TB drugs that reduced the long treatment period to six to eight months as a short-course drug treatment. The short-course TB treatment was more effective, and patients improved faster and became infection-free within a few weeks (18,131). The WHO has adopted various TB control strategies since the early 90's to address the TB burden. These include the directly observed treatment, short course (DOTS), the Stop TB, and the End TB strategies (133). Each of these strategies is discussed in detail below.

1.5.1. Directly Observed Treatment, Short-course (DOTS) strategy

DOTS is the WHO-recommended strategy for TB detection and treatment, as well as an effective method of preventing the spread of TB (134). In 1993, WHO's Global TB Program made an exceptional step by declaring TB a global emergency (131,134). The DOTS was launched on a global scale in 1994/5 (133,135). The strategy includes five components: 1) government commitment to ensure effective TB control, 2) case detection by smear microscopy among self-reporting symptomatic people, 3) standardized short course chemotherapy regimens of six to eight months administered with direct observation, 4) regular and uninterrupted supply of all essential anti-TB drugs, and 5) standardized recording and reporting systems for program supervision and evaluation (133,136,137). The commitment of the government to long-term TB control is required for the other four components to be executed and sustained. This commitment should be translated into policy, and then into the financial, human, and administrative resources required to ensure that TB control is a vital component of health services (131). Case detection is the use of smear microscopy for AFB to identify people with TB among symptomatic patients seeking medical attention. DOTS includes a short-course anti-TB regimen that lasts six to eight months and uses a combination of powerful anti-TB drugs, as opposed to a long-course regimen that lasts 12-18 months. The significance of ensuring continuous drug supply has been fully acknowledged, and an accurate recording and reporting system provides the means to do so. The recording and reporting system is used to assess patient progress, treatment outcomes, and program performance, in a systematic manner (131,133).

The Global TB Control Program began to promote the DOTS strategy after analyzing the nature and magnitude of the global TB burden through an extensive monitoring and surveillance system (131). The DOTS was then expanded from ten countries in the 1990s to

102 countries in 1997. The number of patients treated with DOTS increased from < 1% in 1990 to 16% in 1997. The DOTS strategy was accepted by 102 WHO member states until 1997. However, not all of these member states executed the strategy throughout the whole state due to socio-economic and political problems (131,134). The DOTS is organized in such a way that patients receive the entire course of anti-TB drugs under supervision by securing adherence. Anti-TB drugs can be administered and observed by any trained, acceptable, and accountable TB control program personnel, such as health care providers and community health workers (137,138). Between 1995 and 2006, the DOTS strategy resulted in the notification of 31.8 million incident and relapse cases, as well as 15.5 million new smear-positive cases. The DOTS strategy was executed in 184 countries in 2006, accounting for 93% of the global population (139). The DOTS strategy's aim was to detect 70% of new smear-positive TB patients and to cure 85% of them (133,136,137). However, the global case detection rate for new smear-positive cases was about 61% in 2006 and the treatment success rate was 84.7% in 2005 (139).

1.5.1.1. DOTS-Plus strategy

Poor DOTS implementation may increase development of drug-resistant TB. When patients do not complete standard treatment regimens or receive the wrong treatment regimen, they can remain infectious with drug-resistant TB. To combat an emerging epidemic, the DOTS strategy was suggested to be modified in settings with high levels of MDR-TB by incorporating second-line anti-TB drugs with proper administration (137,140). The aim of DOTS-Plus was to prevent expansion and transmission of MDR-TB. As a result, proper DOTS implementation did help to prevent the development of drug resistance and is the first step in combating MDR-TB (137).

1.5.2. The Stop TB Strategy

Although the global TB control continued with extensive implementation of the DOTS strategy in TB high burden countries, global data revealed that DOTS alone was insufficient to attain global TB control and elimination targets (132,133). The WHO launched the Stop TB Strategy in 2006 in response to the emergence of numerous new priority interventions. To improve TB control efforts, the Stop TB partnership aimed to eliminate TB as a public health problem, followed by a world free of TB (133,139).

The goal of the Stop TB Strategy was to significantly reduce the global burden of TB by 2015, in line with the Millennium Development Goals (MDGs) and targets of the Stop TB Partnership and WHO. Furthermore, the Stop TB Partnership targets related to the MDG include a case detection rate of at least 70% of new sputum smear-positive TB cases and a cure rate of at least 85% of these cases by 2015. In addition, a 50% reduction in TB prevalence and mortality rates by 2015 from 1990 levels, and the elimination of TB as a public health burden (<1 case per million population) by 2050 (132,141,142).

The Stop TB Strategy includes elements such as providing high-quality DOTS expansion and enhancement, addressing TB/HIV, MDR-TB and other challenges such as needs of the poor and vulnerable people, strengthening the health system, engaging all care providers, empowering individuals with TB and the community, and enabling and promoting research to relieve community suffering (132,133,142).

1.5.3. The End TB Strategy

The successive implementation of the DOTS strategy and the Stop TB Strategy reinforced the Global Plan to Stop TB between 2006–2015 (143,144). WHO developed the End TB Strategy as a plan and call to action for governments around the world to work towards eliminating or eradicating TB, rather than just controlling it, as was the case with the Stop TB Strategy (143,144). The World Health Assembly adopted the End TB strategy in 2014 with the goal of ending the global TB epidemic by 2030. The Global Plan enhances the WHO's End TB Strategy and line up with the Sustainable Development Goals (SDGs). The targets set for the End TB Strategy are to decrease TB mortality by 95% and TB incidence by 90% by 2035 (from a 2015 baseline), and to certify that no family suffer from high direct or indirect TB related costs (143–145). The End TB strategy is based on four guiding principles:1) Stewardship and responsibility of government with monitoring and evaluation; 2) Strong partnership with public society organizations and communities; 3) Human rights, ethics and equity protection and promotion; and 4) National strategy and targets adaptation with global partnerships (143,144).

The End TB strategy is built on three strategic pillars: 1) Integrated, patient-centered TB care and prevention that focus on main concepts of the prior strategies of TB diagnosis and treatment, even though prevention starts with identifying and treating persons with latent TB infection; 2) Bold policies and supportive systems that focus on all inter-ministerial actions that are beyond the national TB control groups and pertinent for the long term effect of TB

control and elimination such as poverty alleviation, universal health coverage, and social protection; and 3) Intensified research and innovation that focus on research that is crucial to halt the route of the TB epidemic and achieve the global targets (133,143,144).

The WHO recommended global priority targets for the End TB Strategy to monitor implementation are treatment coverage of ≥ 90%, TB treatment success rate of ≥ 90%, and preventive treatment coverage of ≥ 90%. In addition, zero percent of households face direct and indirect costs related to TB, and new diagnostic and new drug use ≥ 90%. The aim is for all countries to meet these targets by 2025 (143,144,146). Achieving the 2025 targets necessitates the effective utilization of current TB fight tools, as well as universal health coverage and social protection. Furthermore, reaching the 2035 targets needs the insurance of availability of novel tools from the research pipeline (145,147).

1.6. Practical challenges of TB control program

Successful TB control program performance requires optimal implementation of the End TB strategy components (144). In the following section, common challenges that affect the performance of TB control program are discussed.

1.6.1. Poor TB case finding and case holding

Poor case finding and case holding are the main challenges of TB control programs (148,149). The End TB strategy focuses on improving case detection and case holding activities by enhancing an effective patient-centered and community approaches to reach all TB patients. Early detection and treatment of TB is crucial to help patients to get cured, reduce transmission in the community and prevent the development of drug-resistant TB. Nonetheless, in many high-TB burden countries in sub-Saharan Africa, case detection and successful treatment of TB are not yet achieved as per the target set by the WHO (16,18,150). There are two types of TB case finding strategies (passive and active). Passive case finding refers to the screening of individual patients self reporting to a health facility. It is a diagnosis of TB made at a health facility among people who are aware of their symptoms. Active case finding is a systematic and intensified identification of TB cases outside of a health facility in a targeted population considered to be at higher risk of developing TB (24,151). Active case finding can be used to identify latent TB cases who are candidates for TB prophylaxis. Active case finding interventions can take a variety of forms, including household or contact tracing, screening patients door to door, and high risk groups screening (24,151–153).

Annually, more than one-third of individuals with TB are missed by the health systems. The reason is because they rely only on passive case finding strategy and thus many TB patients are missed and do not receive proper TB treatment and care (16,154,155). Identifying missed cases and interrupting TB transmission is crucial for controlling the disease in the community. This suggests the importance of using active case finding as part of the TB control intervention. Besides identifying the undetected (missed) TB cases, active case finding contributes to improving community access to TB care, lowers diagnosis and treatment costs and other TB care related costs, such as transport cost for patients (151,154)

Several studies reported on the advantages of active case finding. A systematic review found that high coverage and intensified community-based active TB case finding were effective in altering the epidemiology of the disease and improving community health by identifying and treating more people with TB cases (156). A previous study of TB REACH projects showed that community health workers (CHWs) were effective in active case finding, because CHWs act as a bridge between health systems and communities (157). A study conducted from Zambia showed that a comprehensive facility and community-based active case finding intervention was cost effective compared to passive case finding (158). Another study in Zambia showed that facility-based active case finding was more effective in TB case detection than community-based active case finding (159). Furthermore, a former study in Cambodia revealed that community-based active case finding was effective in identifying and treating TB in elderly, whereas most of them would have gone undiagnosed (160). A study in Peru also revealed that active case-finding was more equitable and detected TB cases earlier than passive case-finding (161). The WHO recommends that active case finding should be implemented successfully by selecting appropriate population groups, accelerating the procedure's efficiency, and considering its affordability (151). Thus, passive case finding should be supplemented with active case finding particularly in high-risk population groups. In a resource-limited setting like Ethiopia, active case finding using innovative approaches is promptly required to identify, diagnose, and treat TB patients while considering effectiveness and efficiency (162,163).

Non-adherence to TB treatment is a major problem for TB case holding (164,165). Previous studies identified several factors that contribute to non-adherence to TB treatment in Ethiopia. Some of these factors are related to forgetting to take anti-TB drugs, side effects of the drugs, being unable to visit the health facilities on their appointment date (inaccessibility), being away from home, being hospitalized, inadequate knowledge, low level of patient's

educational status, psychological distress, poor mental health status, absence of social support, culturally based beliefs about causation and TB treatment, alcohol intake, cigarette smoking, khat (herbal stimulant) use, patient's economic constraints, patient's dissatisfaction, inadequate provider-patient relationship, and quality of TB care service (166,167). Targeted interventions are required to improve patient adherence to TB treatment which in turn improves the TB control program performance (164,165).

Overall, identifying and effectively treating all TB cases, regardless of geographical and socio-economic inequalities is essential for TB control in developing countries such as Ethiopia (149,168).

1.6. 2. TB diagnostic and treatment delays

Delays in TB diagnosis and treatment are another challenge of TB control program performance in high-burden countries (150,169). It has a major role in complicating patient's illness, increasing mortality and transmission of the disease in the community (150,169). Treatment delay also result in disseminated TB and increased mortality among TB patients (170,171). In addition, delay in diagnosis of TB is one of the contributing factors for low case notification rate. Prompt diagnosis and suitable treatment of TB will avert diseases transmission, reduce severity of illness, improve treatment outcome, and prevent drug-resistant TB (172,173).

Diagnostic and treatment delays have several components (diagnostic delay, treatment delay, patient delay, health systems delay, and total delay). While diagnostic delay refers to the delay period from onset of TB symptom to diagnosis; treatment delay covers the time interval between diagnosis and initiation of anti-TB treatment; patient delay encompasses the delay period from onset of TB symptom to first visit to health care provider (facility); health system delay refers to the time interval between first visit to health care provider (facility) to initiation of anti-TB treatment. Total delay is defined as the delay period from onset of TB symptoms to initiation of anti-TB treatment (150,169).

Many studies have been undertaken on TB diagnostic and treatment delays in various parts of the world (174–181). A systematic review and meta-analysis of 78 countries revealed that the pooled mean total delay was 87.6 days, the mean patient delay was 81 days, the mean doctor delay was 29.5 days, and the mean treatment delay was 7.9 days. The pooled mean delays for diagnostic and health system delays were 70 and 42 days, respectively (169).

Another systematic review and meta-analysis showed that patient delay was the most significant and largest contributor to total delay (150,169). In addition a systematic review and meta-analysis of 124 studies from low-and lower-middle-income countries (LIC and LMIC) and upper-middle-income countries (UMIC) reported the following pooled median delays: patient delay of 28 days and 10 days for LIC/LMIC and UMIC, respectively; health system delay of 14 days and 4 days for LIC/LMIC and UMIC, respectively; and treatment delay of 14 days and zero days for LIC/LMIC and UMIC, respectively. The review also found that studies from high-TB-burden LIC/LMIC had longer median patient and health-system delays than studies from UMIC (150). Another systematic review and meta-analysis from low- and middle-income countries found that median diagnostic delay ranged from 30 to 366.5 days (182). This shows a wide range of delays in TB diagnosis and treatment across countries.

A recent (2022) systematic review and meta-analysis of 16 studies from Ethiopia demonstrated that the median diagnostic delay was 45days. In this review, the prevalence of diagnostic delay among regions of Ethiopia ranged from 9.57% to 68.84% (183). Based on another systematic review and meta-analysis of 12 studies in 2021 from Ethiopia, a high patient delay among TB patients was observed. In this review, the pooled national prevalence of patient delay was 44.29%. Furthermore, the pooled prevalence of patient delay varied across regions, with Oromia (where the study area found) having the highest at 57.789% and Tigray region having the lowest at 38.124% (184). Yet another systematic review and meta-analysis of 24 in 2020 from Ethiopia revealed that median time of the patient delay to TB diagnosis was 24.6 days. In this review, the highest median patient delay was 27.2 days in Southern nation nationality people region (SNNPR) and the lowest was 15 days in the Oromia region (185). A former study from northern Ethiopia revealed that the median patient delay of 30 days, health system delay of 18 days, and total delay of 62 days (186). Another study from northwest Ethiopia showed that the median patient and health system delays were 18 and 22 days, respectively (187). In addition, a study from southwestern Ethiopia reported that the median patient, health system, and total delays were 25, 22, and 55 days, respectively. This study reported that most (54.6%) of the total delay was related to the health system (188). This indicates that many patients were delayed in getting diagnosis and treatment of TB after seeking health care due to health system barriers. The authors concluded that there was a significant delay in TB diagnosis and treatment in Ethiopia. The

high prevalence of diagnostic and treatment delay has a significant impact on TB prevention and control programs (182–184).

With regards to factors associated with TB diagnostic and treatment delays, many studies from different parts of the world have been published (175,177,181,183,189–192). A systematic review and meta-analysis from high-burden countries identified several factors. Some of these factors include poor knowledge about TB, perceived stigma, financial constraints, limited access to health facilities, and long period of health care seeking using multiple care providers before getting a diagnosis (150). Systematic reviews and meta-analyses from Ethiopia also reported that rural residence (184,185), poor knowledge about TB (185), first visit to non-formal health care providers (patients may think they are being treated and may not visit formal health care providers) (184,185), older age (185) lower educational level (184,185), financial burden (185), long distance to reach the nearest health facility (184,185), and having extra pulmonary TB due to absence of major TB symptoms such as cough (184) were associated with TB diagnostic and treatment delays.

A recent systematic review and meta-analysis of 45 studies reported that molecular diagnostic tests such as use of GeneXpert and line probe assays (LPAs) were more effective in reducing delays in diagnosis and starting TB treatment than AFB smear microscopy and microbial culture drug sensitivity testing (DST). In this review, the use of GeneXpert reduced diagnostic delay by 1.79 days and treatment onset delay by 2.55 days compared to AFB smear microscopy for DS-TB due to its high sensitivity and specificity. Similarly, the use of LPAs reduced diagnostic delay by 40.09 days and treatment onset delay by 45.32 days compared to culture DST for DR-TB (19). Another systematic review and meta-analysis also showed that compared to AFB smear microscopy, GeneXpert was effective in reducing diagnostic and treatment delays (193). Thus, early diagnosis and proper treatment of TB patients is a cornerstone for efficient TB control program performance and achieving the End TB targets (144).

1.6.3. Inadequate decentralization of TB diagnostic and treatment services

Inadequate decentralization of TB diagnostic and treatment service is another challenge of TB control program performance. The End TB strategy focuses on reaching all patients and improving case finding through an effective patient-centered and community centered approach (18,144). One of the objectives of community TB care is to increase accessibility to DOTS services in which CB-DOTS and treatment follow-up is one of its elements (110). To

attain high TB case notification and cure rates, successful implementation of facility-based and community-based DOTS (FB-DOTS and CB-DOTS) seem to be required (29).

Facility-based DOTS has been used as standard treatment approach for TB for more than three decades. In many developing countries including Ethiopia, DOTS has mainly been provided in health facilities. In the case of FB-DOTS, patients should travel to a health facility daily to receive their treatment. This may lead to a high burden on patients and health care providers as well as a high workload in health facilities. The burden on patients is due to the long distances that make it difficult to go to a health facility daily (29). Community-based DOTS could solve many of these problems. Studies have demonstrated that CB-DOTS provided by community health workers in Nigeria (194), community-based health workers in Namibia (195), community volunteers in Mongolia (196), treatment supporters or family members in Tanzania (197) , and health extension workers in Ethiopia (198) was more or at least as effective as FB-DOTS.

In Ethiopia, FB- DOTS is delivered by a trained health worker at health facilities (Health Centers and Hospitals), which are located far from the majority of the population, whereas CB-DOTS is delivered by a health extension worker or a trained TB treatment supporter at a health post, the patient's home, or the patient's workplace, which is located close to the majority of the population (155). CB-DOTS is more accessible to patients because it is more convenient being closer to their home (199). Furthermore, when compared to the FB-DOTS approach, CB-DOTS seems to be more flexible not only in terms of location, but also in terms of the time schedules where patients can receive treatment. This type of adaptability may improve a patient's adherence to treatment. FB-DOTS, on the other hand, often requires patients to travel long distances, which takes a long time, and then they may not have money for transportation and/or may need assistance from friends or family members to get there. If family members have to assist to get to a facility, the whole household economy may be affected as they also suffer from direct costs (transportation) and/or indirect costs (loss of opportunity to work as daily laborers) (200–203). Besides, patients may have to wait longer at health facilities to be seen by the attending health care providers, as found in a study from Ethiopia. This was due to high workloads at health facilities (202).

In the case of FB-DOTS, there are several challenges in terms of accessibility to TB care, development of drug side effects, loss to follow-up and the stigma of being a TB patient. The challenges could be even worse during a pandemic such as COVID 19. Thus, CB-DOTS can

help to address these challenges by bringing the service closer to the community (110,204). A global survey on FB-DOTS during the COVID- 19 pandemic demonstrated an overall reduction of TB patients receiving treatment, mainly from the Global Fund eligible countries due to lockdown measures (transportation and liberties restrictions), fear of COVID-19, and perceived stigmatization of patients seeking TB care by thinking the community may consider them as COVID-19 patients (205). These factors demand an alternative approach to increase accessibility of TB care for the community (199), and CB-DOTS is one such alternative approach.

Earlier studies in different countries have shown that CB-DOTS is more effective than the FB-DOTS approach of TB treatment (195–197,200,206–208). For example, a study from Saudi Arabia comparing CB-DOTS and FB-DOTS showed that the overall treatment success rate of patients under CB-DOTS was higher than that of patients under FB-DOTS with 97% and 76% respectively. The RR of TSR was 1.27 (95% CI = 1.13–1.43) (209). Furthermore, a systematic review and meta-analysis of eight comparative studies reported that CB-DOTS was more likely to have a favorable treatment outcome than FB-DOTS (210). Another systematic review of 17 studies (eight RCTs and nine cohort) from 12 countries revealed that CB-DOTS improve treatment outcomes in terms of high cure rate, high treatment completion rate, and low death rate (211). This suggest the need to scale up CB-DOTS in high TB burden countries as it is suggested to be a more cost-effective and acceptable approach (194,198).

Monitoring TB treatment service is essential for all patients' treatment adherence and achieving a successful treatment outcome (110). One of the main components of TB programs is to ensure that patients who have start a quality TB treatment with DOTS are able to obtain the whole course of treatment completely without interruption (110,204). Ethiopia's Health Sector Transformation Plan 2015/16 - 2019/20 includes the need for further decentralization of community-based TB care provided at the health post or community level (212). Thus, TB program managers and policy makers need to consider a scale up of CB-DOTS for mutual benefit of service effectiveness and accessibility to the community at the grass root level.

1.6.4. Poor TB treatment outcomes

An unfavorable treatment outcome is another challenge for TB control program performance. The aim of the End TB strategy is to significantly reduce TB incidence and mortality rates

globally (144). One of the pillars of realizing the strategy is treating all persons with TB, including drug-resistant TB, and to improve patient support. To attain the required TB TSR, the WHO recommends the need for addressing patients and health system related barriers for favorable treatment outcome (28,29). According to the WHO standard for TB cares, all patients with DS-TB and those patients who have not previously been treated with anti-TB drugs as well as those without risk factors for DR should start the WHO-recommended first-line regimen with quality anti-TB drugs (213).

Despite the availability of effective anti-TB drug regimens for TB treatment, most high TB burden countries have suboptimal TB TSR. A systematic review and meta-analysis of 26 studies from Africa reported that the overall pooled TB TSR was about 79.0%, which is lower than the WHO recommended target of 90%. The majority of the unfavorable outcome was related to death (48%) and defaulter rate (47%) (214). A systematic review and meta-analysis of 31 studies from sub-Saharan Africa demonstrated that the pooled TB TSR was 76.2%, which is suboptimal compared to the WHO recommended target (215).

TB TSR varies among the regions of Ethiopia. A systematic review and meta-analysis of 34 observational studies from Ethiopia revealed that the pooled TSR was 86%, which is lower than the WHO target (> 90%). The highest TSR was reported in Addis Ababa (93%) and the lowest was reported in Southern Nations (83%). Similarly, TSR in Oromia region of Ethiopia was found to be 84% (216). Another systematic review and meta-analysis of 34 studies from Ethiopia reported that the pooled estimate of favorable TB treatment outcome was 83.7%, which is lower than the WHO target of achieving a 90% TSR. Among those with favorable treatment outcome, 33.9% were cured cases. From the total cases with an unfavorable treatment, about 50% was dead and the remaining was treatment failures and lost to follow up. In this review, the highes TSR was estimated to be 88.9% (in Afar region) and the lowest was 19.0% (in Amhara region) (217).

Non-adherence to anti-TB drug regimens is the major challenge for successful treatment outcome. A global systematic review of 14 studies in 2020 found that nonadherence to anti-TB drug regimens was significantly associated with lower cure rate, higher death rate, and treatment failure rate (168). A systematic review and meta-analysis of 26 studies from Ethiopia in 2019 showed that the overall pooled prevalence of non-adherence and lost to follow-up were ten percent and five percent, respectively. In addition, the pooled prevalence of intermittent non-adherence was 20% (218). The magnitude of non-adherence to treatment

varies among the regions of Ethiopia and there were different factors associated with non-adherence. A systematic review and meta-analysis of 13 studies in Ethiopia reported that the pooled prevalence of TB treatment non-adherence was 21.29%. The highest prevalence of non-adherence was 23.61% (in Southern Nations and Nationalities region) and the lowest was 10.0% (in Amhara region) (219). Forgetfulness, fear of drugs side effect, long waiting time (> 1 hour) during TB care, and perceived long distance to the health institution were reported as determinants of non-adherence to TB treatment (219).

According to WHO TB standard of care (Standard 22), assessment should be undertaken to identify factors that affect TB treatment outcomes including co-morbid and behavioral conditions such as diabetes mellitus, HIV, malnutrition, alcohol abuse, and tobacco smoking (213). Determinants of an unfavorable TB treatment outcome have been identified in different parts of the world. Some of these include old age, being women, low education levels, underlying diabetes mellitus, cigarette smoking, extra-pulmonary TB, history of previous TB treatment, HIV infection, TB relapse, being sputum-smear positive, and joblessness (220–224). Systematic reviews and meta-analyses from Ethiopia and other countries in Africa reported that HIV co-infection and re-treatment were determinants of an unfavorable treatment outcome (214,217). Another systematic review and meta-analysis of 74 studies from South Asia demonstrated that patients with TB and diabetes had higher odds of death and treatment failure compared to patients with TB only. The increased mortality in TB and diabetes may be due to TB or diabetes's inherent high mortality secondary to cardiovascular disease (225). Furthermore, a systematic review and meta-analysis of 111 studies demonstrated that alcohol use was associated with increased odds of an unfavorable treatment outcome such as death, treatment failure, and lost to follow-up (LTFU) both in DS and MDR-TB studies (226). Mental disorders in TB patients were also associated with an unfavorable TB treatment outcome. A global systematic review and meta-analysis of 10 studies found that there was an association between mental disorders and an unfavorable treatment outcome such as loss to follow-up and non-adherence (227). Another global systematic review and meta-analysis of 8 studies reported that there was a significant association between depressive symptoms and an unfavorable TB treatment outcome such as loss to follow-up and death (228). The COVID-19 pandemic significantly affects the treatment outcomes of TB patients. A recent Global systematic review and meta-analysis of 42 studies showed that the mean overall fatality rate of TB-COVID-19 co-infection was 13.9%, and in-hospital fatality rate of the co-infection was17.5%. In this review, the mean in-

hospital fatality rates were 6.5% and 22.5% for high-income countries and LMICs, respectively (229).

1.6.4.1. TB treatment adherence strategies

There are various strategies to improve TB treatment adherence and increase TB TSR. A systematic review and meta-analysis of 22 randomized clinical trials (RCTs) demonstrated that there was an increase in cure rate by 18% with DOTS and by 16% with education and counseling of the patients. In this review, the lost to follow up rate was reduced by 49% with DOTS and by 26% with incentives (financial) and by 13% with education and counseling of the patients (230). Another systematic review of randomized controlled studies reported that a combination of DOTS by trained community health workers, patient education and counseling, short messaging service (SMS), drug box reminders, and monthly TB vouchers were effective in improving treatment adherence and outcome of TB patients (164). The effectiveness of SMS was also reported in a global systematic review and meta-analysis of 14 RCT and quasi-experimental studies (231). Furthermore, a systematic review of RCTs studies revealed that digital health technology interventions such as video directly observed therapy, video-observed therapy, ingestible sensor (ingestible electronic devices), medication monitor box (a device that records the history of medication use), and SMS reminder were found to be effective in improving TB treatment adherence, treatment completion, and cure rate (232). Another global systematic review and meta-analysis of 129 RCTs and cohort studies demonstrated that adherence interventions such as education (patient, healthcare provider); incentives and enablers; reminders and tracers improved TB treatment outcomes significantly (148). A systematic review and meta-analysis of eight RCTs reported that supplementation of vitamin D during TB treatment increased the percentage of sputum smear and culture conversions (233). A significant association of combined zinc and vitamin D supplementation and an increased sputum smear conversion at 2 months and serum hemoglobin level at 6 months were also reported in a systematic review and meta-analysis of nine RCTs studies (234). This implies that health-care systems should be more flexible and employ a variety of treatment adherence strategies to achieve a successful TB treatment outcome. The WHO recommends that a patient-centered treatment approach should be established to improve treatment adherence, outcomes, and quality of life (235). This suggests that the treatment approach needs to be adjusted to each patient's specific life situation and needs, using different strategies to increase adherence and improve treatment outcomes.

1.7. The health system of Ethiopia

Ethiopia is located in the North-eastern part of Africa (Horn of Africa) with an area of 1.1 million km^2. It is a populous country ranking second in Africa and 12th in the World with a total population of about 101 million with an average household size of 4.6 in 2020. Moreover, 44% of the population are below the age 15, and four percent are 65 years and above (236,237). Ethiopia has nine ethnic and geographical based administrative regions and two administrative cities. In 2019, 87% of urban households and 61% of rural households had access to improved drinking water, and 83% of urban households and 14% of rural households had access to electricity (236).

Ethiopian policymakers seem to understand that investing in health can fight poverty and spur economic progress, and that population health is both a strategy for and a result of development. Ethiopia has established a resilient commitment to health-systems strengthening. As a result, the Ethiopian health sector, along with other stakeholders (sectors), is serving as a source of economic growth (237,238). The Ethiopian health policy focuses on development; building the health system's capacity and improve universal health coverage by delivering an equitable and acceptable health service to its community (237,239,240). Thus, the Ethiopian health sector follows a three-tier health care delivery scheme (237). The first level represents a primary health care unit that is a *Woreda* or District health system encompassing a primary hospital, health centers and their satellite health posts linked to each other through a referral system. A primary hospital provides inpatient and outpatient services for about 100,000 people, is a referral center for nearby health centers, and offer emergency surgery such as caesarean sections. The health centers deliver both preventive and curative services; represent a referral center for the five health posts, and a practical training center for health extension workers (HEWs). There are both comprehensive and basic health posts (HPs). The comprehensive HPs are staffed by HEWs, and other health professionals such as nurses, and midwives to offer more comprehensive health services whereas, the basic HPs are staffed by HEWs and provide disease prevention and health promotion services and selective curative services for the community. The second level represent a general hospital serving a population of 1-1.5 million people, a referral center for primary hospitals and training center for health professionals such as health officers, nurses, and emergency surgeons. The third level represent a specialized hospital serving a

population of 3.5-5 million people, a referral center for general hospitals, and a training center for higher level health professionals such as specialists and subspecialists (238,240).

A systematic review reported that weak primary health-care systems could hinder advancement in meeting programs' targets in resource-limited settings including Ethiopia (240). Community-based primary health care is the basis of the Ethiopian primary health care system, and primary health care is the basis of the health system (241). In this regard, Ethiopia has been capable to strengthen the health system by using an equitable and inclusive strategy (primary health care approach) that focuses on disease control programs, overall health services, and community health programs. The Health Extension Program (HEP) is one of the community-based approaches used to attain universal coverage of primary health care among the Ethiopian rural population (241,242). The HEP is an innovative community-based program that has been designed to provide preventive and promotive services, as well as certain curative services at the community level including households. TB prevention and control is one of the essential health packages under the disease prevention and control program area of the HEP (242).

Ethiopia has developed health sector transformation plans to provide health services, including TB care, and improve the health status of the population (237,242). During the first Health Sector Transformation Plan (HSTP-I) for 2015– 2020, morbidity and mortality due to TB was significantly reduced. Accordingly, the TB incidence rate (per 100,000) was reduced to 156 from a 2015 baseline of 224, and TB mortality rate (per 100,000) was reduced to 22 from a 2015 baseline of 32. Likewise, TB case notification rate increased to 71 percent from a 2015 baseline of 61 percent, and TB treatment success rate increased to 95% from a 2015 baseline of 92% (242). Recently, the Ethiopian health sector introduced the second Health Sector Transformation Plan (HSTP-II) which covers the period from 2020 to 2025. The general objective of HSTP-II is to improve the health status of the community by increasing progress to universal health coverage, protecting the community from health emergencies, transforming *woredas*/districts, and improving responsiveness of the health system. The HSTP II set many targets including TB related targets that comprise increasing TB case notification rate from 71% to 81%, TB treatment success rate from 95% to 96%, and DR TB case detection from 720 to 1,365 cases (237).

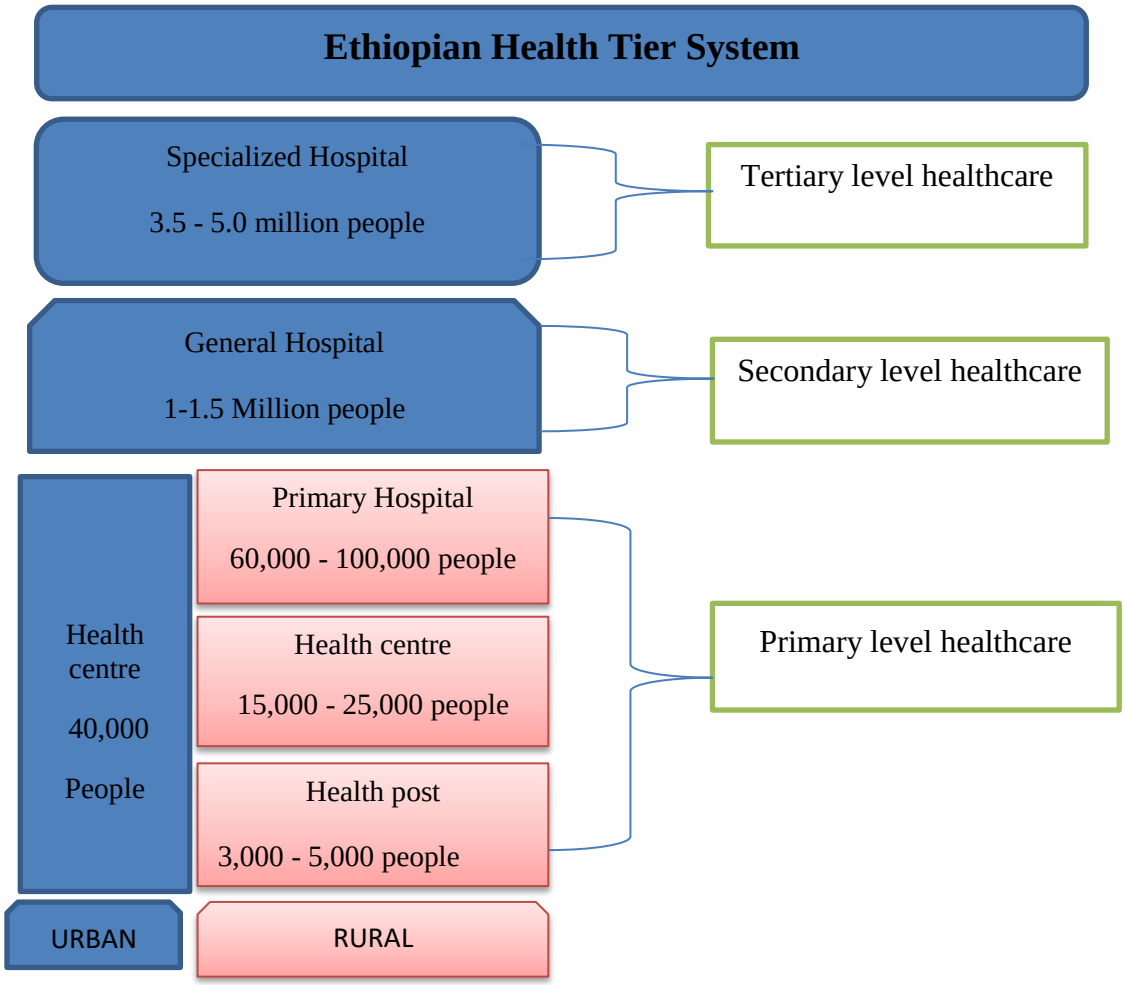

Figure 1. Ethiopian Health Tier System

Source (237)

1.8. Tuberculosis burden and control program in Ethiopia

TB has been recognized as a major public health problem in Ethiopia for the past 60 years (243). Ethiopia is one of the high TB burden countries in the world (18) and TB is among the leading infectious diseases in the country (243). Evidence from the 2016 Global Burden of Diseases study, which spanned over 26 years (1990 to 2016), revealed a high TB burden in Ethiopia. In this study, the age-standardized TB incidence rate in Ethiopia decreased from 201.6 per 100,000 to 88.5 per 100,000, a 56% decrease over the period. Similarly, the age-standardized TB mortality rate fell from 393.8 per 100,000 to 100 per 100,000, a 75%

decrease during the period. However, reductions in TB incidence and prevalence rates in Ethiopia have been slow (244).

The national estimated annual incidence rate of TB was 140 per 100,000 population in 2020, and the mortality rate was 19 per 100,000 population in 2019 (243). The annual TB incidence rate has decreased over time, from 192 cases in 2015 to 140 per 100,000 population in 2019 (16). Ethiopia accounts for 90,000 (three percent) of annually missed TB cases worldwide (17,173). The national TB notification rate (all forms) was 76%, which was lower than the WHO target (90,245). The national TB notification performance in 2020/21 was 106 per 100,000 population, which was lower than the estimated incident TB cases of 140 per 100,000 population (243). Ethiopia's national TB cure rate was 82%, falling short of the WHO target of more than 85% (18,243).

Ethiopia's TB control program started in the early 1960s with the establishment of TB centers and sanatoriums in three major urban areas. The national TB control program (NTCP) central office was established in 1976. Moreover, the National Tuberculosis and Leprosy Control Program (NTLCP) was established in 1994, to coordinate and manage TB and Leprosy on a national scale (155,246). Ethiopia has been implementing the WHO-recommended DOTS strategy since 1997, following an effective pilot program that included the development of a manual for TB and Leprosy prevention. Since then, TB control efforts have been decentralized to public health facilities where TB diagnosis and treatment are provided (246). In 2004, a TB/HIV collaborative program was piloted and consequently scaled up nationally. In subsequent years, community TB care, public-private mix (PPM) and MDR-TB programs have been piloted and combined into the TB Leprosy and TB/HIV control programs (155). Moreover, Ethiopia began to implement the WHO Stop TB strategy in 2006 (110,247).

The STOP TB strategy made significant progress toward meeting the TB-related MDG goals set for 2015 by reducing the TB incidence, prevalence and mortality by half from the baseline of 1990’s. Ethiopia also endorsed the End TB strategy in 2015, aligning with the HSTP to end TB by decreasing TB incidence rate by 90% and the TB mortality rate by 95% from the 2015 levels, as well as reducing the huge costs (related to TB care) to the patient and their household to zero (155,212). Ethiopia is on track to attain one of the three targets of the global End TB Strategy by reducing TB incidence rate by 21% from the 2015 baseline, in line with a 20% target. However, the achievement in declining TB mortality rate was low (only 15%) against a target of 35% of the HSTP-I (212,237).

1.9. TB burden and control strategies in Oromia Region and Jimma Zone

Oromia region is one of the Federal States of Ethiopia. It is the largest and most populous region in Ethiopia with a total population of 39,074,864 in 2020/21 (245). According to Ethiopia's 2021 health and health related indicators, Oromia has 109 public hospitals, 1411 health centers,7099 health posts, outpatient department (OPD) attendance per capita of 0.93, and health staff to population ratio of 2.04 per 1000 population (245).

Oromia region is the place where the DOTS strategy was started as a pilot in its two Zones (Arsi and Bale) (246), and the region now follow the national TB control strategies (155,212). The number of new cases of TB (all forms) in the Oromia region was estimated to be 54705 in 2020/21, with a 79% case notification rate for all forms of TB (245). The Oromia region had a high prevalence and incidence of TB cases. For example, a study from Arsi Zone found an adjusted prevalence of 109 per 100,000 persons for smear positive PTB and 132 per 100,000 persons for bacteriologically confirmed TB. In addition, the incidence of smear-positive PTB was 214/100,000 persons per year, while bacteriologically confirmed TB was 232 per 100,000 people per year (248). The treatment success rate in Oromia region was 84% (216), which was lower than the End TB strategy target $\geq$ 90% (18). In 2020/21, the treatment coverage of all forms of TB (new and relapse) was 79%, falling short of the target of 85%. Among these, TB cure rate for bacteriologically confirmed pulmonary TB cases was 87% (243).

Jimma Zone (the study area) is one of the 21 administrative Zones in Oromia Region, Ethiopia. TB is among the leading causes of morbidity and mortality. Several government and privately owned health providers are rendering health service to the population. Jimma Zone has a Health Department that is accountable to the Oromia Regional Health Bureau. The Health Department has a TB Control Program Unit that coordinate the TB control program activities in all districts under the Zone.

1.10. Rationale for the study

TB remains a major public health problem in high-burden countries including Ethiopia. This indicates that there are challenges impeding the performance of the TB control program. Assessing the challenges is essential in order to recommend evidence-based solutions that help to improve the TB control program performance. The challenges may include several

factors that affect patients' health seeking, the health system organization, and the socio-demographic and economic status of the population in the study area.

According to a prospective cohort study from Ethiopia, only one-third of the prevalent cases of PTB have been reported, implying that two out of every three individuals with smear-positive PTB continue undiagnosed in their communities. The highest incidence rate was observed in the 25-34 year age group, suggesting that TB transmission occurs in the community (249). At the beginning of this PhD project (2016), Jimma Zone (where the studies were conducted) had the lowest TB case notification rate of 47.1% when compared to the national and Oromia region TB case notification rates (245,250). In addition, CB-TB care has not been scaled up, with only 23% of the health posts implementing TB case holding activities in the Jimma Zone (study area) (250). According to a study conducted at Jimma University Medical Center, Jimma Zone, Ethiopia, 11.7% of patients had an unfavorable treatment outcome (251) and 88.3% had a successful treatment outcome. This finding fell short of the End TB strategy's target of achieving ≥ 90 percent treatment success rate (18). Another study from Jimma Zone, Ethiopia showed that two-thirds of all MDR-TB cases had a history of previous TB treatment, 37% had a history of treatment failures, and 27% had a history of relapse (252). Therefore, assessing the challenges of the TB control program is imperative for designing targeted interventions to improve the performance of the TB control program.

1.11. Conceptual framework

This thesis focuses on the challenges and associated factors of TB control program performance. The conceptual framework depicted below used a mixed-methods approach, relying on both qualitative and quantitative data (253–255). We identified barriers to TB case finding in (Paper I); we compared treatment outcomes of patients treated with community-based DOTS to those of patients treated with facility-based DOTS in (Paper II); we determined the length and associated factors of TB total delay in (Paper III); and we assessed TB treatment outcomes and determinants of an unfavorable outcome in (Paper IV). A clear understanding of the challenges to TB control program performance and combating the disease through evidence-based program improvement is essential to attain the targets set out in the End TB Strategy (5,144).

Early TB diagnosis reduces the time it takes to initiate TB treatment. Barriers of early TB diagnosis impede successful TB control program performance. Thus, access to TB diagnostic and treatment facilities is crucial for enabling early case detection and treatment (256,257). One of the reasons for low TB case detection is a delay in TB diagnosis which is a major obstacle to the success of TB control programs performance in low- and middle-income countries (182), including Ethiopia (258,259). A successful TB case identification and treatment outcome necessitates adequate decentralization of TB diagnostic and treatment services both at peripheral health facility and community levels (29). The Search, Treat, and Prevent (three sets of indicators) are vital for monitoring the performance of TB control program and combating TB. The term search refers to active case finding, treat refers to proper treatment, and prevent refers to disease prevention (260). Two of the three indicators (search and treat) were addressed in this thesis.

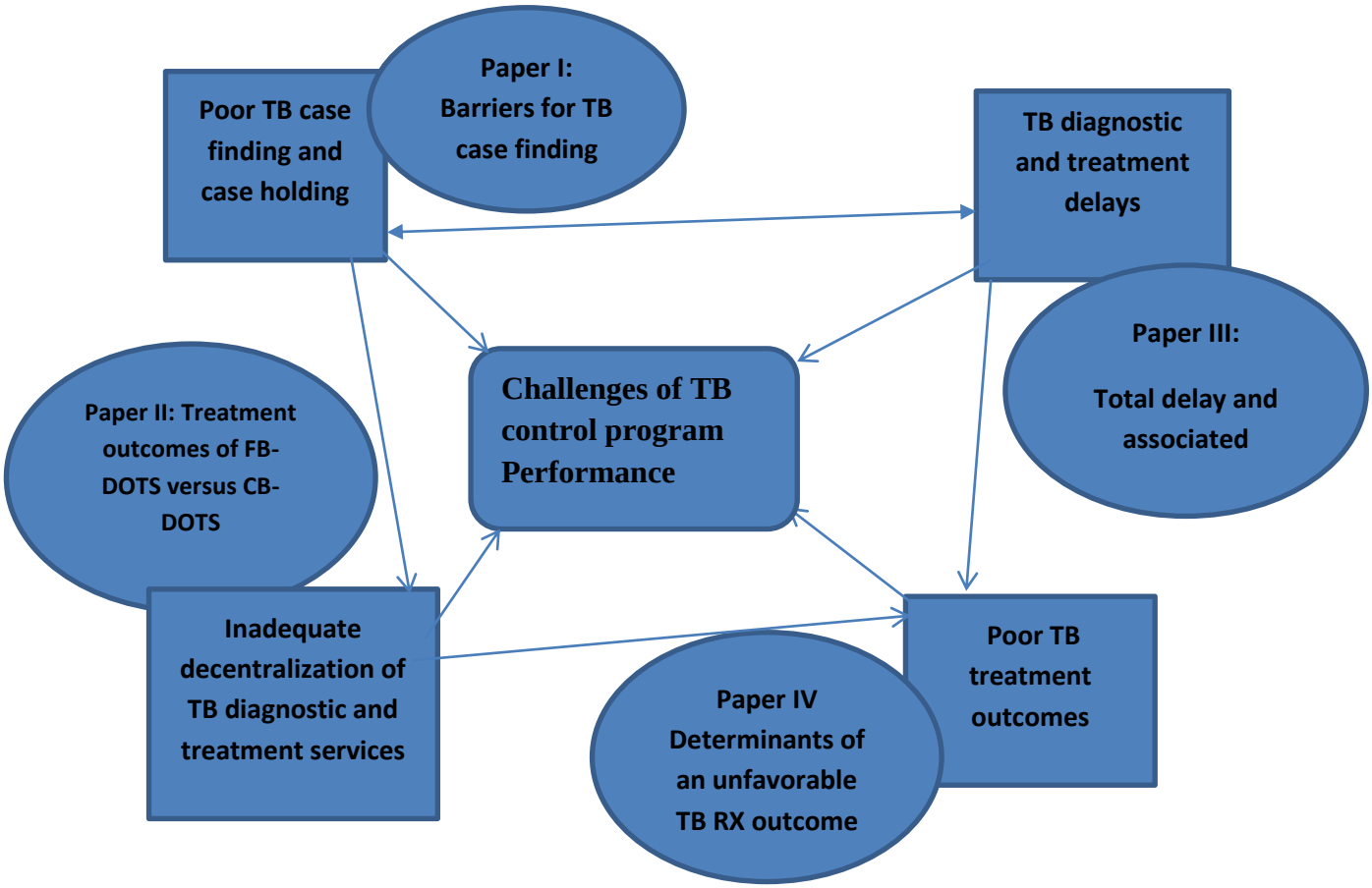

Figure 2. Conceptual framework of challenges for TB control program performance

2. Study Aim and Objectives

2.1. Study aim

This PhD project aimed to explore the challenges of TB control program performance in Jimma Zone, Southwest Ethiopia.

2.2. Specific objectives

1. To explore barriers to TB case finding in Jimma Zone, Southwest Ethiopia (**Paper I**).
2. To compare treatment outcomes and associated factors among TB patients attending CB-DOTS versus FB-DOTS at public health facilities and health posts (**Paper II**).
3. To determine the length and associated factors of total delay among TB patients (**Paper III**).
4. To assess treatment outcomes and determinants of an unfavorable outcome among TB patients in Jimma Zone, Ethiopia (**Paper IV**).

3. Subject and Methods

3.1. Study setting

The data for this thesis were gathered from study participants and documents at public health facilities in Jimma Zone, southwest Ethiopia. The Jimma Zone is situated 354 kilometres from Addis Ababa, the capital city of Ethiopia, and covers a total area of 199,316.18 square kilometres [Jimma Zone health office, 2016]. Based on the 2017 projected population census, Jimma Zone had an estimated population of 3,261,371, of whom 49.9% were women (261). During the start of the project (in 2016), the zone had 17 districts and two town administrations with seven public hospitals (five primary, one general and one specialized); 120 health centres, and 494 health posts. The hospitals and health centers provide both TB diagnosis and treatment services, while health posts provide TB treatment services, screening and referral of TB suspects to the nearest health facility for confirmation of diagnosis. TB diagnostic and treatment services are also provided by nongovernmental health facilities such as the Catholic mission and some private clinics. The TB control program has been implemented with funds and other necessary resources obtained from the Ethiopian government and global health agencies including The Global Fund and The Centre for Disease Control (CDC) United States (US) [Jimma Zone health office, 2016; Jimma town

health office, 2016]. According to Oromia National State Education Statistics annual summary, in 2016/17 there were 1,187 pre-primary schools, 1,184 primary schools (grades 1-8) and 96 secondary schools (grades 9-12) in Jimma Zone. The net enrollment rate for grade one was 96.5%, and the net enrollment rate for primary (grades 1-8) was 122.4%, with a gender gap of 7.4% (girls were less likely to be enrolled). The primary dropout rate was 16.3%, and the primary completion rate was 74.9%. In addition, the gross enrollment rate in secondary (grades 9-10) was 36.8%, the net enrollment rate in secondary (grades 9-10) was 17.6%, the gross enrollment rate in secondary (grades 11-12) was five percent, and the net enrollment rate in secondary (grades 11-12) was 3.2% (262). Figure 3 shows a map of the Jimma Zone with sampled districts and a town administration.

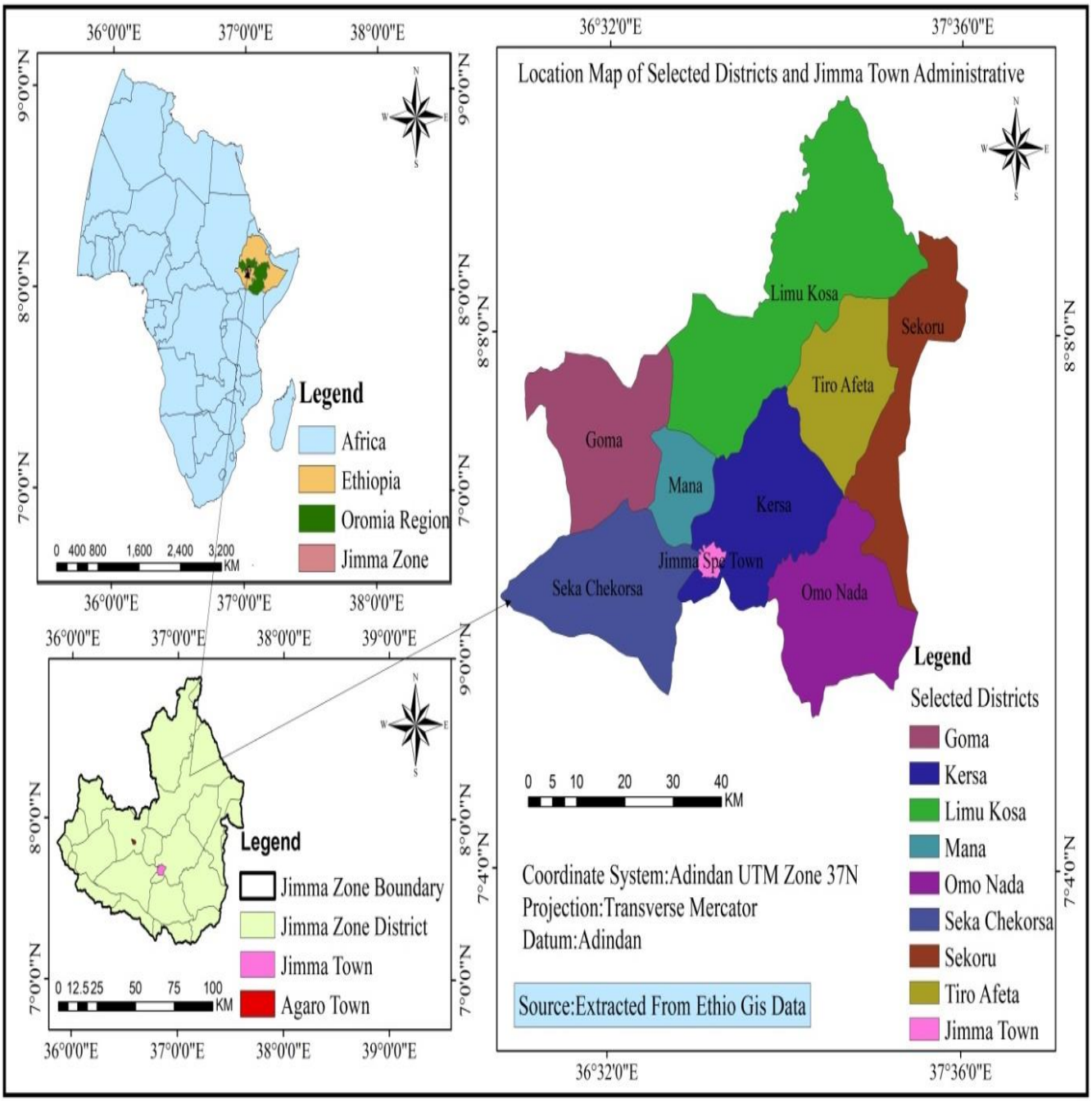

Figure 3. Map of Jimma Zone (study area) 2016/17

3.2. Study designs, population and inclusion criteria

In this PhD project, I chose a combination of quantitative and qualitative methods to gain a deeper understanding of the research subjects and address the research questions. The use of mixed methods is becoming more common in the health sciences. In the field of public health, the use of combined qualitative and quantitative methods is highly valued (263,264).

The mixed-method approach helps to emphasize the how and why aspects, putting a greater focus on choices regarding both the aims to be pursued and the means to achieve those aims (264,265). The importance of qualitative research in health care decision-making is growing (266,267). By exploring unobserved events, qualitative methods can address research questions that cannot be fully addressed by quantitative methods alone (266,268). This thesis describes qualitative, cohort, and cross-sectional study designs that were used and that involved participants at multiple levels.

In **Paper I,** we applied a qualitative descriptive design to gather in-depth insights into barriers of TB case finding and explore the associated factors. The chosen method helped in comprehending the concepts, opinions, and the actual experiences of the study participants. In this part of the study, we recruited DOTS providers (health workers), local and regional program managers who had more than six months experience with coordination of TB control program, diagnosis and treatment services. In addition, TB patients under treatment (from both intensive and continuation phases) were included. The inclusion of different participants representing different levels and experiences in the TB treatment system was done to explore the whole picture of barriers to TB case finding. Furthermore, governmental health facilities including hospitals and health centers were observed in order to investigate the infrastructure and actual availability of resources for TB case finding. To be able to obtain information about the actual availability of necessary resources for TB case finding, health facilities at various levels (urban and rural) from various districts were included.

In **Paper II,** we used a prospective cohort study design to compare TB treatment outcomes and associated factors among patients under CB-DOTS versus FB-DOTS (269**).**

For **Papers III and IV,** we employed a cross-sectional study design to determine the length and associated factors of total delay (Paper III), and to assess treatment outcomes and determinants of an unfavorable treatment outcome (Paper IV).

Papers II, III, and IV have used the same population and inclusion criteria, which are described below. The target population were all forms of TB patients who had started first-line anti-TB drugs regimen at all public health facilities of the Jimma Zone, southwest Ethiopia during the study period. The study population represented patients with all forms of TB who had started a first-line anti-TB drug regimen during the study period in public health facilities, including health posts in the sampled districts and one town administration. Patients

who were unable to answer questions, critically or mentally ill, and who were younger than 15 years of age were excluded from the study.

3.3. Sample size and sampling procedures

In **Paper I**, we included 50 individuals who had experience with TB program coordination, diagnosis, and treatment. The subjects were purposively selected using an intensity sampling technique. Intensity sampling is the process of identifying or selecting information-rich individuals to answer research questions (270). This sampling technique helps in gaining access to information-rich individuals who can provide in-depth information and explore the full picture of TB case finding barriers. The sample represented 25 DOTS providers (health workers), 23 local and two regional program managers. They were chosen for their relevant experiences and thus "representativeness" in the sense of obtaining adequate and nuanced information about TB case finding; being part of their duties and responsibilities at different levels in the health care system. When two or more DOTS providers were present at one facility, we chose the one who had the most work experience. In addition, 10 TB patients undergoing treatment (both intensive and continuation phases) were included in the in-depth interviews. We used a "maximum variation" sampling strategy to address patients with various background characteristics (sex, age, level of education and treatment phase) (270). This sampling strategy was used to select a small number of patients with the greatest diversity pertinent to the research question. This resulted in a total sample size of 60 participants for in-depth interviews, and their characteristics are described in (table 1).

In addition, 42 governmental health facilities were observed for resource inventory purposes. In this regard, we applied a simple random sampling using the lottery method to include eight *Woredas* (districts) and one town administration from 17 districts and two town administrations (271). As a result, a total of 42 health facilities (three hospitals, 11 urban health centers and 28 rural health centers) were selected from sampled districts and a town administration.

Table 1. Characteristics of in-depth interviews' participants in the Jimma Zone, 2016/7

Characteristics		Number
DOTS providers and program managers (n = 50)		
Sex	Male	38
	Female	12
Age in years	≤ 24	9
	25 – 34	40
	≥ 35	1
Responsibility	DOTS provider	25
	District or Zonal level program manager	23
	Regional level program manager	2
Work experience on current responsibility	< 2 years	16
	2 to 5 years	25
	>= 6 years	9
Patients (n = 10)		
Sex	Male	4
	Female	6
Age in years	≤ 24	2
	25 – 34	4
	≥ 35	4

For Paper II, we randomly selected eight districts and one town administration from 17 districts and two town administrations by using a simple random sampling technique (272,273). Subsequently, we included all DOTS sites in the sampled districts and a town administration for the study. The sample size was calculated using Epi Info software, version 7. A confidence interval of 95% and a power of 80% were considered. The outcome variable was treatment success rate and the percentage of outcome in exposed groups (DOTS at health posts or community) and in un-exposed groups (DOTS at health facilities) were estimated to be 89.3% and 83.1%, respectively. These proportions were obtained from a former study conducted in Southern Ethiopia (274). An unequal ratio was employed with unexposed: exposed of 2:1. Hence, the sample size was determined to be 1,161 TB patients (774 under FB-DOTS, and 387 under CB-DOTS). Afterwards, the sample size was assigned for the selected DOTS sites in the sampled districts and the town administration proportionally based on the patient flow. Finally, the study participants were consecutively enrolled until the calculated sample size was reached.

For **Papers III and IV**, we enrolled all study participants (1,161) who were included in Paper II. In fact, the minimum sample sizes for (Papers III and IV) were calculated to be 422 and 506, respectively. The increased sample sizes used in (Papers III and IV) are advantageous and provide a more than adequate representative population for the studies.

3.4. Data collection and management

For this thesis, I chose a variety of data collection methods, including in-depth interviews, health facility-based surveys, facility observation, and review of TB registers and other relevant documents. It is advantageous to study complex health service performance problems using a mixed method (qualitative and quantitative) with a variety of data collection methods (264).

For Paper I

We applied various data sources and methods. Firstly, in-depth interviews were undertaken with TB control program managers, health workers including DOTS providers at various public health facilities (hospital, health centers, health posts) and TB patients who were on treatments (intensive and the continuation phase). We utilized a semi-structured interview guide. The interview guide was translated to *Afaan Oromo* (the local language). The translation was made by an English teacher whose mother tongue is *Afaan Oromo*, and re-translated to English by a different English teacher whose mother tongue is *Afaan Oromo*.

I (BME) conducted all in-depth interviews in the local language. The program managers and DOTS providers were interviewed about barriers they faced during their coordination of the TB program, particularly in relation to TB case finding and providing TB care. The patients were interviewed about their views and experience with the diagnostic process, treatment site, and resource availability, before and during TB diagnosis and treatment. The use of data from various participants at different levels, functions and experiences of TB control program, as well as experience of the patients were used to ensure a "thick description" (270,275). Most (55) of the in-depth interviews were conducted in a private room or area at health facilities and health posts. Five interviews were conducted at the patients' and DOT providers' homes based on their preferences.

Participants in the study were assured of confidentiality and that they were able to participate freely and withdraw from the study at any time. For the first few minutes, the interviewer

sought to make the study participants relaxed by talking about topics unrelated to the study, ensuring that they were comfortable and felt safe before the interview. I did my best to build trust by creating a smooth relationship between me and the study participants. I also tried my best to establish an "optimal" distance (insider-outsider) from the study because I was familiar with the local languages and culture of the study area (270,275). The interviews were conducted as conversations rather than simply asking questions and receiving answers. This helps to elicit genuine responses from participants and minimizes participant bias. The duration of the interviews was 60 to 90 minutes, and the interviews were audio-taped and transcribed verbatim. In addition, descriptive field notes were taken after each interview, including descriptions of non-verbal responses, and facial expressions during the interview. The recruitment of study participants ended when data saturation was reached. This part of the field work, including the interviews and the observations, took place over a period of five months.

Secondly, the governmental health facilities were observed to assess the availability of required infrastructure and other resources for TB case finding. The facility observation was made by using a pre-defined checklist based on the national and WHO guidelines of TB control program and existing studies (110,200,276,277). It was performed by me and a research assistant being a health service management specialist. The availability of resources such as electricity, water supply, patient waiting area, human resources and reagents for TB diagnosis was checked through observation of the facilities' different rooms (TB, laboratory, drug store, and outpatient department (OPD). Patient waiting area, and the overall infrastructure and environment were also observed. The observation was supplemented with confirmatory questions asked to the responsible individuals in the respective units. The observations for each facility lasted between 50 and 70 minutes and took place in the same period as the interviews.

For Papers II, III and IV

We used a structured questionnaire that was developed based on the national and WHO's guidelines, as well as tools used in prior studies (110,197,198,200,274,278) to collect data from the study participants. A checklist attached to the questionnaire was also utilized to obtain clinical data including the treatment outcomes from TB registers at the respective study sites. The questionnaire was translated into the local language by a university English teacher whose native language is the local language. It was checked for any inconsistencies

between the original English version and the forward translation of the questions into the local language (peer review). The translated version of the questionnaire was then translated back into English by another university English teacher who is fluent in the local language. Finally, it was pre-tested to check for clarity and consistency and modified based on the results of the pre-test. We recruited nine data collectors and two supervisors and provided them training on the technique of data collection and ethical issues to be considered during the data collection and supervision. In the first phase of data collection, study participants were consecutively enrolled and interviewed from September 2016 to October 2017. They were followed from the time of enrolment until their treatment outcomes were recorded. In the second phase of data collection, clinical data, including treatment outcomes, were collected for the cohort from April 1 to June 30, 2018. These data were obtained from the TB registers of the participating health facilities. I organized and supervised the entire data collection process.

3.5. Variables' definitions (measurements)

Knowledge about TB was scored by assigning a score of one for correct answers and a score of zero for incorrect answers. The total knowledge score and the median score were then calculated. We categorized those with a total score less than the median as having poor knowledge of TB and those with a score greater than or equal to the median as having good knowledge of TB.

Similarly, total and median perceived stigma scores were calculated. We categorized those with a total score less than the median as having not perceived stigma and those with a total score greater than or equal to the median as having perceived stigma. We also used the median total delay to categorize patients into delayed and non-delayed groups. TB treatment outcomes were categorized as: 1) a favorable outcome, if the treatment outcome was treatment completion and cure, 2) an unfavorable outcome, if the treatment outcome was "death", "treatment failure", and "lost to follow-up". We did not categorize "transferred out" and "unrecorded cases" as favorable or unfavorable because their final outcome was unknown. The definitions of other variables were clearly stated in the (Papers I-IV).

3.6. Data analysis

For Paper I

The analysis of the in-depth interviews started early during data collection by doing a transcription and a preliminary analysis. A thematic analysis was used and the data were presented in major themes and subthemes (279). I (BME) transcribed all the audio-taped interviews and reviewed the transcript based on the recordings. For peer debriefing, a health monitoring and evaluation specialist who is a native speaker of the local languages reviewed the transcripts. I also coded and categorized the data using atlas.ti version 7.1software. MS (main supervisor) then reviewed a list of codes with associated quotations and categories. Furthermore, I and MS discussed and approved the final list of codes and categories for the study. Finally, the data were presented through descriptions of views and experiences of the study participants in relation to the aim of the study (280).

Furthermore, data from facility observations were analyzed descriptively, including the frequency and percentage of the availability of resources for TB case finding. Following that, we compared and validated (method triangulation) the findings from the facility observations with the findings from the in-depth interviews.

For Papers II, III, and **IV**

I and the research assistant (health service management specialist) checked the collected data for its completeness and consistency. We coded the data and entered it into the EpiData entry client software, version 4.4.3.1. Then, I exported the data to the statistical package for the social sciences (SPSS) software version 21. Subsequently, I proposed a list of variables for the three quantitative papers' analyses. SAY (co-supervisor) reviewed and approved the final lists of variables for each paper's analysis. I performed the data analysis using SPSS version 21 and WinPepi version 11.65.

Descriptive statistics were conducted. A binary logistic regression analysis was performed to determine the association between the independent and dependent variables. Bivariate analysis was performed for each independent variable with the respective outcome variable and crude odds ratio (COR) calculated. With a backward stepwise method, multivariable analysis was performed with the candidate variables in the bivariate analysis and the

respective adjusted odds ratios (AOR). Moreover, 95% confidence intervals (CI) were computed, and a statistically significant result was considered at a p-value < 0.05.

For Paper II, relative risk (risk ratio) and risk difference (RD) were computed. Chi-square ($\chi 2$) or Fisher's exact tests were used to compare the groups. The relative risk, RD and 95% CI were utilized for the interpretation of the groups' difference for the dependent and independent variables.

Table 2. Summary of the purposes and methods used in the four papers included in the thesis (Papers I-IV)

	Paper I	Paper II	Paper III	Paper IV
Purpose	To identify and explore the sources of barriers to TB case finding.	To compare treatment outcomes and associated factors for TB patients on CB-DOTS versus those on FB-DOTS	To determine the length and associated factors of diagnostic and treatment delay (total delay) among TB patients	To assess treatment outcomes and determinants of an unfavorable treatment outcome among TB patients
Study design	Qualitative – descriptive	Prospective cohort	Cross-sectional	Cross-sectional
Study population and sample size	Ten TB patients, 25 DOTS providers, 23 local and two regional program managers (total 60), and 42 governmental health facilities	A total of 1,161 TB patients (774 on FB-DOTS, and 387 on CB-DOTS)	A total of 1,161 TB patients	A total of 1,161 TB patients
Data collection method	In-depth interviews, and health facility observation	Structured interviews, and document review	Structured Interviews	Structured Interviews, and document review
Data collection tool	Interview guide, and observation checklist	Interviewer - administered structured questionnaire, and checklist	Interviewer - administered structured questionnaire	Interviewer - administered structured questionnaire, and checklist
Data analysis	Qualitative thematic analysis	Relative risk (risk ratio), risk difference, and $\chi 2$ or Fisher's exact tests	Descriptive statistics, and Logistic regression	Descriptive statistics, and Logistic regression

3.7. Ethical considerations

The research project has been approved by the Regional Committee for Medical Research Ethics (REK), Norway with reference number 2015/2124 REK sør-øst B with the name of my supervisor Prof. Christoph Gradmann. In addition, ethical approval was secured from the Jimma University Institutional Review Board, Ethiopia with reference number of RPGC/389/2016. Permission was granted from Oromia Regional Health Bureau, Ethiopia with reference number of BEFO/ABTF/1-8/2026 and Jimma zone health office, Ethiopia with reference number of WEFBJ/ 0-11/8060/08. Subsequently, written informed consent (oral for patients who could not read and write) was secured from the study participants before starting the data collection. For minors (15-17years), assent (simple agreement) was obtained from the study participants and consent (legally accepted agreement) was secured from their parents or guardians. The privacy of the study participants was ensured by using a private room or area during data collection. Similarly, the study participants' confidentiality was ensured by using numbers (code) to identify and describe them. The collected data were kept in a locked file cabinet (hard copy) and on a computer with a password (an electronic copy).

4. Results

4.1. Main findings: Paper I

Ereso BM, Yimer SA, Gradmann C, Sagbakken M (2020) **Barriers for tuberculosis case finding in Southwest Ethiopia: A qualitative study.** PLoS ONE 15(1)

The aim of this paper was to identify and explore the sources of barriers to TB case finding. We included 60 participants for in-depth interviews and 42 public health facilities for resource availability observations.

The in-depth interviews revealed inadequate resources for TB case finding, including a shortage of health-care providers, inadequate basic infrastructure, and a shortage of diagnostic equipment and supplies**.** Limited access to TB diagnostic services was also identified as a barrier to TB case finding. Limited access was either because of absence of nearby TB diagnostic services (TB diagnostic health facilities) or delays in the diagnostic process of the health system. Overall, inappropriate resource utilization, a turnover of laboratory professionals, difficult topography, the absence of suitable roads, inappropriate design of the health centers, inadequate collaboration with stakeholders (other sectors and

NGOs), and low community mobilization were identified as some of the origin of these barriers. The observation of health facilities revealed that out of a total of 42 health facilities assessed, 11 lacked trained laboratory personnel, 13 lacked clean water, and seven lacked electricity. In addition, the AFB reagents were out of stock at most health facility drug stores. Of these, acid alcohol in 64.3 %, carbol-fuchsin in 61.9 % and methylene blue in 59.5 % of the health facilities were not available on the day of observation. Furthermore, the National TB Control Program guideline was not available in 66.7 % of the OPDs, in 64.3 % of the laboratory units and 45.2 % of the TB clinic in the observed health facilities. Weight scales and masks were not available in 45.2% of the TB clinics.

We concluded that insufficient resources for TB case finding, as well as limited access to diagnostic services, were major obstacles to TB case finding. Addressing the identified challenges is critical to improving the current low TB case notification rate.

4.2. Main findings: Paper II

Ereso BM, Sagbakken M, Gradmann C, Yimer SA. **Treatment outcomes of patients with drug sensitive tuberculosis under community-based versus facility-based directly observed treatment, short course strategy in Southwest Ethiopia: a prospective cohort study**. BMJ Open 2021;11

The aim of this paper was to compare TB treatment outcomes and associated factors among patients attending community-based DOTS versus facility-based DOTS in Jimma Zone, southwest Ethiopia. We included a total of 1,161TB patients in the analyses. Of these, 387 patients were on CB-DOTS and 774 patients were on FB-DOTS.

We found that patients under CB-DOTS were more likely to be cured by 12% (RR =1.12, 95% CI = 0.96 -1.30) compared to those patients under FB-DOTS. Patients treated with CB-DOTS had a lesser risk of death (RR= 0.93, 95% CI=0.49 -1.77) and treatment failure (RR= 0.86, 95% CI= 0.22- 3.30) compared to those patients treated with facility-based DOTS. Likewise, patients who were under CB-DOTS were less likely to have a positive sputum smear result at the end of the treatment period (P=0.042) than patients under FB-DOTS. The absolute effect which was measured by a risk difference also showed that patients who were under CB-DOTS had about four additional cured cases per 100 patients compared to their counterparts (RD=4.26). In addition, about three less death cases per 1,000 patients were found for patients opting for CB-DOTS compared to patients opting for FB-DOTS. The treatment success rate for patients treated with CB-DOTS was 87.6%, and 86, 4% for those

treated with FB-DOTS. In terms of their choice of the two approaches, women and illiterate patients were more likely to choose CB-DOTS over FB-DOTS, whereas HIV co-infected TB patients were less likely to choose CB-DOTS. Compared to patients who chose FB-DOTS, patients who chose CB-DOTS were less likely to have a positive sputum smear result at the end of the treatment period.

We concluded that community-based DOTS is more effective in increasing sputum conversion, cure rate and reducing treatment failure rate compared to facility-based DOTS. Our findings highlight the importance of scaling up and further decentralization of community-based DOTS approach to increase rural community's access to TB treatment services.

4.3. Main findings: Paper III

Ereso BM, Sagbakken M, Gradmann C, Yimer SA (2023) **Total delay and associated factors among tuberculosis patients in Jimma Zone, Southwest Ethiopia**. PLoS ONE 18(2)

The aim of this paper was to determine the length and associated factors of total delay. We included a total of 1,161 all forms of TB patients for the analysis.

We found that there was a long total delay in TB diagnosis and treatment with the median total delay of 35 days (IQR 25, 67 days). About half (50.5 %) of the patients had a total delay of > 35 days, which was classified as delayed. Several associated factors with total delay were identified. Among these: women were more likely to have longer total delay (AOR =1.46, 95% CI: 1.00, 2.14) than men. Patients who attended college or university were 72% less likely to be delayed than those who could not read or write (AOR=0.28, 95% CI: 0.10, 0.81). Patients who had a monthly household income of 1001- 2500 Ethiopian *birr* were more likely to have long total delay than those patients who earned > 3500 Ethiopian *birr* (AOR= 15.75, 95% CI: 2.92, 84.91). Furthermore, TB patients who had neck region swelling or wound were more likely to be delayed than their counterparts (AOR =3.02, 95% CI: 1.62, 5.62). TB patients who had poor knowledge about TB were more likely to have longer total delay than TB patients who had good knowledge (AOR=3.92, 95% CI: 2.65, 5.80).

We concluded that there was a significant delay in diagnosing and treating TB patients in the study area due to a variety of factors. To reduce total delay in diagnosis and treatment of TB,

targeted interventions that improve TB knowledge and practice, early identification of suspect, referral, and management of TB are required.

4.4. Main findings: Paper IV

Ereso BM, Sagbakken M, Gradmann C, Yimer SA (2023) **Determinants of Unfavorable Treatment Outcome among Tuberculosis Patients in Jimma Zone, Southwest Ethiopia**. AJTMH-22-0648

The aim of this paper was to assess TB treatment outcomes and determinants of unfavorable treatment outcome. We included a total of 1,161 TB patients for treatment outcomes and 1,074 TB patients for determinants of unfavorable treatment outcome.

We found that 86.9% of the patients had a favorable treatment outcome and 5.7% of them had an unfavorable treatment outcome. Transferred out and unrecorded cases accounted for 5.7% of all patients. *Omo nada* district (90.2%) and *Sokoru* district (89.8%) scored higher in treatment success than *Limu kosa* district (81.9%). In addition, *Mana* district accounted for a higher proportion of death (6.2%) than *Jimma* town (1.3%). Various factors that were associated with unfavorable treatment outcome were identified. Among these, women were more likely to have unfavorable treatment outcome (AOR = 1.96, 95% CI: 1.06, 3.64) than men. Patients who had a monthly household income of > 3500 Ethiopian *birr* were less likely to have unfavorable outcome than patients who did not have regular income (AOR = 0.04, 95% CI: 0.01, 0.45). Moreover, patients who perceived not to be stigmatized were less likely to experience unfavorable treatment outcome than their counterparts (AOR= 0.32, 95% CI: 0.15, 0.73), and patients who used alcohol were about three times more likely than their counterparts to have an unfavorable treatment outcome (AOR = 3.16, 95% CI: 1.39, 7.15).

We concluded that the observed treatment success rate is lower than the WHO target of successfully treating more than 90% of TB cases, and several factors have been linked to an unfavorable treatment outcome. It is crucial to implement locally acceptable and cost-effective interventions that can assist in addressing social and financial barriers to TB treatment adherence and favorable TB treatment outcome.

5. Discussion

This section presents methodological considerations for qualitative, quantitative, and mixed methods studies. In addition, the main findings and implications of the study findings are briefly discussed.

5.1. Methodological considerations

The primary aim of health service research is to generate knowledge about disease epidemiology and health problems, as well as to propose evidence-based preventive and treatment strategies (281). Therefore, conducting robust and valid health services research is of paramount importance to decision makers in order to develop effective disease prevention and treatment strategies (281,282). By ensuring validity, we may establish confidence that the results are coherent representations of a given reality and increase the credibility of the study's findings. Securing validity and reliability are required measures for both quantitative and qualitative research methods (283). The consistency of a measure is referred to as reliability, while the accuracy of a measure is referred to as validity. All in all, rigorous methodologies are essential for ensuring the trustworthiness of research findings (284,285).

The four papers included in the thesis are based on data obtained through qualitative and quantitative methods. In this section, the overall strengths, and limitations of the four papers are discussed with an emphasis on the strategies used to overcome the limitations that may affect the trustworthiness and validity of the studies.

5.1.1. Methodological considerations: Qualitative study (Paper I)

In qualitative studies, rigor can be said to be synonymous with the concepts of reliability and validity. Rigor refers to how reliability and validity can be applied to a qualitative study during data collection and management. Rigor is a method of establishing trust or confidence in the results of a study. It refers to and depends on the consistency, appropriateness, and strength of the research design and methods, all of which are necessary components of high quality research (286,287). Trustworthiness is defined as the systematic rigor of the study design, the credibility of the researcher, the credibility of the study results, and the applicability of the study method (288,289). Trustworthiness, being an umbrella term, addresses concerns not only related to credibility, but also through the concepts of transferability, dependability, and confirmability (289,290) . The most important criterion in establishing trustworthiness is credibility, which requires that the researcher clearly manage

to relate the research findings to reality in a convincing and coherent way. Transferability is related to "generalizability" in the sense that the reader understands how the research findings can be applied to other contexts, times, and populations. Dependability is synonymous with reliability and is important for trustworthiness as it defines the research study's conclusions as being consistent, reproducible, and supported by the original data they gathered. Similarly, confirmability refers to the degree to which the research study's conclusions are founded on the participants' stories and statements rather than probable researcher biases is the subject of this criterion (289–291). Confirmability is often established through personal and epistemological reflexivity and an audit trail (in which a researcher details the process of data collection, data analysis, and data interpretation) (289,291).

In public health, the use of qualitative method is vital for exploring and understanding broader systems such as contexts, relationships, and patterns (268,292). It is also necessary to conduct a study in such a way that it addresses the larger system in which health interventions and policies are implemented from a complex system perspective. As a result, it may contribute to disease control and may improve health care practices (292,293). In this thesis, a qualitative study was conducted to obtain a broader perspective of the study participants' experiences and opinions about TB case finding (280).

Qualitative research methods have several advantages. While completely unbiased research is considered an ideal, all types of studies may be limited by bias and the researcher's inevitable subjectivity (294). Bias is defined as an inclination or preconception in relation to a person, group, or a general topic. Such preconceptions can lead to reality distortions in the sense of misinterpretations, too much emphasis on certain findings, or being unable to identity certain data, which in turn affects the validity and reliability of the research findings (295). Biases can be classified into two types: participant bias and researcher bias. Participant bias occurs when respondents or participants respond to questions based on what they think is the correct answer or what is socially acceptable rather than what they truly feel (286,295). Acquiescence bias or friendliness bias, social desirability bias, habituation bias, and sponsor bias are all types of participant bias. 1) acquiescence bias happens when a participant prefers to agree with the researcher; 2) social desirability bias arises when participants respond wrongly just to be liked or believe that they will be better accepted; 3) habituation bias happens when participants provide similar answers to similarly worded questions; and 4) sponsor bias arises when a participant has an opinion about the research's sponsor or is

influenced by the sponsor's reassurance (294,295). Researcher bias occurs when researchers unconsciously interpret data to fit their preconceived ideas or hypotheses, or include only data that they think is relevant (286,295). Confirmation bias, question-order bias, and leading questions and wording bias are all types of researcher bias. 1) Confirmation bias occurs when a researcher interprets data to support his or her own pre-understanding ideas or hypothesis. Researchers may also exclude data that contradicts their hypothesis, 2) question-order bias arises when some questions influence answers to the following questions and participants judge following questions based on their response to the previous question, leading to a biased or "wrong" or misleading answer; and 3) leading questions and wording bias arises when questions lead participants to more likely outcomes, resulting in biased responses (287,296). The most common participant bias is the social desirability bias (295,297). Our findings in paper I could be influenced by social desirability bias. Participants in the study may be answering questions in a positive or acceptable manner rather than expressing their true opinions or experiences (295). To mitigate this bias, they were assured that their names would not appear in the transcript. Furthermore, the interviews were focused on exploring their ideas and avoiding leading questions that could influence their answers. Sometimes indirect questions were used, such as asking participants how someone in a similar position would think or feel in a similar situation.

The participant bias and researcher bias for this study were mitigated by ensuring the rigor of the study. To achieve rigor in this study, careful planning during proposal development, meticulous and ongoing researcher reflexivity were conducted (298). We used several mechanisms to ensure the rigor of this study including use of relevant checklists, triangulation of methods, sites and participants, reflexivity, sampling until saturation, ensuring thick descriptions, prolonged engagement, and peer debriefing (287–290).

5.1.1.1. Use of relevant checklist

Consolidated criteria for reporting qualitative research (COREQ) checklist was used while reporting the study findings (268).

5.1.1.2. Triangulation

Triangulation is the use of multiple data sources and methods to obtain comprehensive knowledge of cases or events in order to ensure validity of qualitative studies (299). In this regards, in-depth interviews were conducted with program managers at different levels,

DOTS providers at different levels, and patients in different treatment phases. In addition, facility observation was carried out to verify or challenge the data obtained from the in-depth interviews. Thus, the use of multiple data sources and methods (triangulation) increases the rigor of the study (300).

5.1.1.3. Reflexivity

Reflexivity is the process of a researcher's continuous reflection on the research process; at the core of reflexivity is the concept of self-awareness-from unconscious to semiconscious to fully conscious. Being reflexive helps in detecting any personal beliefs that may have influenced the research inadvertently (268,301). When I was conducting in-depth interviews, I tried my best to build trust between myself (researcher) and the study participants (the researched). This enabled me to ensure the participants' safety while also exploring their genuine perspectives and experiences. Because I was familiar with the study participants' local languages and cultures, I believe I was able to create an "optimal" distance or insider-outsider role (270,275). My insider role allowed me to easily understand the context because I spoke the local languages fluently and was familiar with the community's culture. In addition, my multi-disciplinary background as a nurse, public health officer, and health monitoring and evaluation specialist, combined with about 17 years of work experience first at a health center, hospital, and health office, and later at a university, formed my foundational understanding of how TB care is delivered, and the TB control program is managed. Furthermore, my pre-conception is based on a relatively extensive understanding of how health workers and program managers think, talk, and practice their roles. I played the role of an outsider because I currently work at a university and did not have a working relationship with the study participants. As an outsider, I was able to approach the participants as an expert, as the researcher wanted to hear about the participants' experiences so that they could share their insights. I did not have the same social ties as those I studied because I was an academic staff member rather than a health care provider, a program manager, or TB patient.

5.1.1.4. Sampling and saturation

In the qualitative study (Paper I), all alternatives of the topics relevant to the study were included in the sample, as many perspectives as possible, to ensure information richness (saturation) (268). We included a total of 60 participants, including program managers at different levels, DOTS providers at different levels, and TB patients in different phases of

treatment by using a translated and pre-tested interview guide. I stopped interviewing study participants at each level when I reached information saturation. To ensure saturation, I transcribed each interview and wrote preliminary analytical notes.

5.1.1.5. Thick description

Thick description is a way of describing a study subject and associated findings with many contextual details. It provides a comprehensive description and interpretations of the cases or phenomena detected by a researcher (270,275). In this regard, data obtained from different sources and methods helped describing the context as we obtained various perspectives and experiences of individuals involved in the TB control program and patients who received treatment service. These data also helped in the development of a comprehensive analysis and interpretation of the barriers to TB case finding (288).

5.1.1.6. Prolonged engagement

Prolonged engagement is an approach in which a researcher engages her or him in the study site or context for long adequate time to build trust with the study participants and to experience the extent of variation as well as to solve distortions because of presence of the researcher (288,289). For paper I, the field work during data collection was relatively long (five months) to address the research questions. This helped to build trust with the participants and created familiarity with the participants as well as with context. I used several mechanisms to establish a trusting relationship with the study participants. To be accommodating, I introduced myself and immediately explained my role. To break the ice, I began with small talk unrelated to the study. The interviews were more like a conversation with the participants about their opinions and experiences rather than question and answer. I maintained an open body language at all times by being constantly aware of my body language as I sat, stood, smiled, listened, and wrote. I also avoided barriers between myself and the participants by choosing an interview location where I and the participants could see each other clearly. I dressed appropriately based on the participant's role. Finally, I summarized what the study participants said, showed interest in them, and thanked them.

5.1.1.7. Peer debriefing

Peer debriefing is a method of allowing qualified peers to review the methods, transcripts, and findings of the study to ensure trustworthiness in a qualitative study (288,302). In (Paper I), the transcript was reviewed by a colleague who is a specialist in health monitoring and

evaluation and experienced in qualitative research methods. He checked the transcripts against the audio-recorded data for consistency. In addition, my supervisors reviewed the entire design, data analysis, and interpretation process. Debriefing of codes, categories, and themes was conducted by the main supervisor during data analysis. The supervisors went through the planning (proposal), findings, discussion, and the entire manuscript several times.

5.1.2. Methodological considerations: Quantitative studies (Papers II, III, and IV)

5.1.2.1. Validity

Validity is the degree to which correct inferences can be made from the findings of a study. It is the ability of a research method to consistently yield the same result over repeated measurement periods (283,303). There are two types of validity: internal and external. Internal validity refers to the extent to which the results of a study reflect reality and are not due to methodological errors, thus it represents the accuracy of the findings within the study population. On the other hand, external validity is the ability of a study method to produce findings that can be held true for other cases (population) with similar settings or contexts (303).

The validity of study result depends up on the study design, the way the study is conducted, and the data analysis method used. Thus, the whole research process is the base for the validity of the study. Nevertheless, the quality of data may be affected by the tools used, the selected participants, and recall bias among the study participants (283). No epidemiologic study will be without error, but it is important to minimize potential errors as much as possible, and then to discuss the implications of errors that cannot be avoided (283,304). Systematic and random errors are common threats to validity and both are discussed below (304).

5.1.2.2. Internal validity

In (Paper II), a prospective cohort study design was used to compare TB treatment outcomes and associated factors between TB patients who attended CB-DOTS (exposed) and FB-DOTS (unexposed). A cohort study is a longitudinal study in which investigators observe and follow a selected population who share a common characteristic over a period of time. This design has similarity with an experimental study design because it compares exposed with unexposed group. The difference is that the investigator does not choose who is exposed and does not assign the participants to groups. Rather due to routine clinical practices or their

preferences, the patients may attend either CB-DOTS (exposed group) or FB-DOTS (unexposed group) (281). A cohort study design is applied when one wants to analyze the risk of an outcome in exposed versus the unexposed groups. Moreover, a prospective cohort study design is the strongest analytical observational study design because it has a comparison group and reduces recall bias (269). In (Paper II), the participants were selected from the same population at each treatment site (community and facility). Nevertheless, this is a basic criterion in enrolling participants to be part of a cohort study (305,306). This design has advantages because it has a demarcation timeline of possible confounders from the exposure as well as the exposure from the outcome. It also helped us in computing relative risk or risk ratio as well as risk difference for estimation of actual incidence and differences in both treatment groups (282). Compared to randomized control trials (RCTs), the cohort study design is more feasible and less expensive design (281).

In (Papers III and IV), we used a cross-sectional study design to address the research questions. Although an observational study design is weaker than an experimental study design, this design is important to address our research questions. The research questions and the quality of the methods used to address the questions determine the study design. Observational study designs (Papers II-IV) are appropriate to address our research questions (307). However, biases and confounding factors are the main limitations of the observational studies (308).

5.1.2.3. Systemic errors

Systematic error or systematic bias obscures the correct results and leads the researcher to draw incorrect conclusions. The main sources of systematic error are selection bias, information bias, and confounding factors (304).

Selection bias

Selection bias is a type of systematic error in which the selection of study participants brings a result which is different from the target population. It usually occurs in observational studies because the selection of participants is not following a random allocation (309). It can also happen if data collection analysis methods are not carefully designed. Our studies (Papers II-VI) might be prone to selection bias because the patients were not randomly assigned to the two treatment sites; rather they were selected from the treatment sites based on inclusion and exclusion criteria. In addition, the patients were excluded only during the

enrolment time based on available information at that time. Thus, any potential member exclusion during the follow-up such as treatment changes could be a source of this bias (Papers II and IV) (282,310). To minimize the selection bias, the study participants were recruited from randomly selected districts' treatment sites using simple random sampling technique from all the districts of Jimma Zone, Southwest Ethiopia. In addition, data were collected by trained data collectors and the process was consistently supervised. We used relevant statistical packages and analytical methods to analyze the data. The findings of the studies might only be representative of patients treated at governmental treatment sites of similar TB burden and comparable TB treatment approaches. As the study participants were only from governmental TB treatment sites, the findings of the studies might not be representative of patients attending private clinics. This is because patients who choose private clinics may have a different socioeconomic status than those who choose governmental health facilities. However, the number of TB patients who visit private health care providers is small because the number of private health facilities that provide standard TB care is limited. Therefore, the chance of selection bias in this case is minimal, although it is not easy to avoid completely.

Confounding factors

Confounding is a distortion of the identified result of an association. It occurs when the main exposure is mixed with an extraneous factor (confounders) and is associated with the outcome (309). Confounding may happen during the study period, as the outcome of the study may be affected by political insecurity, or socioeconomic and environmental changes (282,305,310). Due to the nature of observational studies, the findings of the three papers (Papers II-IV) might be affected by confounding. The confounders can be controlled by applying various methods including use of randomization, restriction, matching or analysis such as use of stratification and multivariable models. Multivariable adjustment was the primary strategy for accounting for measured confounders (282,309,310). The multivariable logistic regression analysis was applied to control for potential confounders in (Papers III and IV), and relative risk and risk difference were computed to interpret the findings in (Paper II).

Information bias

Information bias is an error that arises when the main study variables are incorrectly measured or misclassified. It is one of the most common sources of bias and tends to yield wrong findings or conclusions that differ from the truth in a systematic way. Information bias

includes various types such as recall bias and reporting bias, observer bias, misclassification bias, and performance bias (311).

The findings reported in papers II-IV may be influenced by the information bias. There were key variables such as time of onset of symptom, time of first visit to medical providers, time of first diagnosis, and start of treatment, that depends up on the recall ability of the study participants and might be measured incorrectly. To minimize these potential biases, we used the approach of relating the timing with major religious or national holidays during data collection. For variables such as time on set of diagnosis and start of treatment, we compared data from interviews with data from TB and laboratory registers to verify the information. To minimize observer and performance biases, data collectors were trained on data collection techniques, including practicing as a pretest before beginning actual data collection. A pre-tested structured questionnaire was used to ensure consistency in the data collection.

5.1.2.4. Random error (chance)

A random error is a difference that occurs by chance between the observed and true values of a variable. It can reduce data reliability or the extent to which results can be replicated. Random error can occur by chance and can be easily minimized by adequate sample size, repeated measurement, and controlling for confounding factors (304). The precision of a relative effect estimate (the relative risk and odds ratios) can be improved as sample size increases (312). In this thesis, a total of 1,161 TB patients were included to compare treatment outcomes between patients on CB-DOTS and those on FB-DOTS (Paper II). In the main analysis, the sample size allows us to detect a relative risk ranging from 0.62 to 1.12 with 80% power. The inclusion of 1,161 TB patients to determine the length and associated factors of total delay in (Paper III) allows us to detect AOR ranging from 0.28 to 15.75 with 80% power. Furthermore, the sample size of 1,161 used in (Paper IV) to identify factors associated with an unfavorable treatment outcome in TB patients allows us to detect AOR ranging from 0.32 to 3.16 with 80% power.

5.1.2.5. External validity

External validity refers to whether or not the findings can be inferred to larger or different populations (generalizability) (304). External validity includes population validity, ecological validity, and temporal validity. 1) population validity is the extent to which the study findings can be generalized to a target population; 2) ecological validity represents the extent to which

the study findings can be accurately generalized in different contexts; and 3) temporal validity refers to the extent to which the findings of a study can be generalized to another period of time (313–316). Papers II-IV rely on data from TB patients treated at government health facilities in Southwest Ethiopia. As a result, the findings may only be representative of TB patients living in similar settings in other parts of Ethiopia, but may also be representative of other resource-limited settings with a comparable TB burden and treatment approaches. There may be socioeconomic status differences between those treated in government and private health facilities, and our findings may not be representative of TB patients treated in private health facilities. However, in most cases, the number of TB patients treated in private health facilities was small.

5.1.3. Methodological considerations: Mixed methods

The use of both qualitative and quantitative data in a research project represents a substantial work. The collection of large amounts of data will almost certainly result in multiple outputs from a single project (263,317). This PhD project produced four papers due to the strength of the combination of the methods. It helps us to study complex health-care performance problems because the mixed method approach provides richness and depth in answering the research questions (264). As described in the preceding sections, to evaluate the quality of a mixed method study, the validity and reliability or rigor of each method should be considered. If the validity and reliability or rigor of any of the methods is compromised, the overall mixed-methods design is compromised (318).

Using qualitative and quantitative methods in a single PhD study requires proficiency in both methodologies. The large volume of data generated by mixed methods research can make analysis and dissemination difficult (317). Furthermore, using mixed methods necessitate significant financial and time resources. Given the limited budget and time, data collection for (Paper I, the qualitative study) took about five months, while data collection for (Paper II, the cohort study) took about one year and five months. The vast scope with budget and time constraints of my PhD project made it difficult to master all the methods. To overcome this challenge, qualitative data were analyzed first, and its report was written before the quantitative data collection was completed. After the quantitative data collection was completed, quantitative data analysis and report writing followed.

5.2. Discussion of main findings

The overall aim of the thesis was to pinpoint challenges of TB control program performance and produce evidence-based findings that would be useful to TB program managers and decision-makers to use for program improvement. In this section, the overall findings from each of the four papers are briefly discussed in relation to the overarching aim and to one another.

The performance of TB control programs in high burden countries is still hampered by limited and inadequate expansion of TB diagnostic and treatment services, MDR TB, and HIV co-infection. This thesis has focused on exploring barriers to TB case finding, analyzing delays in TB diagnosis and treatment, as well as assessing TB treatment outcomes and factors associated with unfavorable treatment outcome in Southwest Ethiopia.

5.2.1. Challenges to TB case finding

The diagnosis of TB in resource-limited settings is mainly based on the examination of patients who visit health facilities (passive case finding). Passive case finding is influenced by people's health-seeking behavior, awareness of TB, socioeconomic status, stigma, access to health services, service quality, resource and capacity constraints at health institutions and referral linkages within the health system, and the interaction of these factors (28,319). The other approach is active case finding (provider-initiated screening for TB), which requires systematic identification of individuals with suspects of active TB in a predefined target population using diagnostic tests, and other targeted interventions. The complementary approaches (which use both passive and active case finding) enhance TB case detection and treatment (319), as TB infection may be difficult to detect early because the infected person may be delayed in exhibiting symptoms (320).

In (Paper I), our findings suggest that there are a number of interrelated challenges to TB case finding. Inadequate resources, such as shortage of health-care providers, insufficient basic infrastructure, shortage of diagnostic equipment and supplies, and limited access to TB diagnostic services, such as lack of nearby TB diagnostic service and health system delays in diagnostic process, are significant hindrances (250). Our findings are in line with previous studies in Ethiopia that reported inadequate resources as a challenge to TB case finding (199,321,322). In addition, our findings are consistent with a qualitative study from northern Malawi that reported a shortage of resources (human and material, including lack of basic

equipment and laboratory supplies), as a barrier to TB case finding (323). Our findings are also consistent with the results of a qualitative study from Malaysia, which identified inadequate resources, such as human resources, as a challenge to the implementation of TB control program (324). Shortage of resources such as human resources was also reported as barrier for TB control program in Thai-Myanmar border (325). Moreover, active case finding is an important approach to increasing TB case detection. A scoping review of 73 studies from all WHO regions identified several factors that influence active case finding in TB control program implementation. The availability of resources, including financial resources, diagnostic tests, and existing systems and structures, were among the factors influencing active case finding implementation (326). According to the Stop TB Partnership action framework for TB case detection, low case detection and treatment delay are caused by a limited basic infrastructure and a shortage of health workers (327). Inadequate resources may significantly impede the provision of TB diagnostic services as expected, resulting in a decrease in TB case notification rate in the study area. Furthermore, shortage of these resources may affect the performance and quality of the TB control program. This is because the resources, activities, and outcomes of any healthcare service determine its quality. The resources serve as the foundation for carrying out activities and achieving desired results (328). This suggests that a shortage of necessary resources affects the performance of the TB control program by affecting not only the coverage but also the quality of TB diagnostic services.

Limited access to TB diagnostic services is one of the challenges identified in (Paper I). Our findings are consistent with a qualitative study from Ghana that identified a lack of TB diagnostic services in rural health facilities as a key health system barrier to TB case finding (329). In addition, our findings are in line with a qualitative study from northern Malawi, which reported that inadequate access to TB services was a barrier to TB case finding (323). Limited accessibility and capacity for TB diagnosis are also reported as a barrier to TB control program in a qualitative study from the Thai-Myanmar border (325). Furthermore, our findings are consistent with a qualitative study from Nepal, which reported that a main barrier to accessing TB services is high direct out-of-pocket costs (for food and transport) due to long travel distances (330). WHO recommends that TB diagnosis should be accelerated by improving access to care, including lowering the direct and indirect costs of health care, and responding to the specific needs of vulnerable groups by improving primary health care services, and expanding diagnostic services (28,319).

Our findings suggested that many people were not adequately accessing TB diagnostic services and were therefore delayed in receiving a TB diagnosis. Limited access to health services because of distance may have a significant impact on the health-care seeking behavior of the majority of the rural population, resulting in diagnostic delays and low TB case detection. Previous studies from many other countries and Ethiopia have also identified long distance from the health facility as a barrier to TB case finding (177,331–335). To reduce the incidence and prevalence of TB in the community, there should be access to and utilization of TB diagnostic and treatment services. When TB diagnosis services are only available in hospitals and health centers, TB suspects and patients must travel long distances to access confirmatory diagnostic services. This results in out-of-pocket expenses and lost productivity to access diagnostic services, or not receiving the service at all (199,336). This may be connected to the economic situation of the country in terms of delivering TB diagnostic services at the community level, as well as the plight of rural impoverished people who cannot afford the fees of travel and investigation costs.

According to the WHO TB Standard 1(one) guideline, if a person presents with signs or symptoms suggestive of TB, prompt clinical evaluation is required to ensure early and accurate diagnosis (213). TB case finding could be improved if functional diagnostic and treatment health facilities are easily accessible for the community. As a result, the TB control program requires identifying alternative approaches that lowers the expenses of the health service while also allowing the community to access the service. This suggests the need to scale up TB diagnosis and treatment services to health posts or communities.

5.2.2. TB diagnosis and treatment delays

Delays in TB diagnosis and treatment contribute to poor performance of TB control programs in high burden countries (182). In (Paper III), we found that about half (50.5%) of patients had a long total delay (> 35 days), with the median total delay being 35 days (IQR 25, 67 days) (337). Our findings are similar with a study from Addis Abeba, Ethiopia, which reported a median total delay of 35 days (338). The observed median total delay in our study is higher than the findings of other studies in Ethiopia, which reported 23 and 33 days (258,259), but lower than the median total delay reported in previous studies in different regions of Ethiopia (188–191,339,340). This disparity could be related to differences in study settings, study population, study methods, and the study period. Our findings also differ from a study from Mozambique, southeastern Africa, which reported a median total delay of 150

days (341), and a study from Burkina Faso, western Africa, where the median total delay was 45 days and less than half (41.25%) of patients experienced a long total delay (>45 days) (342). Differences in study settings, such as socioeconomic status, study population, access to TB diagnostic facilities, and utilization of health care services, study methods, and study period, may explain the differences. Although the total delay observed in our study was less than several previous studies in Ethiopia and the aforementioned African countries, it is still a significant delay given the need for TB patients to be diagnosed and treated as soon as possible. Several barriers were identified in (Paper I) that could increase the proportion of patients with long total delay in the study area. Inadequate resources, such as basic infrastructure, diagnostic equipment and supplies, and limited TB diagnostic services, as well as delays in the diagnostic process at health facilities, were among the identified barriers (250).

Identifying only the major challenges of the TB control program is not sufficient to improve the performance of the TB control program, but assessing the associated factors (determinants) is necessary to address the modifiable factors that may help improve the program (343,344). In (Paper III), the factors associated with increased total delay were low educational status, poor knowledge about TB, swelling or wound in the neck region, being a woman, low household income, and long-distance to travel (337). Our findings are similar to the findings from previous studies in Ethiopia and elsewhere (150,180,184). Low educational status and long distance travel were also identified as independent predictors of delays in TB diagnosis and treatment in a study from Ethiopia (184). A systematic review and meta-analysis from high burden countries revealed that, being a woman, poor knowledge about TB, and low household income were identified as factors associated with delay in TB diagnosis and treatment (150). Low education levels and poor knowledge about TB were reported as barriers to TB diagnosis and treatment in a study from Nigeria, western Africa (180).

Educational level and knowledge about TB are associated with total delay because individuals with higher levels of education tend to have better knowledge about TB (345) and are more likely to have a better economic status, which could improve their access to health information and health services (258,345). We found that having swelling or wound in the neck region was associated with a long total delay. Swelling or wound in the neck is a common symptom of cervical TB lymphadenitis. As a result, the diagnosis of this type of TB necessitates the use of several diagnostic methods. In practice, it is impossible to perform all

diagnostic procedures to all symptomatic patients to rule out cervical TB lymphadenitis. This is because most peripheral health facilities such as health centers in Ethiopia, including the study area, lack culture and pathology services, making it difficult to early diagnose extrapulmonary TB such as TB lymphadenitis, resulting in a long total delay (171,346). In our study, being a woman is also associated with a long total delay, which may be related to the fact that most women in developing countries such as Ethiopia often economically dependent on men, have less decision-making power, and are less able to care for themselves compared to men (189). In addition, women in Ethiopia may prioritize their family over themselves, because women are primarily responsible for domestic activities and caring for family members, particularly children and the elderly (68). We found that low household income was associated with a long total delay, which may be related to the fact that individuals with low monthly income were unable to seek health care early due to a variety of factors, such as the cost of health care and transportation, resulting in delays in TB diagnosis and treatment (256,258). Most patients in resource-constraint settings such as Ethiopia often seek care from informal health care providers due to various traditional practices and low access to formal health services. As a result, patients may be treated traditionally, which may delay them from seeking timely care from formal medical providers, making symptoms to more advanced before treatment is initiated. Low-income patients are more likely to seek formal health services only when they are seriously ill (256,258).

5.2.3. Inadequate decentralization of TB diagnostic and treatment services

An earlier study from Ethiopia showed that decentralizing TB diagnosis and treatment services close to the community increases access to services, the number of cases detected and treated, and improve treatment outcomes (198). At the start of this PhD project, community-based TB care in the study area was not fully decentralized. Only 23% of the health posts in the Jimma Zone offered TB treatment using DOTS (250). Previous studies in various countries have demonstrated the effectiveness of community based TB treatment (CB-DOTS) (195–197,200,206–208). In (Paper II), we compared the outcomes of TB treatment and associated factors in a cohort of patients treated in health facilities (hospitals and health centers) versus those treated at health posts (community level) (347). To achieve high TB case notification and cure rates, adequate implementation of facility-based and community-based DOTS seems essential (29,213).

The findings presented in (Paper II) indicate that patients treated with CB-DOTS are more likely to be cured than those treated with FB-DOTS. In addition, patients receiving CB-DOTS had a lower risk of death and treatment failure than those receiving FB-DOTS (347). Our results differ from a previous study in Ethiopia, which reported that the cure rate for CB-DOTS and FB-DOTS was almost identical (208), and from two other studies conducted in Tanzania, which reported that the cure rate did not differ significantly between the two treatment approaches (197,201). On other hand, our findings are consistent with several previous research findings from Africa and Asia, where CB-DOTS was more effective than FB-DOTS (194–198). A systematic review and meta-analysis of cohort studies and RCTs found that CB- DOTS provide a better TB treatment outcome than clinic-based DOTS for pulmonary TB patients. This is because CB-DOTS is cost-effective approach in low-income countries, and is widely accepted by community members (211). According to a scoping review of 41 studies (34 RCTs and 7 before and after), community-based TB treatment provision by community health workers improved access and service utilization, as well as capacity building for routine TB recording and reporting (348). This may be related to the fact that CB-DOTS may be more convenient and time flexible, and that patient has the opportunity to discuss the schedule of treatment with DOTS providers (HEWs or TB treatment supporters). This type of adaptability may improve the patients possibility to adhere to treatment (208,349). FB-DOTS, on the other hand, requires patients to travel long distances, implying using a long time on a daily basis, and often experience additional waiting time to receive treatment (202). As a result, the long distance between a patient's home and a health facility and the time required to receive treatment may reduce patient adherence to treatment (199,349). These findings clearly indicates the importance and effectiveness of TB treatment expansion at the community level, as CB-DOTS has the potential to improve access to treatment services for poor rural communities as well as vulnerable populations such as women and children (194,198,348). In accordance with this, adequate supportive supervision of CB-DOTS is required to maintain its effectiveness. Strict follow-up of the CB-DOTS approach seems necessary to prevent the development of MDR-TB, as it is provided by low-level health workers or community health workers and where resources, including laboratory equipment and supplies, are limited (29).

Treating patients with DOTS is one of several actions designed at increasing treatment adherence. As a result, the combat against TB, a global scourge, necessitates a collaborative effort from the health system, health care providers, and the community. According to a

global review, community health workers have made significant contributions to the global effort to end TB through their involvement in TB care, such as TB suspect identification, referral, treatment support and follow-up, as well as TB prevention (350). CB-DOTS may be economically appealing to patients, households, and the health system. It could be a method for solving the challenges of TB control program performance in resource-constrained settings with low health-care coverage and shortage of health-care workers like the study area in Ethiopia. According to the results of our study, CB-DOTS is the most effective way to increase TSR and appears to be a patient-centered service that is accessible and convenient.

5.2.4. An unfavorable TB treatment outcome

The WHO recommends that patients and health system-related challenges affecting successful treatment outcomes should be addressed in order to achieve optimal treatment success rate (29,351). In (Paper IV), we assessed treatment outcomes and factors affecting an unfavorable treatment outcome. We found that 86.9% of patients had a favorable treatment outcome, while 5.7% had an unfavorable treatment outcome. Transferred out and unrecorded cases accounted for 5.7% of all patients. Our findings fail to meet the WHO and national targets of successfully treating more than 90% of the detected TB cases (90,245). However, our result showed better results compared to a systematic review and meta-analysis from Ethiopia, which indicated a pooled TB treatment success rate of 86% (216); while another systematic review and meta-analysis from Ethiopia reported a pooled estimate of a favorable TB treatment outcome of 83.7% (217). In addition, a systematic review and meta-analysis report from sub-Saharan Africa showed a pooled TB TSR of 76.2% (215). Another systematic review and meta-analysis from Africa also reported an overall pooled TB TSR of about 79% (214). These disparities could be related to the fact that our study was conducted in a single location in southwest Ethiopia. In contrast, the above systematic reviews and meta-analyses were conducted in larger regions of Africa and Ethiopia, and the results are averages of all studies included in the analysis.

We identified several factors that influence treatment outcomes. Being women, having low level household income, alcohol use, and stigma were all associated with an unfavorable treatment outcome. Previous primary studies, as well as systematic reviews and meta-analyses from around the world, support our findings. Being a woman (352–354), perceived TB stigma (355), low socio-economic status (356–359), and alcohol use (83–85,226) are all factors that previously have been associated with an unfavorable treatment outcome. We

found that being a woman was associated with an unfavorable treatment outcome. This may be related to the fact that women may have less access to household income compared to men, which may influence treatment outcome. In developing settings like Ethiopia, women's economic dependence on men may lead to social inequality of women in health care service utilization. As a result, women may have less decision-making power to use money for transportation and other expenses compared to men (150,175,176,360). DOTS is a time-consuming treatment approach, and most women in developing countries such as Ethiopia are occupied with routine domestic activities and may not get adequate time to follow the treatment properly, having an impact on the treatment outcome. Our results showed that low household income was also associated with an unfavorable treatment outcome. This may be because patients' adherence to daily DOTS treatment may be related to the cost of transportation and time use. Patients with low level of income, such as daily wage earners, may not be able to get to the treatment site in the morning while looking for work and may not adhere to treatment, resulting in an unfavorable treatment outcome (203,361). Furthermore, related psychosocial stress due to long treatment regimens may lead to poor treatment outcomes in patients with low household income. According to previous studies, excessive stress may lead to poor treatment outcomes because financial insecurity may negatively affect immune function (362,363). In addition, patients with low household income may not receive adequate nutrition, resulting in poor immune function and poor disease prognosis (364). We found that perceived stigma was also associated with unfavorable treatment outcome. This may be related to the fact that TB stigma among others association with poverty may lead to poor adherence to treatment, which again lead to unfavorable treatment outcome (355,365). A study from Ethiopia found that due to the similarity in symptoms between TB and HIV/AIDS (like cough, losing weight) and an awareness of the two diseases being linked somehow (high co-infection rates) made many think that TB was the first symptom of HIV/AIDS; HIV/AIDS being a more advanced form of TB. Such misunderstandings can make patients afraid to disclose their TB status (366). In general, TB patients on treatment may not adhere to treatment or may discontinue their treatment in fear of being discriminated against by others. Patients' disclosure of TB has been found to be influenced by fear of job loss and isolation, again affecting their adherence to treatment, and the treatment outcomes (365,367). Our finding also showed that alcohol use was associated with unfavorable treatment outcome. This may be because patients who frequently consume alcohol are more likely to discontinue their TB treatment or to forget to take their medication when they are intoxicated. In addition, unwanted interactions between

anti-TB drugs and alcohol may lead patients to discontinue anti-TB drugs (85). Previous studies from Ethiopia and Kenya showed that alcohol use may lead to non-adherence and interruption of TB treatment and then for poor treatment outcome (84,85). All in all, these findings underscore the importance of addressing the determinants of unfavorable treatment outcomes in order to improve treatment adherence and outcomes among TB patients, as well as the performance of TB control programs (348).

TB treatment emphasize both curing the TB patient and minimizing TB transmission to other individuals; thus, a favorable TB treatment outcome benefits both the TB patient and the community in which the patient lives. The success of TB treatment depends on a variety of factors, only some of which are currently predictable or modifiable (368). Monitoring TB treatment and determining TB treatment outcomes have been a significant challenge for TB control program efforts. Current TB treatment monitoring practices in the study area mainly depend up on AFB result and culture conversion. AFB smear microscopy has low sensitivity and microbial culture processing takes long time to assess culture conversion time. This contributes to delay in obtaining treatment monitoring results to TB patients (369). Molecular diagnostic tests like GenXpert and line probe assays (LPAs) are more effective than AFB smear microscopy and microbial culture in terms of assessing drug sensitivity testing (DST). This necessitates significant investment in resource-constrained countries such as Ethiopia (19,193). Another challenge in determining TB treatment outcomes is the presence of "not evaluated" cases, which in most cases, including our study, are not included in the denominator for measuring treatment outcomes. However, the WHO recommends using diagnosed TB patients as the denominator for calculating treatment outcomes for transferred-out patients (370). This suggests the need to obtain the treatment outcome of transferred-out cases and strengthen the TB treatment monitoring system. Finally, many adherence interventions can improve the performance of TB control programs by improving patient's possibility to adherence and thus also the treatment outcomes (148,164,230–232).

5.3. Implication of the findings

In this section, the implications of key findings from the four papers are briefly discussed.

Our findings related to barriers of TB case finding (inadequate resources and limited access to diagnostic services) may indicate an increase in the pool of undiagnosed TB cases in the study area, which may contribute to diagnostic and treatment delays resulting in severity of illness and increased transmission and burden of TB disease (199,327,336). Furthermore,

presence of undiagnosed TB cases and low TB case notification have an impact on the quality and performance of the TB control program (148,149). Our findings on factors associated with major challenges to TB case finding (such as inappropriate resource utilization, absence of suitable roads, insufficient collaboration with stakeholders, and low community mobilization) may help in guiding the planning of practical solutions to address the challenges identified (343,344). The WHO strongly recommends the need for conducting systematic TB screening in populations with a high TB prevalence (0.5% or higher), among high risk groups such as the urban poor, homeless individuals, migrants, refugees, people with HIV, populations with limited access to health services, and in household with close contacts of TB patients (28). Thus, our findings suggest that the need to avail the necessary resources for TB case detection and enhance decentralization of TB diagnostic services to the community (335,371–373).

The long median total delay in TB diagnosis and treatment observed in our study may have contributed to the low case notification rate reported in the study area. Besides this, the long median total delay may have resulted in increased severity of illness among patient and transmission of TB in the community. Such consequences have also been reported in several other studies in resource-limited settings (150,169–171). Diagnostic and treatment delay has a significant impact on the performance of the TB control program (182,258,259). Our findings on determinants of long total delay such as poor knowledge about TB, being a woman, having low educational status, having low level household income, and having swelling (wound) in the neck region may help in the development of targeted interventions for these groups (343,344). This will enhance the detection and treatment of more active TB cases which will contribute in achieving the End TB targets at local level (study area) (18,144).

Our study showed that CB-DOTS is more effective than FB-DOTS in terms of increasing cure rate, sputum conversion rate, and reducing treatment failure rate. This suggests the need for scaling up CB-DOTS in the study area in order to increase TSR and meet the End-TB target of achieving >90% TSR. In addition, our result reaffirms the effectiveness of CB-DOTS approach over FB-DOTS as reported in earlier studies in many countries (194–198,200,206–211). Our findings that women and illiterate patients preferred CB-DOTS over FB-DOTS suggest that CB-DOTS improves access to TB treatment service for those with limited access who are residing in rural areas and/or being poor (208,349,371,374).

Moreover, CB-DOTS is a more patient-centered treatment approach that improves treatment adherence and treatment outcomes (235).

The TSR (86.9%) observed in our study falls short of the WHO target of successfully treating more than 90% of the detected TB cases. This suggests that there were patients who were not adherent to the prescribed anti-TB drug regimens (168,218,219). The TB TSR is suboptimal in the study area, which is similar to what has been observed in other resource-limited and high TB-burden settings (214–217). This may contribute to the development and transmission of drug-resistant TB unless the local authorities managing the TB control program undertake regular monitoring and evaluation of the TB control program performance and take corrective action to improve the TSR (122,123,375). Our findings on the determinants of unfavourable treatment outcome (being a woman, having low household income, being perceived as stigmatized, and using alcohol) suggest the importance of designing targeted strategies to improve treatment outcomes among these patient groups (28,29,213,235).

6. Conclusion and Recommendations

6.1. Conclusion

This PhD project assessed challenges of TB control program performance in Jimma Zone, Ethiopia. As shown in (Papers I-IV), there were various challenges affecting the performance of the TB control program in the study area. Inadequate resources and limited access to TB diagnostic services were major challenges to TB case finding. Each of these challenges originates from several health system and socio-economic related issues (Paper I). Another challenge identified in the study area is the long total delay in diagnosis and treatment. Poor knowledge about TB, swelling or wounds around the neck (symptom of cervical TB lymphadenitis), being woman, and having low level of education were identified as determinants of total delay (Paper III). Our study in Paper IV revealed that the TSR observed in this study was lower than the WHO target of achieving a TSR of >90% of the detected TB cases. Being woman, using alcohol, having low household income level, and feeling stigmatized were all associated with unfavorable treatment outcome. From the study in (Paper II), we found that the CB-DOTS outperformed the FB-DOTS approach in terms of improving cure rate, lowering treatment failure rate, and improving sputum conversion rate. Women and illiterate patients were more likely to choose CB-DOTS over FB-DOTS, whereas HIV co-infected TB patients were less likely to choose CB-DOTS. The convenience

and increased accessibility of CB-DOTS makes it an effective and alternative approach to TB treatment in our setting and other resource-limited settings in order to increase TB TSR.

6.2. Recommendations

6.2.1. Policy recommendations

1. To improve case finding and case notification rate, it is important to train all health extension workers on how to collect sputum samples from TB suspects, prepare smears at the community level, and send samples to health facilities for confirmatory testing. In Ethiopia, HEWs are the first formal health care providers who have access to the majority of the population at peripheral level. HEWs play a key role in improving access to TB care by enhancing TB suspect identification and early case detection and referral.

2. Establishing diagnostic algorithms and strong referral linkages between health posts, health centers and hospitals is imperative for early detection of TB lymphadenitis and disseminated TB cases.

6.2.2. Operational recommendations

1. Health professionals (nurses, health officers, medical doctors) working at the various departments at health centers and hospital, and HEW should accelerate systematic TB screening, which includes screening for TB using cough of any duration, identifying people with symptoms suggestive of TB, and initiating treatment for those who have TB, or referring suspected cases for diagnostic evaluation as soon as possible. This will help to reduce missed opportunities for detecting TB cases.

2. To increase service utilization and adherence to TB treatment among patients and the general population, all health professionals including HEW should work on raising community awareness about TB through well-crafted information education and communication (IEC) and behavioural change communication (BCC) strategies. Special attention should be given to women, patients with low household income level, alcohol users and patients that perceive to be stigmatized. The strategy may follow providing IEC/BCC services at health facilities, using the various community gathering events, through the media, and TB clubs and other innovative approaches.

3. HEWs should maintain the current performance of the CB-DOTS approach while working to improve its quality so that program managers can expand it to the remaining health posts.

4. TB diagnostic services should be made more accessible (through mobile clinics or campaigns) to the population by allocating the necessary resources and expanding TB diagnostic services to those in close proximity to the community. This reduces indirect costs such as lost opportunities to work, to leave the house as a woman, and direct costs such as transportation costs.
5. Regular supportive supervision and program monitoring and evaluation is needed to timely identify challenges and provide solutions for improving case detection and treatment outcomes for TB patients.
6. One of the components of DOTS strategy is the uninterrupted supply of anti-TB drugs and laboratory reagents. TB diagnostic equipment and supplies should be adequate and timely procured and distributed to health facilities in the study area from Zonal or District health offices level.
7. Strengthening intersectoral collaboration with relevant government sector offices and NGOs may help to address infrastructure-related challenges (water, electricity, roads) that affect TB case detection and treatment. In particular, communicating the challenges to the District, Zonal and Regional administrative councils that are responsible for allocating budgets for infrastructure development in the study area is of paramount importance.

6.3. Future research

1. Our study included patients who were already attending the health facility and receiving TB treatment. A community-based, mixed-methods study that includes individuals not yet seeking TB care is needed to identify additional barriers of TB case finding in the community and to improve community TB care.
2. In this study, we assessed TB treatment outcomes based on drug regimens that were recommended for use in Ethiopia prior to 2018. Currently, a new 4-month regimen of isoniazid, rifapentine, moxifloxacin, and pyrazinamide (2HPMZ/2HPM) has been recommended for 12 years or older patients with drug-susceptible pulmonary TB. As a result, further research is needed to assess the effectiveness of these regimens in resource-limited settings.
3. A cost-effectiveness study of community-based sputum collection, smear preparation, and sample shipment to health facilities is required to plan the need for expansion of TB diagnostic services to the community in the study area.

4. Our studies were conducted before the COVID-19 pandemic emerged. Therefore, it is important to assess the effect of COVID-19 on the performance of the TB control program in the study area.
5. Finally, implementation research to assess the capacity of health systems to improve TB control performance to meet the End TB targets needs to be conducted in similar settings in other parts of Ethiopia.

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Appendixes

Errata list

Name of candidate: Berhane Megeressa Ereso

Title of thesis: Challenges of Tuberculosis Control Program Performance in Jimma Zone, Southwest Ethiopia

Abbreviations for different types of corrections:

Cor – correction of language

Cpltf – change of page layout or text format

Pun – correction of punctuation

Page	Line	Original text	Type of correction	Corrected text
5	18	…. on dialysis (18,30)	Pun	…. on dialysis (18,30).
5	19	… disease prevention…	Cor	… TB prevention…
5	25	…environmental control dilution, …	Pun	…environmental control, dilution, …
6	11,13,15,17, 20	…18.5 kg/m2…	Cpltf	…18.5 kg/m^2 …
14	1	… systems (16,18) Thus, poverty reduction…	Pun	… systems (16,18). Thus, poverty reduction…
36	16	… had a history relapse…	Cor	… had a history of relapse…
38	6	… (Paper I) (Paper I).	Cpltf	… (Paper I).
50	9	… 45.2% the TB facilities.	Cor	… 45.2% of the TB clinics.

Appendix 1: Papers I-IV

I

PLOS ONE

RESEARCH ARTICLE

Barriers for tuberculosis case finding in Southwest Ethiopia: A qualitative study

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Abstract

Background

Ethiopia is one of the countries with a high burden of tuberculosis (TB). Jimma Zone has the lowest TB case notification rate compared to the national and World Health Organization's (WHO) targets. The aim of the present study was to identify barriers, and explore the origin of these barriers in relation to TB case finding.

Methods

A qualitative study was conducted by using different data collection methods and sources. Sixty in-depth interviews with TB treatment providers, program managers and TB patients were included. In addition, 42 governmental health facilities were observed for availability of resources. Data obtained from the in-depth interviews were transcribed, coded, categorized and thematized. Atlas.ti version 7.1 software was used for the data coding and categorizing.

Results

Inadequate resources for TB case finding, such as a shortage of health-care providers, inadequate basic infrastructure, and inadequate diagnostic equipment and supplies, as well as limited access to TB diagnostic services such as an absence of nearby health facilities providing TB diagnostic services and health system delays in the diagnostic process, were identified as barriers for TB case finding. We identified the absence of trained laboratory professionals in 11, the absence of clean water supply in 13 and the electricity in seven health facilities. Furthermore, we found that difficult topography, the absence of proper roads, an inadequate collaboration with other sectors (such as education), a turnover of laboratory professionals, and a low community mobilization, as the origin of some of these barriers.

Strategic and Collaborative Capacity Development in Ethiopia and Africa (SACCADE) Project, Norwegian Program for Capacity Development in Higher Education and Research for Development (NORHAD), University of Oslo.

Competing interests: There are no financial or non-financial competing interests among the authors. The authors have declared that no competing interests exist.

Conclusion

Inadequate resources for TB case finding, and a limited access to diagnostic services, were major challenges affecting TB case finding. The optimal application of the directly observed treatment short course (Stop TB) strategy is crucial to increase the current low TB case notification rate. Practical strategies need to be designed to attract and retain health professionals in the health system.

1. Introduction

Tuberculosis (TB) is a major public health problem in the world [1]. Globally, it is one of the leading causes of death from an infectious disease [2], with an estimated 10.4 million TB cases and 1.6 million deaths from TB in 2016 [1]. Most of the deaths are preventable, as long as people can receive an early diagnosis and proper treatment. Additionally, over 95% of all deaths from TB occur in low- and middle-income countries [3].

Ethiopia is one of the 30 highest TB burden countries (HBCs) in the world. These HBCs account for approximately 87% of the total Global TB burden [2]. Moreover, TB ranks sixth out of the top 10 causes of mortality in Ethiopia [4]. In 2015, the national case notification rate for all forms of TB was 67.3%, with a cure rate of 77.9%. In the Oromia Region in Ethiopia, where this study was conducted, the TB case notification rate was 65.4%. Unfortunately, this achievement is lower than the WHO targets for TB control of a 70% case notification rate and 85% cure rate [4].

The early diagnosis of TB is crucial for controlling TB since this will reduce the length of delay in the diagnosis of TB and prevent transmission. To be able to facilitate the early diagnosis of TB, accessibility to TB diagnostic and treatment facilities is crucial [5,6]. The Stop TB strategy was launched by the WHO and adopted by Ethiopia in 2006 [2,7]. It focuses on pursuing a high quality directly observed treatment short course (DOTS) expansion and enhancement, improving case finding and cures through an effective patient-centered approach aiming at reaching all patients [3]. The continuation of the Stop TB strategy is the End TB Strategy, which covers the period from 2016 to 2035. It has a target of a 90% reduction in TB mortality and an 80% reduction in TB incidence by 2030 from the 2015 baseline [2]. The early diagnosis of TB, and the screening of contacts and high-risk groups in a systematic way, are components of the End TB strategy [1].

The aim of early diagnosis and treatment is to cure more patients, interrupt transmission to healthy individuals, and prevent drug-resistant TB from arising. However, these aims are not yet achieved as expected in many sub-Saharan African countries [2]. Factors that negatively affect early TB diagnosis are limited access to a health facility, and a lack of diagnostic supplies [8–10]. Expenses related to hospitalization, transport, diagnostic investigations and care are other challenges for patients in sub-Saharan Africa [11]. Furthermore, self-treatment, limited community awareness of the risks associated with delayed care seeking and low educational status are all factors significantly associated with delayed TB care seeking. Among those who have not had previous TB treatment, and who have not had a cough for a long duration, there is a delay in TB care seeking [12–16].

According to the Roadmap (strategic document) for TB operational research conducted in Ethiopia, the major problems of the TB control programs in Ethiopia are primarily related to a lack of efficient and effective ways of delivering services and equitably reaching the population at risk [17]. The National TB control program in Ethiopia recently started to scale up

community TB care, using health extension workers to ensure access to DOTS at the kebele level (the lowest administrative unit in the community). In Ethiopia, community-based TB care is provided by health extension workers. These workers provide TB treatment for patients at health posts or at the patient's home, and refer people who screen positive for TB to health facilities [18].

According to a study in Ethiopia, community-based DOTS could enhance existing health services by improving the access to- and success rate of TB programs [19]. Among others, studies have shown that community-based TB care may improve the speed of case findings of smear-positive TB patients. Moreover, it may increase the TB case notification rate (the number of all TB cases notified to the national health authorities per 100,000 population during a specified period of time) and treatment success rate (percentage of all TB cases that successfully completed treatment), while decreasing the loss to follow-up of those on treatment [20,21]. Community-based TB care may also be more acceptable by patients and providers because of its accessibility to a majority of people. It can also make the diagnoses and treatment of TB services more accessible for those who cannot afford costs related to transportation and investigations, and for the elderly [20–22]. Furthermore, it is cost effective due to reduced travel distance, reduced transportation costs and time lost to obtain the services [19].

In Ethiopia, presumptive TB cases are managed using two approaches: (1) For clients with a low risk to drug resistance (DR) TB, HIV-negative and adults >15 years old—a two-spot AFB microscopy should first be done. If one AFB is smear-positive, the patient should be treated with first-line TB drugs (FLD), whereas if the sputum is negative, antibiotic treatment should be followed by GenXpert mycobacterium tuberculosis or rifampicin (MTB/RIF) Assay. (2) For clients with a high risk to DR, HIV positives, children and presumptive TB involving the meninges, a GenXpert MTB/RIF Assay should be done. If MTB is detected but rifampicin resistance (RR) is not detected, the patient could be treated with FLD; if MTB and RR are detected, the patient should be treated as DR-TB and referred to a MDR-TB treatment center. But if MTB is not detected, a clinical re-evaluation such as a culture, drug susceptibility testing (DST) and chest X-ray should be done, and a GenXpert test should be repeated [7].

TB case finding can be passive or active. In Ethiopia, including the study area, TB case finding mostly rely on a passive case finding (PCF), which means the identification of persons who may have active TB at the health facility level and enhanced TB case finding at the community level. At the health facility level, health-care providers assess clients for signs and symptoms of TB, and start appropriate medical evaluations and diagnostic tests based on standard algorithms for TB. In addition, intensified case finding is used for high-risk patients such as HIV-infected individuals. In relation to enhanced TB case findings at the community level, health extension workers screen clients who come to the health posts with symptoms and conduct regular home visits for people with symptoms of TB. They also detect close a (household) contact of infectious TB patients, subsequently referring all TB people who screen positive for TB to nearby health centers for medical evaluation and further investigation [7]. By only relying on passive case finding, it is not possible to identify more than two-thirds of the estimated TB cases annually [7]. An active case finding (ACF) is a systematic and intensified screening of a latent TB infection in the community that attempts to identify individuals with TB earlier than they have previously been identified using a passive case finding [23]. An active case finding is more effective than a passive case finding, particularly in risk groups such as TB patients' household contacts, the homeless, prisoners and HIV-infected individuals [24]. PCF systems should be complemented with ACF strategies, especially for these just mentioned risk groups [24].

The TB prevalence identified with a combined active and passive case finding is much higher than with only a passive case finding [25]. Evidence shows that patients who came by

an ACF had less of a patient delay (the time delay from the onset of TB symptoms until the first visit to a health-care facility) and less total delay (the time delay from the appearance of the symptoms until the first diagnosis for TB) than those who had come by PCF. The total delay is the sum of the patient delay and health system delay [24].

The Jimma Zone (the study area) had a TB case notification rate of 47.1% in 2016 [26], which is much lower than the national level (67.3%), as well as the Oromia Region, where Jimma is located (65.4%) [4]. To the best of our knowledge, the causes for this low case notification rate are not yet explored, and there is no published study about barriers for a TB case finding in the study area. Moreover, community-based TB care in the study area is not yet scaled up to full coverage. To identify barriers is not adequate for solving the problem, while exploring the root causes seems crucial to tackling it [27,28]. The present study aimed to identify barriers and explore the origin of these barriers in relation to TB case finding in Southwest Ethiopia. This study is part of a larger project with the general aim of assessing the performance and quality of the current TB case finding and treatment services.

2. Materials and methods

2.1. Study setting and period

The study was conducted from August 2016 to January 2017 in the Jimma Zone including Jimma town, Southwest Ethiopia. Jimma is one of the zones in the Oromia Region in Ethiopia, and is located about 354 kilometers from Addis Ababa, the capital city of Ethiopia. In 2016, the Jimma Zone had a total of 17 woredas (districts) and two town administrations and comprises a total area of 18,412.54 square kilometers [29]. According to a 2007 census, it had a total population of 2,607,115, of which 90% were rural residents [30], with the projected population for 2016 being 3,174,418. In 2016, it had seven hospitals (five primary, one general and one specialized teaching and referral), 120 health centers and 494 health posts. The hospitals and health centers (health facilities) provide both diagnostic services and directly observed treatment for TB patients (DOT), whereas the health posts provide DOT for TB patients, in addition to TB screening and referrals to the health facilities. In the study area, TB diagnostic services coverage was 80%, and health posts' DOT coverage 23% [26]. Furthermore, non-governmental health institutions such as the Catholic mission and private clinics in Jimma Town also provide TB care. The Jimma Zone had approximately a 52% health service coverage (measured by the ratio of health facilities to the population) [29]. Communicable diseases are one of the major health problems in the study area [29]. The sources of funds and other resources for the implementation of the TB control program are the Ethiopian government, and global health agencies such as The Global Fund and The Center for Disease Control (CDC). Community-based TB care has started in many health posts, and there is a plan to scale up this type of decentralized TB care to all health posts or kebeles.

2.2. Sample size and sampling techniques

2.2.1. In-depth interview. Fifty DOT providers and program managers with experience of the diagnosis and treatment of TB, or the coordination of a TB control program for more than six months, were included with a purposive selection by using an intensity sampling technique [31]. We preferred this sampling technique to access information-rich individuals, and through that explore the entire picture of barriers to TB case finding. The included participants were 25 DOT providers, 23 local and two regional program managers. They were chosen because they represented TB control program implementers, and held relevant information about the TB control program in relation to their duties and responsibilities. In cases where two or more DOT providers were at one site, the more experienced provider was selected. In

addition, 10 TB patients under treatment were selected from five treatment sites for in-depth interview by using a "maximum variation" sampling strategy, which helped to obtain access to patients with different background characteristics, such as sex, age, level of education and phase of treatment [31]. The total sample size for the in-depth interview was 60 participants.

2.2.2. Facility observation. Eight woredas (districts) and one town administration were selected by a simple random sampling using the lottery method from 17 districts and two town administrations [32]. Subsequently, a total of 42 governmental health facilities, which comprised three hospitals, 11 urban health centers (located in districts or zonal towns) and 28 rural health centers, were selected from the sampled districts. Thus, different types of health facilities were included from a variety of districts to help obtain a comprehensive picture about the presence or absence of necessary infrastructure and other resources for TB case finding.

2.3. Study participants and data collection

We used different sources and methods for the data collection. Firstly, in-depth interviews were conducted with health professionals responsible for managing or coordinating a TB control program at different levels and providing DOT at the facility level, health extension workers who were providing DOT at the health post level and TB patients who were receiving their treatment (in the intensive and the continuation phase). The intensive phase treatment covers the first two months for new cases and the first three months for retreatment cases, whereas the continuation phase covers the last four months for new cases and the last six months for retreatment cases. For the interviews, a semi-structured interview guide was used (S1 Text). The interview guide was translated to the local language (Afaan Oromo) by an English teacher whose mother tongue is Afaan Oromo and re-translated to English by another English teacher whose mother tongue is Afaan Oromo.

The first author (BME) conducted the in-depth interviews using the local language to explore health workers' experiences and views about barriers for TB case finding in the study area. Different people were interviewed to access as many perspectives as possible in regard to the overall aim of the study. The patients were interviewed about their views and experience before and during the diagnosis for TB. The majority (55) of interviews were conducted at the health facilities. Based on their preferences, five interviews were conducted at patients' and DOT providers' homes. The study participants were assured of confidentiality and the interviews were conducted in a private setting. We tried our best to make the study participants became relaxed through small talk for the first few minutes, and to make sure that they were comfortable before the interview. The interviews lasted 60 to 90 minutes, and audio-taped and transcribed verbatim, with descriptive field notes written after each of the interviews. The interviews for the health workers were conducted as a form of conversations than questions and answers.

Secondly, the governmental health facilities were observed based on a predefined checklist to acquire an overview of the existing situation in relation to the availability of necessary infrastructure and other resources, such as electricity, human resources and reagents for TB diagnosis (S2 Text). It was conducted through observing the facilities' (TB room, laboratory room, drug store, outpatient department (OPD), patient waiting area, the overall infrastructure and environment), combined with asking questions to the responsible persons in the respective units of the facilities. The observation lasted 50 to 70 minutes for each facility. The facility observation was carried out by BME and a research assistant (health service management specialist). The data collection tools were prepared based on national and WHO guidelines of TB control programs, as well as existing studies [7,19,33–35].

2.4. Data analysis, data quality control and trustworthiness

A data analysis of the in-depth interview started during data collection by transcribing on a daily basis and by performing a preliminary analysis. The first author (BME) transcribed all the audio-taped interviews and reviewed the transcript by listening to the recordings. Descriptive notes were made during the review of the transcripts. This process also included the inclusion of new probing questions and a merging of some of the other questions in the interview guide. De-identified audio-taped interviews (transcripts) were reviewed by a health monitoring and evaluation specialist who is a native speaker of the local languages (Afaan Oromo and Amharic) for peer debriefing.

BME conducted the data coding and categorizing using atlas.ti version 7.1 software. The last author (MS) reviewed a list of codes with associated quotations and categories; BME and MS then discussed and agreed upon the final list of codes and categories. A thematic analysis approach was used for identifying, analyzing and describing patterns and deviant cases within the data. The data were summarized in major themes, such as inadequate resources for TB case finding, and subthemes like a shortage of human power, a limited basic infrastructure and a shortage of diagnostic equipment and supplies [36]. Lastly, we attempted to paint a broad picture of what all the study participants described as their views and experiences in regard to TB case finding. The data were presented through descriptions of events and experiences relevant to the aim of the study [37].

The facility observation data were checked and computed for frequency of presence and an absence of selected resources and stock-out of acid fast bacilli (AFB) reagents. Narrative data based on the observation of each health facility, and its environment was also written up. Consequently, the observations from the facilities were used to validate the findings from the in-depth interviews, in addition to enriching and deepening the understanding of the data.

We used a translated and pre-tested interview guide. Triangulating with both data sources and data collection methods helped to challenge the data from various sources and findings already found by other methods. The sample size was relatively large, with an extensive amount of fieldwork over five months. The in-depth interviews were conducted by putting an emphasis on collecting data sufficient to provide a description of the existing barriers. We stopped the recruitment of the study participants when we reached saturation. The data from different people at different levels helped to ensure a "thick description" of the different functions and experiences of people working within the TB control program, as well as the patients receiving the services [31,38]. The interviewer (BME) also tried her best to ensure that the relationship between her and the study participants was built on trust so that the participants felt safe.

The interviewer knew the local languages and culture, and she believed that she managed to establish an "optimal" distance (insider-outsider) from the study [31,38]. She considered herself as an insider due to her being a fluent speaker of the local languages, thereby helped her to understand the context. The outsider role was partly preserved by not working with the DOT providers and program managers. The research assistant had experience in doing qualitative interviews, and is a fluent speaker of the local languages. Finally, there were frequent discussions and consultations on the design, data analysis and result interpretations among the authors up to the manuscript approval. The purpose of the discussions was for experience sharing and to have a common understanding.

2.5. Ethical considerations

Ethical approval was obtained from The Regional Committee for Medical Research Ethics (REK), Norway with reference number of 2015/2124 REK sør-øst B and the Jimma University

Institutional Review Board, Ethiopia with reference number of RPGC/389/2016. Subsequently, permission was obtained from both regional and local health departments in Ethiopia. Additionally, the study participants were informed about the purpose of the study and written informed consents (oral for patients who could not read and write) were obtained. Furthermore, privacy and confidentiality were ensured by using numbers to identify and describe the study participants. The collected data were stored in a locked file cabinet (for a hard copy) and on a computer with a password (an electronic copy).

3. Results

3.1. Characteristics of the study participants

Of the 60 individuals participating in the in-depth interview, 50 (83%) of them were health workers, 42 (70%) were male and 44 (73%) were in the age range of 25–34 years. From 50 health workers, 23 (46%) of them had a first degree, and 25 (50%) of them had 2 to 5 years of work experience for their current position or responsibility (Table 1).

From the analysis of the in-depth interviews, two major themes and five subthemes were identified from the data. The major themes were: (1) Inadequate resources for TB case finding, and (2) Limited access to TB diagnostic services. These are described below in detail, with

Table 1. Characteristics of the study participants for in-depth interviews in the Jimma Zone, 2016/7.

Variables		Number
Health workers (n = 50)		
Sex	Male	38
	Female	12
Age in years	≤ 24	9
	25–34	40
	≥ 35	1
Position or responsibility	DOT provider	25
	District level manager	20
	Zonal or regional level manager	5
Professional education	Certificate	6
	Diploma	18
	First degree	23
	Master (2^{nd} degree)	3
Duration of experience for current responsibility	< 2 years	16
	2 to 5 years	25
	> = 6 years	9
Patients (n = 10)		
Sex	Male	4
	Female	6
Age in years	≤ 24	2
	25–34	4
	≥ 35	4
Duration of treatment	< 2 months (intensive phase)	7
	≥ 2 months (continuation phase)	3
Residence	Rural	6
	Urban	4
Type of TB	Pulmonary TB	7
	Extra pulmonary TB	3

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respective subthemes and illustrative quotes. It was supplemented by findings from the observations at the health facilities.

3.2. Inadequate resources for TB case finding

This theme has three subthemes: (1) shortage of health-care providers, (2) inadequate basic infrastructure, and (3) inadequate diagnostic equipment and supplies.

3.2.1. Shortage of health-care providers. A majority of the study participants among the DOT providers and program managers at various levels reported that there was a shortage of health-care providers, especially laboratory professionals for the provision of TB diagnostic services. They explained that sometimes they did not have trained laboratory professionals, committed DOT providers and health extension workers to provide quality TB services for their community. One participant explained:

> *. [. . .] We do not have an adequate number of health extension workers and laboratory professionals [. . .].* (A district program manager)

In addition, our findings from observations at 42 health facilities show that there was an absence of trained laboratory professionals in 11(26%) of the facilities. These 11 health facilities were rural health centers which means there was a mal-distribution of the available professionals in the urban health facilities with rural health facilities.

The participants (program managers and DOT providers) described possible causes for the shortage of health-care providers. The shortage of laboratory professionals was claimed to be due to a closed laboratory program in some training institutions (Ethiopian politicians considering the saturation of laboratory professionals in the country). Other reasons related to a high turnover of laboratory professionals as many laboratory professionals leaving government institutions and joining private institutions. According to the participants, the shortage of health extension workers was due to health extension workers joining long-term training and not being substituted for. A lack of committed DOT providers was suggested to be due to an absence of risk allowance (incentive) and personal protective materials, such as masks for health personnel assigned to the TB clinic. Many underscored that working at a TB clinic has its own risk, as one participant expressed:

> *DOT is very good if implemented strictly. Currently, health professionals do not want to be assigned at TB clinics. They are at risk: there are no personal protective materials, no risk allowance and necessary resources for TB.* (A DOT provider)

3.2.2. Inadequate basic infrastructure. A majority of the study participants of DOT providers and program managers stated that there was a limited basic infrastructure, such as water supply, electricity, proper roads and rooms. They described that they often did not have the required resources, such as separate and equipped TB rooms to provide quality TB services for their community. The majority of health posts (at community level) and several health centers did not have a clean water supply and electricity; most health centers did not have patient waiting area and sputum collection area. They often lacked proper roads and affordable transportation services in their catchment. One participant clarified:

> *. [. . .]. Only five out of the nine health centers found in our district have electricity; four out of the nine health centers do not have electricity. Only four out of nine health centers have a clean water supply. In addition, our health posts do not kept minimum standards. [. . .].*

Inconvenient roads also make it difficult to travel with a car during the rainy season. (A district program manager)

We found an absence of a clean (protected) water supply in 13(31%) health facilities, an absence of electricity in seven (16.7%), an absence of room for TB treatment in five (11.9%), and an absence of a waiting area for patients in nine (21.4%) of the health facilities during the observation of the health facilities. From the 33 health facilities which had patient waiting area, only four (12.1%) of these had a separate waiting area for TB patients. Moreover, only one health center had a sputum collection area and only one hospital had a separate laboratory room for sputum examination.

Based on the interviews with the DOT providers, the consequences of an absence of the different resources were many. Patients expectorated just outside the laboratory rooms because of the absence of a sputum collection area, which could increase the transmission of TB to healthy individuals. Moreover, patients were travelling long distances on foot to access TB diagnostic services because of the absence of proper roads or affordable transportation services.

During our facility observation, we detected that many 10 (23.8%) of health centers had only two blocks and a shortage of rooms: one room divided into two rooms (for example, a TB room in front and a trachoma room in the back). Seven of the health centers' buildings were old and required maintenance, such as painting and reconstructing. In four health centers, staff were collecting rainwater during the rainy season because of a lack of pipe water. Additionally, nine of the patient waiting areas did not have adequate chairs or benches, while the waiting areas of three health centers were occupied with patient cards and non-functional tables.

The participants of program managers and DOT providers mentioned different possible causes for the shortage or absence of basic infrastructure. They explained that a lack or shortage of equipped and separated TB rooms was due to an inappropriate designing of the health facilities, as most newly constructed health centers had only two blocks. As a result, health personnel did not access separate TB rooms for TB-related services. A shortage or absence of a clean water supply, electricity and proper roads were explained as being related to budget constraint, a problem of the sustainability of projects (for water, electricity), as well as a low mobilization of the community for fund raising.

According to the participants, the budget constraints could be a result of inadequate budget allocation, inappropriate budget planning and a lack of accountants to use health-care financing system from internal revenue. Other causes, like an inappropriate utilization of resources such as money and an inadequate collaboration with other sectors, such as the education sector, were also mentioned. A participant elaborates on this issue:

There is a low involvement of the community in contributing money for infrastructure. Even what was contributed in our kebele (village) was not used for our kebele [. . .]. Also there is a low engagement of the community to avail or contribute locally available resources. (A DOT provider)

According to a majority of the study participants, an increased participation of the community in contributing money and availing locally available resources such as wood, stone and labor might help in the construction of protected spring water and for electricity.

3.2.3. Inadequate diagnostic equipment and supplies. The absence of functional microscopes and shortage of AFB reagents were major challenge for an early diagnosis of TB and follow-up, which was reported by many of the DOT providers and program managers. The

majority 39 (92.8%) of the health facilities had reagents for AFB (methylene blue, acid alcohol and carbol-fuchsin) at the laboratory room on the day of observation. However, the AFB reagents were not available in the drugstores of most health facilities: acid alcohol in 27 (64.3%), carbol-fuchsin in 26(61.9%) and methylene blue in 25(59.5%) health facilities on the day of observation. Moreover, the national TB control program guideline was not present in 28(66.7%) outpatient departments, 27(64.3%) laboratory rooms and 19(45.2%) TB rooms of the facilities. Functional weighing scales and masks were not present in 19(45.2%) TB rooms of the facilities. Nevertheless, these resources are supposed to be available in all 42 health facilities.

According to DOT providers and program managers, causes for the shortage of reagents and supplies were a result of a failure to timely distribute reagents and supplies for the health facilities. This was explained as being related to an inadequate number or total absence of vehicles (cars, motorcycles) to distribute the reagents and other supplies for the facilities. Almost all program managers mentioned that the absence of vehicles for TB control programs hindered them from conducting various activities. For example, they often could not deliver drugs and reagents in time or conduct a supportive supervision of the health facilities and health posts involved in providing TB care. They also mentioned other causes such as a delay of service providers in requesting the necessary resources, including reagents from district or zonal health offices, whereas many DOT providers reported that the reagents for AFB often reached the health facilities close to their expiration date (have short shelf life), which then expired within a short time. During the observations, this was confirmed as we found reagents for AFB with near their expiration date in the drugstores of some health facilities, and expired reagents in the drugstores of many health facilities.

3.3. Limited access to TB diagnostic services

This theme has two subthemes: These are the absence of nearby health facilities providing TB diagnostic services and health system delays in the diagnostic process.

3.3.1. Absence of nearby health facilities providing TB diagnostic services. Most participants, both patients and health personnel, spoke about how health facilities (hospitals and health centers) providing TB diagnostic services were far away from many of the patients. This was related to the use of time, as well as the indirect costs involved for transportation and examinations, such as x-rays and biopsy. In general, a long travel distance for patients due to the absence of nearby health facilities was reported as the main problem in relation to TB care. One patient, being in the intensive phase of treatment, talks about her struggle:

> *. [. . .]. My residence is far away from this health center (a two-hour walk) and there is no nearby health post, the health post is also far away from my residence. [. . .].* (A TB patient)

The DOT providers and district level program managers also confirmed the problem with travel distance through several examples. A program manager spoke about one such example:

> *.[. . .]. I have experienced a 50-year-old mother coming to a health center after walking for eight hours, I was shocked when I saw her. [. . .].* (A district level program manager)

One participant stated that his district had only seven diagnostic centers for TB out of 11 health centers found in the district, meaning that four health centers only provided TB treatment. Another participant described some of the problems related to this:

. [. . .]. Our major problem is the absence of laboratory service in our health center, we are collecting sputum and sending it to other health centers for acid fast bacilli (AFB), and even we do not have a budget to do this. (A DOT provider)

Most participants among the DOT providers and program managers expressed that it is important to provide TB services at health posts, including diagnostic services, so that everybody can access all the elements TB care. Some said that there might be patients in "hard to reach areas" dying of TB due to the topography of their districts, thus making TB diagnosis and care geographically inaccessible. For example, Sekachokerssa, Omonada and Dedo represent districts which are more difficult for a majority of people to seek healthcare due to their physical inaccessibility. However, a few district level program managers believed that all of their health centers and health posts were geographically accessible for their community members.

In the interviews, we explored what the program managers and DOT providers said to explain the possible causes for the paucity of decentralized sites providing diagnostic services in the study area. The majority of program managers and DOT providers mentioned the following causes: (1) an inadequate expansion of TB diagnostic sites to the community–most DOT providers and district level program managers mentioned that some of their health centers do not providing TB diagnostic services except the treatment; (2) the absence of proper road and public transportation services–in most rural areas the centers are only accessible by motorcycles. Even so, using motorcycles might be difficult during the rainy season; (3) the presence of hard to reach areas related to an inconvenient topography, which leads to physical inaccessibility for some patients; and (4) budget constraints.

3.3.2. Health system delays in the diagnostic process. We probed selected TB patients in the study area about their experiences in the process of the diagnosis and treatment of TB. A majority of the patients reported that they had been suffering from symptoms of TB, such as cough and chest pain for several months, before they were diagnosed as TB patients. Based on patients' descriptions, there seemed to be an unnecessary period of health system delay in obtaining the proper diagnostic service after the patients had sought such services at a health facility. The patients reported that it took between one to five months to recognize their illness as TB and start their treatment after they initiated contact with the health care providers. The delay was mainly related to a referral from health posts to health centers, as well as health centers to governmental hospitals for further investigation. One of the patients reported that he did not know what illness he suffered from before two months after his first health center visit; the health professionals simply gave him medicine (antibiotics) for seven days after a negative result of sputum examination. After two months without being diagnosed, he went to a private clinic which had an x-ray machine. Lastly, the patient was diagnosed after two weeks additional time as being pulmonary TB-negative with further investigation (with an x-ray).

Another patient reported that her illness was diagnosed as TB after five months of repeated visits to a health facility. Her diagnostic process was delayed due to a delayed sputum examination and chest x-ray. Yet, another patient reported that it took four months for his illness to be diagnosed, starting from the first visit in a health center. The patient was continuing to a private health facility where he was diagnosed for TB after different investigations like a sputum examination, blood tests and an x-ray, which he was not offered at the health center he visited. Subsequently, he was transferred from a private health facility to the health center he visited so that he could start the treatment, as only some private health facilities have permission to treat TB patients. However, he was not able to start the treatment immediately because the DOT provider was not there (at the health center). He was therefore again delayed, and started his treatment at the health center five days after receiving the diagnosis.

Some DOT providers and program managers spoke about laboratory service interruption, implying that no tests were performed for seven to 14 days in some health facilities. The interruption of laboratory tests could be one cause for the health system delay for diagnosis. This was solved by sending patients to nearby health centers for a sputum exam, and by sending laboratory technicians from one health center to another health center. The delay was described as having negative effects on the daily life of the patients, both in terms of suffering from symptoms of the illness such as cough and pain, as well as expenses related to TB investigations. Furthermore, the expenses might increase as a result of costs related to transportation and investigations done at private clinics. A patient expressed his feelings about how the delay had affected his daily life:

> *I think my daily life has been affected much during examination (before illness was known). I was examined at a private clinic with high expenses, although my illness was not detected at that time. I went to Jimma hospital (a referral hospital in Jimma) for further examination with an x-ray. During all this time, I was suffering from chest pain and sleeplessness; I couldn't sleep for several days. Moreover, I had many expenses and my job hours were affected. My workplace is out of this town and I have to travel about one hour in walking distance (to reach the clinic).* (A TB patient)

According to most patients, their daily life was highly affected due to the delay in the diagnostic process.

The origin for barriers of TB case finding and interrelated factors were summarized and presented by diagram (Fig 1).

4. Discussion

The present study explores patients', DOT providers', and program managers' views and experiences related to barriers for TB case finding in Southwest Ethiopia. These views and experiences are supplemented with findings based on observation of a variety of health facilities. Our findings suggest that there are different and interrelated barriers for TB case finding in the study area. Major barriers include inadequate resources, and limited access to TB diagnostic services. Furthermore, the origin and interrelation of the barriers were described [27,28].

Our findings suggest that there were inadequate resources which were necessary for TB case finding. The findings are consistent with previous studies in Ethiopia which reported that there were inadequate resources, such as trained health-care providers and laboratory reagents for the TB control programs [12,39,40]. Inadequate or the absence of necessary resources might significantly hinder the provision of TB diagnostic services as expected, and cause TB case notification to become low in the study area. Moreover, the shortage of these resources could influence the performance and quality of the TB control program.

According to the Stop TB partnership action framework for TB case detection, a limited basic infrastructure like clean water, a limited number of health workers and a lack of incentive systems for providers are all possible causes for a low case detection rate and a treatment delay [41]. A good and effective service provision requires a trained and competent staff serving with the correct medicines and medical equipment, which required adequate financing. An organizational system that provides proper incentives, such as an allowance to service providers and users, is necessary to obtain a desirable health outcome or for successful treatment. There is also a significant association between health workers' density and health service coverage and outcomes [42].

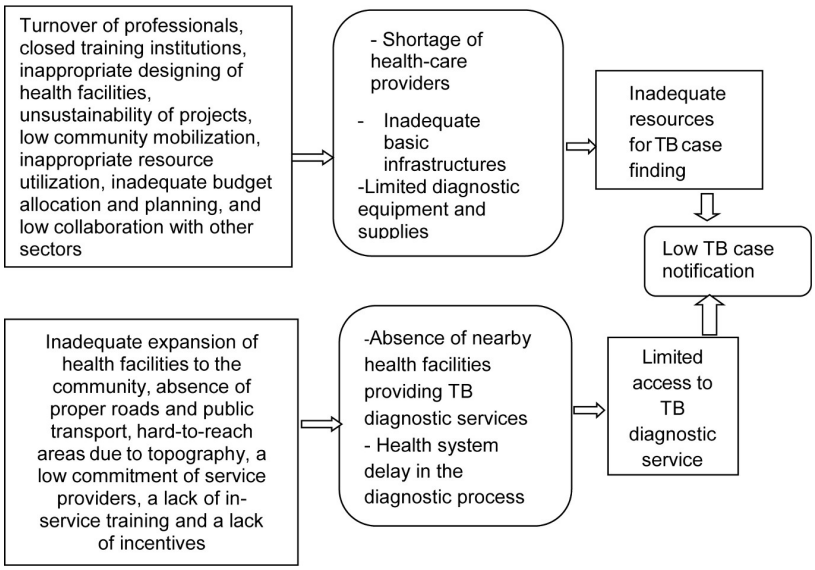

Fig 1. Origin for barriers of TB case finding and interrelated factors, Jimma Zone, Southwest Ethiopia, 2016/17.

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Limited access to TB diagnostic services, being a result of an absence of nearby health facilities providing TB diagnostic services, was another barrier for TB case finding. Most of the rural residents of the study area do not easily access health centers and hospitals. As a result, individuals who have symptoms of TB are expected to seek TB diagnostic services by traveling long distance. Hence, the individuals might be delayed or not seek the services at all [12,16]. This could be related to the country's economy in availing TB diagnostic centers at the community level, and poor rural residents not able to afford costs related to transportation and investigations.

We found a long health system delay, ranging from one to five months. A much longer health system delay was observed in our study than in that of a study conducted in Gonder Town, Ethiopia, in which the median health system's delay was five days [5]. This difference might be due to the differences in study settings and methods. Our study included both rural and urban settings using a qualitative method, whereas the study in Gonder Town included only an urban setting and they used a quantitative method. As a result, rural residents might have less access to TB diagnostic centers and health information than urban residents. Accessibility to health services and awareness about TB might influence their early health-seeking behavior and follow-up after the first visit to the health facility. The health system delay could also amplify the total delay and TB transmission rate [43]. The health system's delay in the present study seems to primarily be related to a referral from a lower level to higher level health system for further investigations. This finding is similar to a previous study result in Ethiopia, in which the diagnostic delay was associated with care-seeking from multiple health care providers and visiting primary level health-care facilities for initial care [5].

Long distance traveling to obtain TB diagnostic services was another challenge for most patients from rural areas. Kleinman describe clients as a part of a community in a particular socio-cultural context, and health, illness and health-care related issues of communities as cultural systems. He divides the health-care system into popular, folk (traditional) and professional sectors [44]. The popular sector includes the family context of illness and care and social network, as well as community services related to the individual; the folk sector comprises

non-professional healing consultants and the professional sector contains modern medicine. A majority of the illnesses and healthcare, as well as most decisions on the time to seek help, where clients go and consult, and the way of compliance with treatments, are often dependent on the popular sector [44,45]. Consequently, limited access to health services due to distance could significantly affect the health-care seeking behavior of most of the rural population, which could lead to diagnostic delays and a low TB case notification. A long distance from the clinic was also reported in previous studies from many other countries and Ethiopia as a barrier for TB case finding by impacting their timely health-seeking behavior and lengthening a patient's delay [46–51].

TB case identification may be improved if the community could easily access health facilities with TB diagnostic services. Studies show that case notification and treatment outcomes increase in areas where community members have better access to facilities with TB diagnostic and treatment services [12,52,53]. Studies in Southern Ethiopia show that an involvement of health extension workers in sputum collection for microscopy at the community level significantly increased TB case finding and improved treatment outcomes [21,52]. Furthermore, TB case notification was higher in areas with better access to TB diagnostic and treatment facilities. Moreover, community-based interventions, such as active case finding played an important role for increased case notification rate [12]. A community-based active case finding using door-to-door household symptom screening, supplemented with laboratory tests, also increased TB case finding in rural China [54]. Moreover, active case finding through community outreach improved the speed of TB case finding, which indicated a possibility to reduce delays in TB diagnosis by at least half in Southern Ethiopia [20].

In Ethiopia, health extension workers (HEWs) are intentionally placed at the community level to reinforce the accessibility of the rural population to different health services, including TB care. The government case finding strategy also includes the identification of most rural presumptive TB cases in the duties and responsibilities of the HEWs [51,55]. This strategy could help in solving problems related to unmet health needs in general, and undiagnosed TB cases in particular, for the rural population.

In the present study, we recognized that the patients had difficulty to obtain even the simplest type of TB diagnostic service (AFB) due to absence of nearby health facilities with TB diagnostic services. A prompt TB diagnosis is crucial for interrupting TB transmission in the community. It is well known that the major source of TB spreading to healthy individuals is untreated AFB smear-positive TB patients. However, studies show that TB could be transmitted by AFB smear-negative TB suspects, because AFB smear microscopy has a very poor sensitivity and specificity compared to GenXpert MTB/RIF assay and MTB culture to detect Mycobacterium tuberculosis (MBT) [56,57]. A study revealed that from 168 AFB smear-negative sputum specimens, 28.57% and 34.52% were identified as MTB-positive by GeneXpert MTB/RIF assay and MTB culture, respectively [57]. In other studies, GeneXpert MTB/RIF assay had a higher sensitivity (93.75%) than AFB smear microscopy (50.00%) [56].

Other qualitative studies also revealed similar barriers to TB control programs, such as a shortage of human resources, inadequate access to TB services, and transportation problems, were reported along the Thai-Myanmar border [58]; a shortage of resources, poor accessibility and a capacity for TB diagnosis, as well as a weak community involvement, were reported in Northern Malawi [59]. Moreover, a shortage of resources, and a lack of access to TB diagnostic services at peripheral health facilities, were reported in Northwest Ethiopia [40].

According to the WHO's health system framework, there are six building blocks for strengthening health systems in order to improve health outcome. These include good health service delivery, a health workforce that performs well, a functional health information system, a strong health financing system, leadership and governance, as well as necessary medical

products, vaccines and technologies. All health systems should accomplish some basic tasks: the provision of services, having health workers and other essential resources, mobilizing and allocating finances, and maintaining of health system leadership and governance [42]. Our findings are related to four of the building blocks: limited access to TB diagnostic service delivery, an insufficient number and type of health workers, an inadequate budget and challenge to use the health-care financing system and a shortage of diagnostic equipment and supplies, including reagents. Ideally, all (the six) building blocks should be in place to improve health outcomes [42].

The roots of poor health outcome mostly seem to be based on a system failure related to a lack of well-established polices, process and procedures [60]. Most of the origins for the barriers of TB case finding in the present study also seem to be related to policies and process. To improve a specific outcome of health care within a health system, all the causes contributing to health outcomes should be known. After the origins of a particular health outcome are recognized, improvements can be done to help address these causes and finally change the outcome [61]. Hence, an improvement in the origins of barriers to TB case finding could increase TB case identification and improve the TB control program. Although some of the barriers are related to the country's poor economic condition and being difficult to tackle, other barriers can be improved through different interventions.

As a limitation, the present study reflects the views of a limited number of patients, DOT providers and program managers at different levels who participated in the study. We interviewed patients who have been on treatment, but not those individuals who had symptoms of TB in the community and had not yet sought TB care. Thus, we might miss essential information regarding barriers to TB case finding from symptomatic individuals who did not yet seek biomedical care. Moreover, the responses from the study participants might tend to be positive, and may not address their concern fully (social desirability bias) since most of the interviews were conducted at health facilities and health posts. We attempted to reduce this bias by informing about the objective of the study, assuring their confidentiality and indirect questioning, which meant asking about what others thought and felts. As a strength of the study, we used a relatively large sample size of in-depth interviews and facility observations. This helped to provide a great deal of data sources and method triangulation.

5. Implications for practice

We believe that the TB control program should address further decentralization of diagnostic services to the community. At the very least, all health extension workers should be trained and practice collecting sputum samples, preparing smears at the community or health post level and sending samples to laboratories for testing. This could have a positive effect on case finding, and may increase the case notification rate [51,55].

To help increase TB case identification in the community, it is better to learn from the Ivory Coast's process of decentralization for TB control. The Ivory Coast has carried out various activities, including the establishment of a steering committee, health site rehabilitation with lower costs by using containers, the integration of TB services, conducting dissemination workshops and the adoption of decentralization by stakeholders; and conducting training at different levels of health care providers, including traditional practitioners. Simultaneously, an ENGAGE-TB approach (integrating community-based tuberculosis care into the activity of non-governmental and other civil society organizations) was taken at the community level. These include a situation analysis, operational guideline development for community activities, community health workers' training and a high involvement of NGOs [62].

Furthermore, building future health facilities with TB diagnostic services should be done with a mind to separate potentially active TB patients from other sick patients by considering the location and proper design. Referral systems from a lower to a higher level should be strengthened with feedback to ensure that all referred patients have visited the clinic to which they were referred. Moreover, proper and timely distribution of TB diagnostic equipment and supplies from Zonal health departments or District health offices to the health facilities should be strengthened. A strong collaboration with different sectors and non-governmental organizations may help for the development of the necessary infrastructure's projects (water, electricity, roads, etc.) [42].

Active case finding using an outreach strategy could be an important strategy to enhance TB case finding within the community. The enhanced type of TB case finding may lead to an earlier diagnosis, and result in a reduced transmission of TB within the community. Active case finding through community-based chronic cougher follow-up have been shown to improve TB case finding and be helpful for socioeconomically underprivileged individuals in Ethiopia [63]. Attention should be given to improve TB case finding, and to reduce the perceived barriers, by making TB diagnostic services more accessible, affordable and acceptable by the community [22]. Identifying persons with symptoms and signs of TB, and the start of a medical evaluation as early as possible, could avoid the lengthy process and unnecessary delays. In addition, an innovative TB screening approach, such as screening any patient with a cough of any duration with at least one of the suggestive TB symptoms present, should be considered to improve TB case finding [64]. An integrated intensive case finding of TB, not only for HIV-infected individuals but also for patients with diabetic and cardiac problems, as well as maternal and child health clinics, could improve TB case finding [65].

It is possible to construct a TB patient waiting area and sputum collection area by mobilizing the community to avail or contribute locally available resources such as wood and stones, as well as free labor. Moreover, basic masks should be availed and provided not only for health workers who are providing TB care, but also for any coughing patients, to reduce nosocomial transmission. The role of social support systems like "Edir and Ekub" (community-based social support systems in Ethiopia) might help in providing psychological, financial and service support for individuals who have symptoms of TB. In addition, providing feasible incentives not only money but also moral support like education opportunities, reviewing performance and salary, could be possible solutions for a shortage of health-care providers and a low commitment of service providers [42]. These solutions may help to retain and motivate health-care providers in the governmental health system.

Finally, a future study using a community-based mixed method is necessary to identify further barriers of TB case finding in the community, and to improve community TB care.

6. Conclusion

There were different challenges in relation to TB case finding in the study area. Inadequate resources, and a limited access to TB diagnostic services, were major barriers identified in the present study. There is an interrelation between these barriers, and each barrier has its own basic causes. Strategies aimed at addressing the identified barriers for TB case finding should be recognized to increase TB case identification. These strategies could help to improve TB case finding in particular, and TB control programs in general. The findings of this study may help decision makers to focus on the origin of these barriers to help tackle the problems.

Supporting information

S1 Text. Interview guide and information sheet with consent form English and local language versions.
(PDF)

S2 Text. Checklist for facility observation.
(PDF)

S3 Text. Consolidated criteria for reporting qualitative research (COREQ) checklist.
(PDF)

S1 Data. In-depth interview data.
(ZIP)

S2 Data. Facility observation data.
(SAV)

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Treatment outcomes of patients with drug-sensitive tuberculosis under community-based versus facility-based directly observed treatment, short course strategy in Southwest Ethiopia: a prospective cohort study

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ABSTRACT

Objective To compare tuberculosis (TB) treatment outcomes and associated factors among patients attending community-based versus facility-based directly observed treatment, short course (DOTS).

Design A prospective cohort study.

Setting The study was conducted in Southwest Ethiopia. There were seven hospitals (five primary, one general and one specialised), 120 health centres and 494 health posts.

Participants A total of 1161 individuals consented to participate in the study (387 patients under community-based DOTS (CB-DOTS) and 774 patients under facility-based DOTS (FB-DOTS)). Individuals who could not respond to the questions, mentally or critically ill patients, and those less than 15 years old, were excluded from the study.

Primary outcome measure TB treatment outcomes were compared among patients under CB-DOTS versus FB-DOTS. Risk ratio (RR), risk difference (RD) and confidence interval (CI) were calculated among the study groups. In addition, χ^2 or Fisher's exact tests were used to compare group differences, with a p value of <0.05 considered statistically significant.

Results Patients who opted for CB-DOTS were more likely to be cured by 12% than those who opted for FB-DOTS (RR=1.12, 95% CI=0.96 to 1.30). Patients under CB-DOTS had a lesser risk of death (RR=0.93, 95% CI=0.49 to 1.77) and a lower risk of treatment failure (RR=0.86, 95% CI=0.22 to 3.30) than those under FB-DOTS. Furthermore, patients who opted for CB-DOTS were less likely to have a positive sputum smear result at the end of the treatment period (p=0.042) compared with their counterparts.

Conclusion The study showed that CB-DOTS is more effective than FB-DOTS in terms of improving cure rate and sputum conversion rate, as well as lowering treatment failure rate. Our findings show the need for scaling up and a further decentralisation of CB-DOTS approach to improve access to TB treatment service for the rural community.

Strengths and limitations of this study

- This study applied a relatively large sample size of patients with drug-sensitive tuberculosis under facility-based directly observed treatment, short course (DOTS), and those under community-based DOTS for comparison.
- The strongest observational study design (prospective cohort study design) was used.
- Relative risk and risk difference were applied to interpret the findings.
- The findings could be prone to selection bias due to the patients' preference to be under community-based or facility-based DOTS and the observed unknown outcomes of transferred out and not recorded cases.

INTRODUCTION

Tuberculosis (TB) is still a common cause of illness and death in low-income and middle-income countries. Globally, there were an estimated 10 million cases of TB in 2018. Moreover, there were an estimated 1.2 million among HIV negative and 251 000 (among HIV positive) deaths due to TB.[1] The 30 high TB burden countries shared 86.8% of the global TB incidence, with 24% of all cases found in Africa. Ethiopia is one of the 30 highest TB burden countries, and one of the 10 highest for TB, TB/HIV and multidrug-resistant (MDR) burden countries.[1 2] Based on the 2018 Global TB report, 117 705 TB cases were reported in Ethiopia. The report showed a 68% treatment coverage for drug-sensitive TB in the country.[3]

Ethiopia started implementing the enhanced form of the directly observed treatment, short course (DOTS) and the

WHO Stop TB strategy in 2006.[4 5] The expansion and enhancement of a high-quality DOTS is one of the focuses of this strategy. The strategy is an effective patient-centred strategy with the aim of reaching all patients and improving case findings.[6] While reinforcing the Stop TB strategy, the WHO has recently launched the End TB strategy for the period from 2016 to 2035, with a target of a 90% reduction in TB mortality and an 80% reduction in TB incidence by 2030, compared with what was achieved in 2015.[2] In order to achieve these targets, the scaling up of TB diagnostic and treatment services to the community is crucial.

Ethiopia has been implementing the DOTS strategy since 1997.[7] DOTS is currently being implemented using two approaches: facility-based DOTS (FB-DOTS) (provided by a trained health worker at health facility level) and community-based DOTS (CB-DOTS) (provided by a health extension worker (HEW) or a trained TB treatment supporter at health post, patient's home or patient's workplace). The health facilities (hospitals and health centres) provided TB diagnostic and treatment services, whereas the health posts rendered the TB treatment services, identification and referrals of TB suspects to the nearest health facilities for confirmatory testing using an acid-fast bacilli smear microscopy test (diagnosis).[5 8] In the Jimma Zone (the study area), the DOTS was initiated in 1998.

The Health Sector Transformation Plan 2015/2016–2019/2020 of Ethiopia includes the need for a scaling up of community-based TB care which is provided at health post or community level to all health posts or kebeles (the lowest administrative level in Ethiopia).[9]

Studies in Ethiopia revealed that a long distance from TB clinics, a lack of money for transport, direct and indirect costs associated with the illness and the daily treatment, a loss of employment, a poor quality of health services and a lack of social support are the primary reasons for failing to fully comply with TB treatments.[10 11] A recent study conducted in the Jimma Zone, Ethiopia, showed that of all the MDR TB cases, two-thirds had a history of previous TB treatment, 37% had a history of treatment failures and 27% had a relapse history.[12]

The optimal implementation of FB-DOTS and CB-DOTS is crucial to achieve high TB case notification and cure rates.[13] Previous studies in different countries have shown that CB-DOTS is more effective than the FB-DOTS approach.[14–20] In the Jimma Zone, where this study was conducted, only 23% of the health posts provided TB treatment at the community level during the study period. To the best of our knowledge, a comparative study on CB-DOTS versus FB-DOTS delivery approaches has not been conducted in Southwest Ethiopia. Therefore, this study aimed at comparing TB treatment outcomes and associated factors among drug-sensitive patients attending CB-DOTS versus FB-DOTS at public health facilities and health posts in Jimma Zone, Ethiopia.

Findings from this study may contribute to the improvement of the TB control programme performance by providing evidence-based recommendations for decision-makers about CB-DOTS versus FB-DOTS in particular in the study area, and in Ethiopia at large.

METHODS

Study setting

The study was conducted in the Jimma Zone, Southwest Ethiopia, which is one of the zones in the Oromia Regional State of Ethiopia. It is located 354 km from Addis Ababa, the capital city of Ethiopia, with a total area of 199 316.18 km^2 (Jimma Zone health office, 2016; Jimma town health office, 2016). In 2016, the Jimma Zone had a total of 17 districts and two town administrations. There were seven hospitals, of which five were primary, one general and one specialised, as well as 120 health centres and 494 health posts during the study period. In addition, non-governmental health facilities, such as the Catholic mission and some private clinics, also provided TB diagnostic and treatment services. The Ethiopian government and global health agencies, such as The Global Fund and the US Center for Disease Control (CDC), have been the sources for funding and other resources, such as drugs and laboratory reagents for the implementation of the TB control programme (Jimma Zone health office, 2016; Jimma town health office, 2016). Based on a projection of the 2007 population census, the Jimma Zone had an estimated population of 3 261 371, of which 49.9% were women in the year 2017.[21]

Study design, study population and sampling

The study followed a prospective cohort study design.[22] The target population was all patients with drug-sensitive TB who were initiated on first-line anti-TB DOTS regimens at all public health facilities and health posts of Jimma Zone during the study period. Patients with drug-sensitive TB who started the first-line anti-TB DOTS regimens at sampled districts' and a town administration's public health facilities and health posts were consecutively enrolled in the study. Patients who could not respond to the questions, mentally or critically ill patients, as well as those less than 15 years old, were excluded from the study.

Eight districts and 1 town administration were randomly selected from 17 districts and 2 town administrations by using a simple random sampling (lottery method).[23 24] Afterwards, all DOTS sites in the sampled districts and a town administration were included in the study. The sample size was determined using Epi Info software, V.7. We considered a CI of 95% and a power of 80%. The treatment success rate was selected as an outcome variable, whereas the percentage of outcome in unexposed groups (DOTS at health facilities) and exposed groups (DOTS at health posts or community) was estimated to be 83.1% and 89.3%, respectively. This result was taken from a previous study done in Southern Ethiopia,[25] with an unequal ratio being employed (unexposed:exposed of 2:1). Accordingly, the sample size was calculated to be 1161 (774 under FB-DOTS and 387 under CB-DOTS).

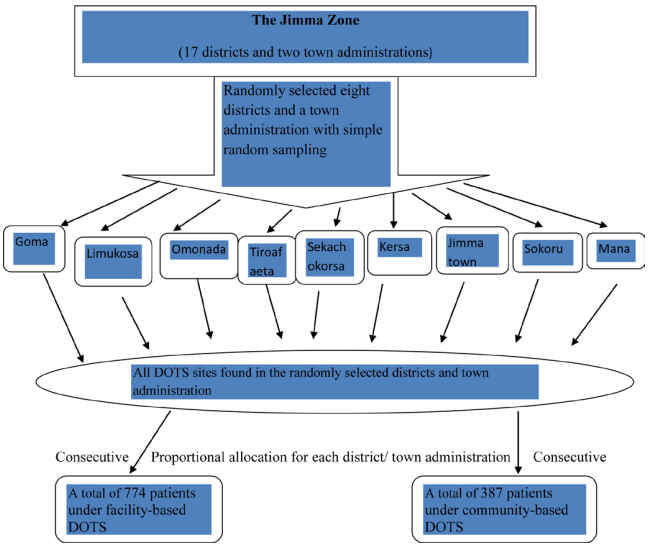

Figure 1 Schematic presentation of sampling procedure for a cohort study, Jimma Zone, 2017. DOTS, directly observed treatment, short course.

The sample size was proportionally allocated to the selected health facilities in the sampled districts, and the town administration based on a patient flow of the previous one year before the study's start. Subsequently, the study participants were consecutively enrolled until the required sample size was obtained (figure 1).

Data collection and analysis

A structured questionnaire was used to collect the data (sociodemographic characteristics and other independent variables) from the study participants. Clinical data including the treatment outcomes were collected with a checklist attached to the questionnaire from laboratory and unit TB registers. The data collection tool was prepared based on national and WHO's guidelines, as well as tools used in previous studies.[5 15 16 25–27] The questionnaire was translated to local language (Afan Oromo) by a University English teacher whose mother tongue is the local language. It was peer reviewed to check for any discrepancies between the forward translation and the original English version of the questions. The translated version of the questionnaire was translated back to English by another University English teacher who speaks and writes the local language fluently. Then, it was pretested in a district outside of the study area to check for the clarity and time needed to complete the questionnaire. Then, modifications like clarifying phrases were made based on the findings of the pretest. The overall process of data collection was organised and supervised by the principal investigator. Data collectors and supervisors were recruited and provided with the necessary training on the technique of data collection in the presence of the principal investigator. The enrolment of the study participants was done consecutively starting from September 2016 to October 2017. All patients were interviewed during the enrolment period. The patients were followed up from the first time of enrolment until their treatment outcomes were recorded (until June 2017). The second phase of data collection, including the treatment outcomes, was conducted from 1 October to 30 December 2018. Information from the laboratory and TB registers was gathered after obtaining permission from the head of the health facilities. The data on the treatment outcomes for the cohort were obtained from the unit TB register at the respective health facilities included in the study. The data were checked for completeness and consistency, then coded and entered into the EpiData entry client software, V.4.4.3.1, and exported to the Statistical Package for Social Sciences software (SPSS) V.21 for analysis. Additionally, WinPepi V.11.65 was used to calculate the risk ratio (RR) and risk difference (RD). Descriptive statistics were also computed. Groups were compared using the χ^2 or Fisher's exact tests when appropriate, with a p value of <0.05 considered statistically significant. The RR, RD and 95% CI were applied to interpret the groups' difference for the dependent and independent variables.

Definition of terms

Definitions used in this study are according to the National and WHO Tuberculosis guidelines.[5 28]

New case: The patient has never been treated for TB or has taken anti-TB drugs for less than 1 month.

Relapse: The patient has previously been treated for TB, was declared cured or treatment completed at the end of his/her most recent course of treatment, and was diagnosed with a repeated episode of TB.

Cured: A patient with bacteriologically confirmed pulmonary TB at the beginning of treatment, who was smear or culture negative at the end of treatment, and at least one previous time.

Treatment completed: A patient with TB who completed treatment without evidence of smear or culture negative at the end of treatment, and at least one previous time.

Treatment failure: A patient whose sputum smear or culture is positive at the fifth month or later in the course of treatment.

Lost to follow-up: A patient with TB who has been on treatment for at least 4weeks and who interrupted the treatment for 8 or more consecutive weeks.

Died: A patient who dies from any cause during the course of TB treatment.

Transferred out: TB cases transferred to another treatment unit, and whose treatment outcome is not assigned.

Not recorded: Cases for which the treatment outcome is not recorded in the unit TB register.

Favourable treatment outcome: The sum of cured and treatment completed outcomes.

Unknown treatment outcome: The sum of transferred out and not recorded cases.

Unfavourable treatment outcome: The sum of deaths, treatment failures and lost to follow-up outcomes.

Facility-based DOTS: TB treatment provided at governmental health centres or hospitals by a trained health worker.

Community-based DOTS: TB treatment provided at a health post or patient's home by a HEW or a trained TB treatment supporter.

Not applicable: Sputum examination is not required either because the patient was not pulmonary TB positive or the outcome was known at this stage (died, transferred out).

Patient and public involvement

Representatives of the public, such as previous patients, were not involved in the development of the research question and the design of the study. The findings of this study will be disseminated to concerned stakeholders after being published in a peer-reviewed journal.

RESULTS

Characteristics of the study participants

A total of 1161 patients with drug-sensitive TB were enrolled (774 who opted for FB-DOTS and 387 who opted for CB-DOTS) in the study. The mean age of the total cohort was 33.2 years with an SD of ±14.4, and the range was from 15 to 90 years. The mean age for patients under FB-DOTS was 32.3 years with an SD of ±13.8, while for those under CB-DOTS, it was 35.1 years with an SD ±15.4. Most (47.7%) of the patients under FB-DOTS versus 45.2% of the patients under CB-DOTS had an age range of 24–44 years (tables 1 and 2).

The average money paid in relation to TB care was approximately 203 Ethiopian birr (ETB) for patients under FB-DOTS, and 101 ETB for patients under CB-DOTS (table 2).

Patient factors associated with choice of FB-DOTS versus CB-DOTS

Compared with patients who opted for FB-DOTS, patients who opted for CB-DOTS were more likely to be female (p=0.009) and illiterate (p<0.001) (table 1). HIV coinfected TB patients were less likely to opt for CB-DOTS (p<0.001). Patients under CB-DOTS were less likely to have a positive sputum smear result at the end of the treatment period compared with their counterparts (p=0.042). Patients under CB-DOTS were more likely to have a contact person registered with an address compared with patients under FB-DOTS (p<0.001). The majority (96.5%) of patients under FB-DOTS versus (97.2%) patients under CB-DOTS were new TB cases (table 3).

TB treatment outcomes among patients who opted for CB-DOTS versus those who opted for FB-DOTS

Patients who opted for CB-DOTS were more likely to be cured by 12% than those who opted for FB-DOTS (RR=1.12, 95% CI=0.96 to 1.30). Moreover, patients under CB-DOTS had a lesser risk of death (RR=0.93, 95% CI=0.49 to 1.77) and a lower risk of treatment failure (RR=0.86, 95% CI=0.22 to 3.30) than those under FB-DOTS. The treatment success rate for patients opting for CB-DOTS was 87.6%, whereas for those opting for FB-DOTS, it was 86.4% (tables 3 and 4).

In relation to absolute effect (risk difference), patients who were treated under CB-DOTS had approximately four additional cured cases per 100 patients compared with patients treated under FB-DOTS (RD=4.26%). There were approximately three less death cases per 1000 patients opting for CB-DOTS, compared with their counterparts. In general, there was approximately one excess favourable treatment outcome case per 100 patients who opted for CB-DOTS, compared with those who opted for FB-DOTS (RD=1.16%). However, the difference was not statistically significant, which means both patients under CB-DOTS and those under FB-DOTS had comparable favourable treatment outcomes (p=0.854) (tables 3 and 4).

DISCUSSION

The present study compares TB treatment outcomes and associated factors among a cohort of drug-sensitive patients attending CB-DOTS versus FB-DOTS in Southwest Ethiopia. Our finding shows that patients who were treated under CB-DOTS were more likely to be cured than those who were treated under FB-DOTS. This result is different from a previous study report in Ethiopia, whereby the cure rate was almost similar for both CB-DOTS and FB-DOTS performance (88.9% vs 88.2%).[19] The finding is also different from two other studies conducted in Tanzania, whereby the cure rate did not significantly differ between the two treatment approaches.[15 29] Conversely, the study result is comparable to a study reported from Mongolia, whereby patients who opted for CB-DOTS showed a higher cure rate than those who attended the FB-DOTS approach (89.9% vs 77.2%)[22] and a study in Namibia in which the cure rate was significantly increased with the implementation of CB-DOTS.[20] Our finding could be explained by the fact that the CB-DOTS option is more accessible to patients, as it is convenient and nearer to their home.[30] In addition, CB-DOTS is flexible in terms of time and place for patients to obtain DOTS service compared with the FB-DOTS approach. The discrepancies in the study findings may be related to differences in the study settings and study period, as well as study designs used in the respective studies.

Lower risk of death and treatment failure were observed for patients under CB-DOTS than those under FB-DOTS. These results are similar to findings from former studies in Ethiopia,[19] Nepal and Tanzania.[15 18] Some of the reasons for these findings could be related to a less severe TB disease among patients who chose CB-DOTS than those who chose FB-DOTS. It is common that most patients with TB comorbidities (TB/HIV or TB and diabetes or cardiovascular diseases) are treated at hospitals where FB-DOTS service is offered.[31 32] The risk of treatment failure and death among such patients is higher compared with patients attending CB-DOTS, who are often ambulatory cases with less severe TB disease.[33 34]

Table 1 Sociodemographic characteristics of the study participants under FB-DOTS and CB-DOTS

Variables		Total cohort (N=1161)	Patients under FB-DOTS (n=774) n (%)	Patients under CB-DOTS (n=387) n (%)	P value
Sex	Male	594	417 (53.9)	177 (45.7)	
	Female	567	357 (46.1)	210 (54.3)	0.009
Age in years	15–24	365	253 (32.7)	112 (28.9)	0.092
	25–44	544	369 (47.7)	175 (45.2)	
	45–64	202	120 (15.5)	82 (21.2)	
	>=65	50	32 (4.1)	18 (4.7)	
Marital status	Single	330	246 (31.8)	84 (21.7)	
	Married	765	476 (61.5)	291 (75.2)	<0.001
	Divorced	30	25 (3.2)	5 (1.3)	
	Widowed	34	27 (3.5)	7 (1.8)	
Educational level	Illiterate	459	268 (34.5)	191 (49.4)	
	Read and write only	98	61 (7.9)	37 (9.6)	<0.001
	Primary school	396	269 (34.8)	127 (32.8)	
	Secondary school	132	105 (13.6)	27 (6.9)	
	College/University	76	71 (9.2)	5 (1.3)	
Occupation	Farmer	739	430 (55.6)	309 (79.8)	
	Merchant	74	64 (8.3)	10 (2.6)	<0.001
	Government/non-government organisations employee	58	50 (6.5)	8 (2.1)	
	Daily labourer	88	81 (10.5)	7 (1.8)	
	Housewife	19	18 (2.3)	1	
	Student	142	102 (13.2)	40 (10.3)	
	Unemployed	41	29 (3.6)	12 (3.1)	
District/town administration	Goma	220	120 (15.5)	100 (25.8)	
	Jimma	157	157 (20.3)	0 (0.0)	<0.001
	Kersa	122	73 (9.4)	49 (12.7)	
	Limmu Kosa	144	90 (11.6)	54 (13.9)	
	Mana	97	64 (8.3)	33 (8.5)	
	Omo Nada	102	73 (9.4)	29 (7.5)	
	Seka Chekorsa	120	80 (10.3)	40 (10.3)	
	Sokoru	108	62 (8.1)	46 (11.9)	
	Tiro Afeta	91	55 (7.1)	36 (9.4)	

CB-DOTS, community-based directly observed treatment, short course; FB-DOTS, facility-based directly observed treatment, short course.

Furthermore, obtaining CB-DOTS services could be less stressful, more convenient and provide flexible time and the opportunity for negotiation between patients and HEWs or TB treatment supporters regarding a suitable time for getting the service by patients.[19 35] This type of flexibility could increase a patient's adherence to the treatment. On the contrary, attending FB-DOTS leads patients to travel long distances, which takes a lot of time. In addition, patients need to wait for some more time at health facilities to be seen by the attending clinician or health worker.[36] Thus, the long distance from a patient's home to a health facility, in combination with the time required for travel, might decrease patients' adherence to treatment.[30 35] CB-DOTS has the potential to solve problems related to the need for travelling every day to a health facility to receive DOTS services. Due to the long travel distance and waiting time at health facilities, the chance of skipping breakfast or lunch among patients is high.[29 36] Waiting for a long time on an empty stomach may expose patients to increased drug side effects, and thereby reduce their possibility to adhere to the treatment.[35] Furthermore, most patients under FB-DOTS are likely to have

Table 2 Community vs facility-based DOTS in relation to mean age and mean money paid

Variables		Mean	SD	SEM
Age in years	FB-DOTS (n=774)	32.28	13.84	0.50
	CB-DOTS (n=387)	35.10	15.37	0.78
Money paid in ETB	FB-DOTS	202.98	585.45	21.08
	CB-DOTS	100.91	359.22	18.26

CB-DOTS, community-based directly observed treatment, short course; ETB, Ethiopian birr; FB-DOTS, facility-based directly observed treatment, short course.

increased costs for transportation service, food and other expenses, than patients who chose CB-DOTS.[16] Based on former studies in Ethiopia, various healthcare providers were inspired by the effectiveness and acceptability of a community-based TB care approach for poor communities and households.[37 38] Compared with FB-DOTS, patients who opted for CB-DOTS were less likely to have a positive-sputum smear result at the end of the treatment period. This finding is different from a previous study report in Tanzania, which showed no significant difference in smear conversion rates between patients under CB-DOTS versus FB-DOTS (99.5% vs 99.5%).[15] Our findings may show an optimal implementation of CB-DOTS approach in the study area.

DOTS has been primarily undertaken in facility settings in many developing countries, including Ethiopia. FB-DOTS may lead to a high patient load in health facilities and require patients to travel daily to a health facility for their treatment. CB-DOTS could solve most of these problems. The findings from the present and previous studies conducted in Nigeria, Namibia, Mongolia, Tanzania and Ethiopia, where CB-DOTS was provided by community health workers,[39] community- based health workers,[20] community volunteers,[17] treatment supporters or family members,[15] and HEWs[27] proved that CB-DOTS was more or at least as effective as FB-DOTS. Such findings encourage the involvement of the community health workers or HEWs into TB treatment supervision. The CB-DOTS approach seems to be highly accepted by patients and has been shown to be cost-effective.[27 39]

Our findings suggest that HIV-infected patients with TB were less likely to be under CB-DOTS compared with their counterparts. This finding is similar to a previous study done in Ethiopia, in which patients with HIV positive who opted for FB-DOTS were higher than those who attended CB-DOTS.[19] However, the study result is different from a study reported from Nigeria, where the proportion of HIV-coinfected patients was similar in both DOTS approaches.[39] Our findings may be related to the observed high proportion of rural patients with TB who preferred CB-DOTS compared with the FB-DOTS approach.[19] In Ethiopia, the prevalence of HIV infection is lower in rural areas (0.4%) than urban areas (2.9%).[40]

In this study, sociodemographic factors were found to be linked to patients' choice between the two DOTS approaches. Patients who opted to CB-DOTS were more likely to be illiterate than patients who chose FB-DOTS. The reason for this might be linked to access inequalities in terms of educational opportunity for urban and rural communities in Ethiopia. Based on the 2016 national report, the school enrolment rate for children in urban areas was 57.93%, while it was only 3.36% for rural children.[41] Because a majority of patients who live in rural areas preferred CB-DOTS, most of them may not have gotten the chance for education and may have become illiterate.[41] Our study also revealed that women were more likely to opt to CB-DOTS than men. This finding is in contrast to a study result reported in Ethiopia, whereby a gender difference did not show a statistically significant difference between the two DOTS approaches.[19] Nonetheless, the study result is in line with the findings reported in Tanzania and Mongolia.[15 17] Our findings could be linked to the fact that Ethiopian women are the main caretakers for their families and are occupied with daily home activities. Thus, they may perceive the CB-DOTS option as interfering less with their daily activities, as it is more accessible than FB-DOTS.[27]

According to the WHO and the national TB control programme of Ethiopia, an increasing cure rate and a reducing death rate are among the primary objectives of TB treatment. To help achieve these objectives, anti-TB chemotherapy needs to be provided correctly and regularly taken by patients for the recommended period of time. The proper monitoring of DOTS implementation is crucial to confirm that all patients are adhering to the treatment and attaining a successful treatment outcome.[5] Ensuring that those patients who have received a quality TB treatment with DOTS, and who are able to take the entire course of treatment consistently and completely without interruption, is one of the basic components of TB programmes.[5 42] Health facilities (hospitals and health centres) and health workers alone cannot do all of the TB programme activities. To reach the Global TB elimination goal, more people in the community and other organisations need to be involved in TB care. TB treatment requires taking several types of drugs regularly for the course of several months. This could cause challenges, such as developing drug side effects, lost to follow-up and the stigma of being patients with TB. Therefore, the involvement of HEWs and TB treatment supporters at the community level may help to solve these difficulties.[5 42] Furthermore, improving access to DOTS services is one of the objectives of community TB care, with community-based DOTS and treatment follow-up being one of its components.[5] Studies in Tanzania and Mongolia show that the TB treatment success rate was higher for patients under CB-DOTS than patients under FB-DOTS.[15 17 43] Based on the combined results of all cohort studies and randomised controlled trials,

Table 3 Association of type of TB, sputum smear conversion, HIV/TB coinfection and treatment outcome with type of DOTS approaches among the study participants

Variables		Total cohort (N=1161)	Patients under FB-DOTS (n=774) n (%)	Patients under CB-DOTS (n=387) n (%)	P value
TB classification	Smear-positive PTB	567	364 (47.0)	203 (52.5)	0.097
	Smear-negative PTB	251	166 (21.5)	85 (22.0)	
	Extrapulmonary TB	343	244 (31.5)	99 (25.5)	
TB treatment category	New	1123	747 (96.5)	376 (97.2)	0.560
	Retreatment	38	27 (3.5)	11 (2.8)	
HIV status	Reactive	38	31 (4.0)	7 (1.8)	<0.001
	Non-reactive	1040	669 (86.4)	371 (95.9)	
	Unknown	83	74 (9.6)	9 (2.3)	
Contact person registered with address	Yes	1104	722 (93.3)	382 (98.7)	<0.001
	No	57	52 (6.7)	5 (1.3)	
Sputum result at the end of second or third month	Negative	493	318 (41.1)	175 (45.2)	0.216*
	Positive	16	11 (1.4)	5 (1.3)	
	Not done	58	34 (4.4)	24 (6.2)	
	Not applicable	594	411 (53.1)	183 (47.3)	
Sputum result at the end fifth month	Negative	434	280 (36.2)	154 (39.8)	0.150*
	Positive	5	3 (0.4)	2 (0.6)	
	Not done	120	73 (9.4)	47 (12.1)	
	Not applicable	602	418 (54.0)	184 (47.5)	
Sputum result at the end the treatment	Negative	399	260 (33.6)	139 (35.9)	0.042*
	Positive	3	3 (0.4)	0 (0.00)	
	Not done	156	92 (11.9)	64 (16.5)	
	Not applicable	603	419 (54.1)	184 (47.6)	
TB treatment outcomes	Cured	435	279 (36.1)	156 (40.3)	0.756*
	Treatment completed	573	390 (50.4)	183 (47.3)	
	Died	41	28 (3.6)	13 (3.4)	
	Treatment failure	10	7 (0.8)	3 (0.7)	
	Lost to follow-up	15	10 (1.3)	5 (1.3)	
	Transferred out	34	26 (3.4)	8 (2.1)	
	Not recorded	53	34 (4.4)	19 (4.9)	
TB treatment outcome category	Favourable outcome	1008	669 (86.4)	339 (87.6)	0.854
	Unfavourable outcome	66	45 (5.8)	21 (5.4)	
	Unknown outcome	87	60 (7.8)	27 (7.0)	

*Fisher's exact test was applied.
CB-DOTS, community-based directly observed treatment, short course ; FB-DOTS, facility-based directly observed treatment, short course ; TB, tuberculosis.

systematic reviews and meta-analysis of studies conducted in all high, middle and low-income countries, CB-DOTS provides a successful TB treatment outcome compared with clinic-based DOTS for all pulmonary TB cases. This is because of the cost-effectiveness of CB-DOTS, especially for low-income countries, and its acceptance by most community members.[44] Thus, findings from the present study and previous studies indicated that CB-DOTS is an effective approach to decentralise TB treatment services for a majority of the community.

The present study has several strengths and some limitations. The strengths include use of the strongest observational study design (prospective cohort study design); the risk of recall bias is lower as the data were collected in a prospective manner. In addition, the study has a relatively large sample size and has applied a relative risk

Table 4 Comparison of TB treatment outcomes among patients who opted for CB-DOTS with those opted for FB-DOTS

TB treatment outcomes	CB-DOTS (%)	FB-DOTS (%)	Risk difference (%)	Risk ratio (RR)	95% CI of RR
Cured (1)	40.31	36.05	4.26	1.12	0.96 to 1.30
Treatment completed (2)	47.29	50.39	−3.10	0.94	0.83 to 1.06
Died (3)	3.36	3.62	−0.26	0.93	0.49 to 1.77
Treatment failure (4)	0.78	0.90	−0.13	0.86	0.22 to 3.30
Lost to follow-up (5)	1.29	1.29	0.00	1.00	0.34 to 2.91
Transferred out (6)	2.07	3.36	−1.29	0.62	0.28 to 1.35
Not recorded (7)	4.91	4.39	0.52	1.12	0.65 to 1.93
Favourable outcome (1+2)	87.60	86.43	1.16	1.01	0.97 to 1.06
Unfavourable outcome (3+4+5)	5.43	5.81	−0.39	0.93	0.56 to 1.54
Unknown outcome (6+7)	6.98	7.75	−0.78	0.90	0.58 to 1.39

CB-DOTS, community-based directly observed treatment, short course; FB-DOTS, facility-based directly observed treatment, short course; TB, tuberculosis.

and RD to interpret the findings. The limitation of the study is that our findings could be prone to selection bias because of the patients were not randomly assigned but opted to FB-DOTS and CB-DOTS. We have tried to minimise this by consecutive enrolment of patients in both groups. The selection bias could also happen due to the observed unknown outcomes of transferred out and not recorded (attrition) TB cases. However, since the number of such cases is very low, the effect of selection bias may not significantly affect the interpretation of our findings.

CONCLUSION

Compared with the FB-DOTS approach, the CB-DOTS approach showed a better performance in terms of improving cure rate, lowering the treatment failure rate and improving the sputum conversion rate. These attributes of CB-DOTS make it to be considered as an effective and alternative approach of implementing DOTS in our setting and other resource-limited settings. Our findings show the need for scaling up and a further decentralisation of CB-DOTS approach particularly in the study area generally in Ethiopia to help improve access to TB treatment service for the rural community.

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III

PLOS ONE

RESEARCH ARTICLE

Total delay and associated factors among tuberculosis patients in Jimma Zone, Southwest Ethiopia

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Abstract

Background

Delays in diagnosis and treatment of tuberculosis (TB) increases severity of illness and continued transmission of TB in the community. Understanding the magnitude and factors associated with total delay is imperative to expedite case detection and treatment of TB. The aim of this study was to determine the length and analyze factors associated with total delay.

Methods

Analytic cross-sectional study was conducted in Jimma Zone, Southwest Ethiopia. All newly diagnosed TB patients > 15 years of age were included from randomly selected eight districts and one town in the study area. A structured questionnaire was applied to collect socio-demographic and clinical data. The median total delay was used to dichotomize the sample into delayed and non-delayed patient categories. Logistic regression analysis was used to analyse the association between independent and outcome variables. A p-value < 0.05 were considered statistically significant.

Results

A total of 1,161 patients were included in this study. The median total delay was 35 days. Patients who had swelling or wound in the neck region were more likely to be delayed than their counterpart [adjusted odds ratio (AOR) = 3.02, 95% confidence interval (CI): 1.62, 5.62]. Women were more likely to experience longer total delay (AOR = 1.46, 95% CI:1.00, 2.14) compared to men. Patients who had poor knowledge of TB were more likely to be delayed compared to those who had good knowledge (AOR = 3.92, 95% CI: 2.65, 5.80).

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Conclusion

The present study showed long total delay in diagnosis and treatment of TB. Targeted interventions that enhance TB knowledge and practice, expedite early suspect identification, referral and management of all forms of TB is imperative to reduce total delay in diagnosis and treatment of TB.

1. Introduction

Tuberculosis (TB) is a major cause of illness in low-resource countries. It is among the top 10 causes of death, and has been the leading cause of death from a single infectious agent in recent years [1, 2]. There were an estimated 10.0 million TB cases, and 1.5 million deaths due to TB in 2020 [3]. The 30 high TB burden countries are responsible for the majority (86%) of the estimated incident TB cases [2].

Ethiopia is among the high TB burden countries [3]. TB is a major public health problem and one of the leading infectious diseases in Ethiopia. There were an estimated 140 new incident TB cases per 100,000 population in 2020 and TB mortality rate of 19 per 100,000 populations in 2019 in Ethiopia [4]. Ethiopia accounts for 90,000 (3%) of annually missed TB cases worldwide [2, 5]. A recent national case detection rate of all forms of TB was 76 percent, which is below the target of World Health Organization [3, 6]. One of the contributing factors for low case detection is the delay in diagnosis and treatment of TB. Delay in diagnosis and treatment is commonly divided into three components (patients' delay, health system's delay and total delay). While patient delay refers to the delay period from onset of the major TB symptoms to first visit to a medical provider, health system delay encompasses the delay period from first visit to a medical provider to first start of anti-TB treatment. Total delay is defined as the delay period from start of major TB symptoms to first start of anti-TB treatment. Delay in TB diagnosis and treatment remains a major problem of TB control program generally in low and middle income countries [7] particularly in Ethiopia [8, 9]. Patients' health care seeking delay differs among different regions of Ethiopia [10, 11].

Prompt diagnosis and treatment is crucial for efficient TB control program performance and achieving the End TB targets. The target set for the End TB Strategy for the year 2035 include: 1) reduction of TB mortality by 95%, 2) decreasing TB incidence by 90% (i.e compared to the baseline of 2015), and 3) to certify that no family is suffered with TB related catastrophic costs [12]. The End TB Strategy targets can only be realized if diagnosis, treatment, and preventive services for TB are delivered based on the context of universal health coverage, which implies that all people with TB should be early detected and properly treated [2, 5]. Delayed diagnosis and treatment of TB cases has major role in the transmission of the disease in the community in most high TB burden countries. Early diagnosis and proper treatment of TB will reduce severity of illness, prevent transmission, increase cure rate, and prevent the development of drug-resistant TB [2, 13].

Various studies have been conducted on delays in diagnosis and treatment of TB in different parts of the world [14–21]. A systematic review and meta-analysis conducted in low- and middle-income countries showed that the median total delay ranged from 30 in Zimbabwe and Vietnam to 366.5 days in Afghanistan [7]. Another systematic review and meta-analysis conducted in Ethiopia revealed that the median diagnostic of 45days. The prevalence of diagnostic delay in Ethiopia ranged from 9.57% in Addis Ababa city and 68.84% in Somali region [22]. Various factors that are associated with diagnostic and treatment delay were identified in

earlier studies in Ethiopia and elsewhere. Some of these factors included poor knowledge about TB [23], patient first visit to lower level facilities [21], long distance to health facility [19], low level of income [23], being female [19, 24], being illiterate [15, 22], perceived TB stigma [25], rural residence [19, 22], having extra-pulmonary TB [14, 22, 26], having smear negative pulmonary TB [26], self-treatment [21, 23, 26], being HIV negative [22, 23], absence of chest pain and presence of haemoptysis [17] etc.

Although various studies were conducted in Ethiopia and elsewhere to assess TB diagnostic and treatment delay, there is limited study to date that has been conducted to assess the length and associated factors of total delay in diagnosis and treatment of TB in Jimma Zone, Ethiopia. The length of total delay and associated factors may vary according to the local setting, including the socio-demographic and economic condition of the population in the study area [10, 11]. Understanding the contribution of these factors is important to propose targeted interventions to address diagnostic and treatment delay at the local setting. Therefore, the aim of the present study was to determine the length and analyze factors associated with total delay in Jimma Zone, Ethiopia.

2. Materials and methods

2.1. Study setting and design

Analytic cross-sectional study was conducted among all forms of TB patients who started treatment from September 2016 to October 2017. The study was conducted in Jimma Zone, Oromia Region, Southwest Ethiopia. Jimma Zone is located 354 kilometres from Addis Ababa, the capital city of Ethiopia, with a total area of 199,316.18 square kilometres [Jimma Zone health office, 2016]. According to 2017 projected population census, Jimma Zone had an estimated population of 3,261,371, of which 49.9% were women [27]. In 2016, the Zone had 17 districts and two town administrations. A total of seven public hospitals (five were primary, one general and one specialized); 120 health centres, and 494 health posts were registered in the study area during the study period. The hospitals and health centres have been providing TB diagnostic and treatment services. Health extension workers at health posts have been rendering TB treatment services, screening and referring of TB suspects to the nearest health facilities for confirmatory testing. Non-governmental health facilities such as the Catholic mission and several private clinics were also providing TB diagnostic and treatment services. In 2016, a total of 3,008 all forms of TB patients were identified in Jimma Zone. Among these, 1,468 patients were bacteriologically confirmed pulmonary TB cases [Jimma Zone health office, 2016; Jimma town health office, 2016].

2.2. Study population and sampling

A total of 1,161 newly diagnosed TB patients were included from sampled districts' public health facilities and health posts. Patients whose age was less than 15 years, who could not respond to the interview questions and critically ill patients were excluded from the study. Eight districts and one town administration were selected from the 17 districts and two town administrations by using a simple random sampling method. Subsequently, all TB DOTS sites in the sampled districts and a town administration were covered by the study.

This study is part of a PhD project. It follows a recently published sub-study that compared community- versus facility-based DOTS in a cohort study that enrolled a total of 1,161 study participants [28]. We included all of the 1,161 study participants in the current study. However, in order to address the research objective in the current study, a total sample of 422 calculated using formula for estimating single proportion could have been enough (i.e. considering 50% proportion of delay of more than one month at 95% confidence interval and a margin

error of 5%). The inclusion of the 1,161 study participants in the current study is advantageous as it provides more than adequate representative population to address the research questions. The sample size was proportionally allocated to the selected public health facilities based on the previous one year's (before the study's start) patient flow. The study participants were consecutively included until the required sample size was achieved [Fig 1].

2.3. Data collection and analysis

A structured questionnaire was developed based on the national and WHO's guidelines; and previous studies [29–34]. The questionnaire was translated to the local language (Afan Oromo) by a professional whose mother tongue is the local language. It was checked and peer reviewed for any inconsistencies between the translated version and the original English version of the questions. The translated version of the questionnaire was re-translated to English by another professional who fluently spoke and wrote the local language. Then, it was pre-tested to check for the clarity and applicability of the questionnaire for the context of the study area. Based on the findings of the pre-test, modifications such as clarifying statements were

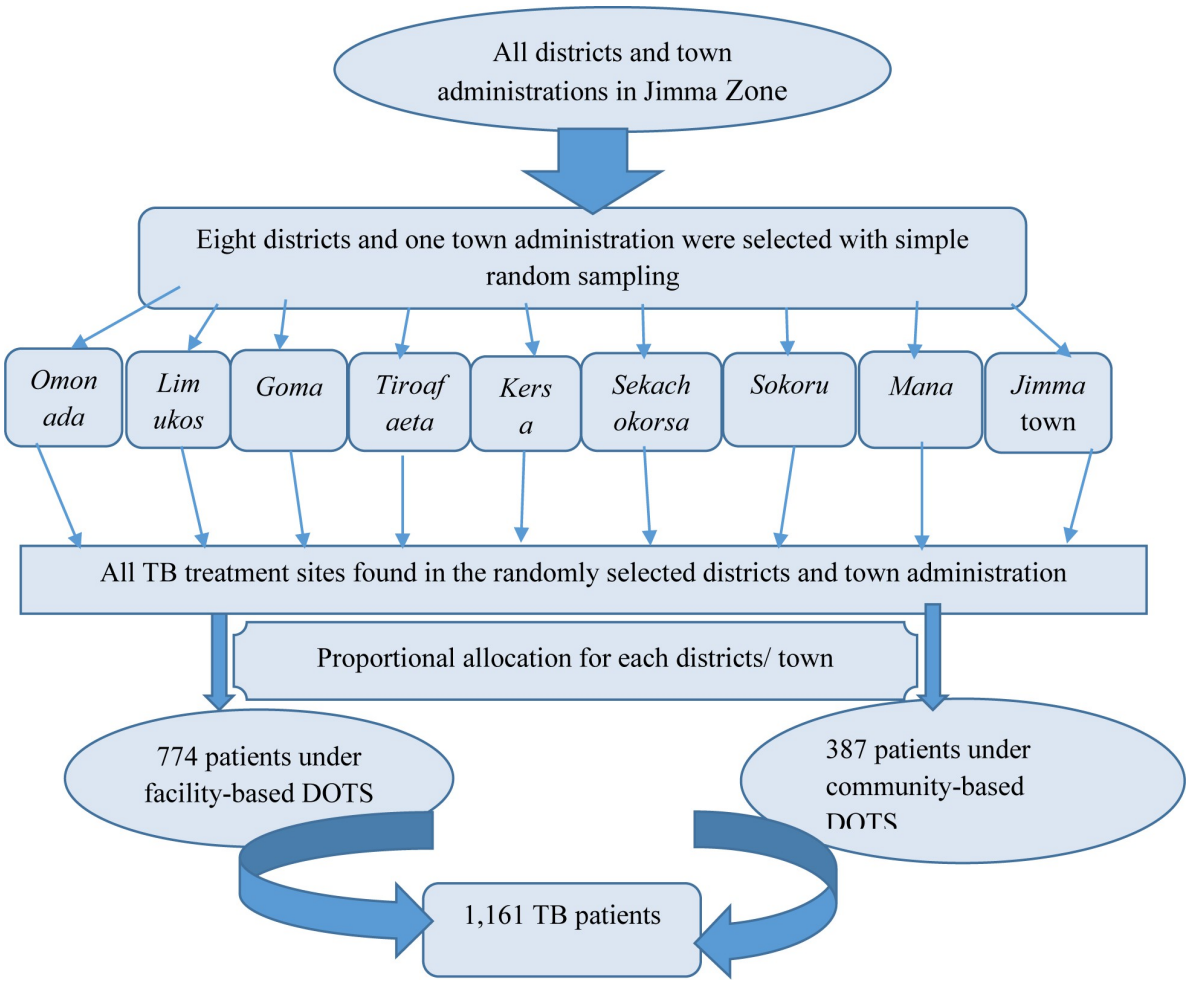

Fig 1. Schematic presentation of sampling procedure for TB patients, Jimma Zone, 2017.

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made. We recruited experienced data collectors and supervisors and they were provided with the required training on the data collection and supervision techniques. The whole process of data collection was supervised by the principal investigator. The study participants were consecutively enrolled starting from September 2016 to October 2017. They were all interviewed during the enrolment time. Clinical data such as HIV status, main mode of TB diagnosis, TB classification were collected by a checklist attached to the questionnaire from TB register.

The collected data were checked for completeness and consistency, coded and entered into the EpiData entry client software, version 4.4.3.1. Then, the data were exported to the statistical package for social sciences software (SPSS) version 21 for analysis. Descriptive statistics were computed for the variables. To assess TB knowledge, a score of one was given for the correct responses and a score of zero was given for wrong responses. Then the total knowledge score and median score were computed. Those with a total score of less than the median value were categorized as having poor knowledge, while those who scored greater than or equal to the median value were classified as having good TB knowledge. Likewise, the total perceived stigma and median scores were determined. Those with a total score of less than the median value were classified as not having perceived stigma, whereas those who scored greater than or equal to the median value were categorized as having perceived stigma.

The median total delay was used to categorize the sample into delayed and non-delayed patient groups. To analyse the association of independent variables with the dependent variable, we used binary logistic regression analysis. First, bivariable analysis was performed for each independent variable against the respective outcome variable and crude odds ratio (COR) was calculated. Multivariable analysis was conducted comprising candidate variables in the bivariable analysis that scored a p-value of < 0.25 with a backward stepwise method. Besides, the respective adjusted odds ratios (AOR) and 95% confidence intervals (CI) were computed. A p-value < 0.05 was considered statistically significant.

2.4. Operational definitions

Patient delay: the time from onset of symptoms (cough) until first visit to a medical provider.

Health system delay: the time between the first visit to a medical provider and the first start of anti-TB treatment.

Total delay: the period between onset of TB symptoms and the first start of anti-TB treatment (the sum of patient delay and health system delay).

Delayed: operationally defined as delayed if the period between the onset of TB symptoms and first start of anti-TB treatment is more than the calculated median total delay (> 35 days).

Community based DOTS: TB treatment offered at a health post or patient's residence by a HEW or a trained TB treatment supporter.

Facility based DOTS: TB treatment offered at public health facility (health center or hospital) by a trained health care provider.

Medical provider/ formal health care provider: include hospitals, health centres, health posts, private clinics, and drug retail outlets.

Non formal-health care providers: traditional healers or herbalists, religious healers.

2.4.1. TB diagnosis. The national guideline for TB, and DR-TB was followed to diagnosis and treat TB [5]. Health care providers identify, triage and examine individuals who present with persistent cough of two or more weeks (any duration for HIV positive), fever for more than two weeks, night sweats, and weight loss of more than 1.5 kg per month. TB diagnosis is made with proper investigations using one or more of the following methods: mycobacteriologcal examination, chest x-ray, and cytological/histopathology (analysis of body parts/fluids) examinations. Acid-fast-bacilli (AFB) smear microscopy is the most common method used for

TB diagnosis and follow up of treatment response. A patient is diagnosed as a pulmonary positive TB case, when he/she has at least one positive result on AFB microscopy, or when his/ her Xpert MTB/RIF test result is positive for mycobacteria. A patient is diagnosed as a pulmonary negative TB case when he/she has signs and symptoms suggestive of TB with at least two negative result on AFB smear microscopy, and secondly, when his/her Xpert MTB/RIF test results detects mycobacterium and a decision to treat with a full course of anti-TB drugs is made. The decision is made based on suggestive findings from supporting laboratory tests and with the aid of proper clinical examination [5].

2.5. Ethical considerations

Ethical clearance was sought from the Regional Committee for Medical Research Ethics (REK Øst), Norway with reference number of 2015/2124 REK sør-øst B. Ethical approval was also obtained from the Institutional Review Board of Jimma University, Ethiopia with reference number of RPGC/389/2016. Permission was granted from Oromia regional health bureau, Ethiopia with reference number of BEFO/ABTF/1-8/2026 and Jimma zone health office, Ethiopia with reference number of WEFBJ/ 0-11/8060/08. Written (for literate) and oral (for illiterate) informed consent was secured from the study participants before starting the data collection. For minors (15 – 17years), assent was obtained from the study participants and consent was secured from their parents or guardians.

2.6. Inclusivity in global research

Additional information regarding the ethical, cultural and scientific considerations specific to inclusivity in global research is included in the S3 Text.

3. Results

3.1. Characteristics of the study participants

In this study, we assessed the length of total delay and associated factors among TB patients in Jimma Zone, Ethiopia. Accordingly, a total of 1,161 patients participated in this study: 774 (66.7%) under FB-DOTS, 387(33.3%) under CB-DOTS) were included. Of these, 51.2% were male, 65.9% were married, and 39.5% were illiterate. The mean (± SD) age for the study participants was 32.2 (±14.41) years, with a range of 15 to 90 years. Nearly half (46.9%) of the patients were 25–44 years of age. Of the total study participants, 63.7% were farmers by occupation, 51.7% were rural residents, and 48.8% were smear-positive pulmonary TB patients (Table 1).

3.2. Study districts and time to reach the nearest medical provider

A majority (18.9%) of the study participants were from *goma* district. The mean (± SD) time taken to reach the nearest medical provider was 32.86 (±28.52) minutes, ranging from two to 180 minutes (Table 2).

3.3. Patients' first visit to medical providers

A total of 708 (60.98%) patients visited other medical providers (health posts and private clinics) before visiting the current health facility where they got their TB diagnosis and initiated anti-TB treatment. Of these, a majority (169) of the patients who first visited private clinic were not delayed. On the contrary, most (45) of the patients who visited health posts were delayed (Fig 2).

Table 1. Socio-demographic and clinical characteristics of the study participants in Jimma Zone, 2017 (N = 1,161).

Variables		Frequency	Percent (%)
Sex	Male	594	51.2
	Female	567	48.8
Age in year	15–24	365	31.4
	25–44	544	46.9
	45–64	202	17.4
	≥65	50	4.3
	Mean ± SD (32.22±14.41); Minimum 15; Maximum 90; Median 30 (IQR 22, 40)		
Marital status	Single	330	28.4
	Married	765	66.1
	Divorced	30	2.6
	Widowed	34	2.9
Educational level	Illiterate	459	39.5
	Read and write only	98	8.4
	Primary school	396	34.1
	Secondary school	132	11.4
	College/University	76	6.5
Occupation	Farmer	739	63.7
	Merchant	74	6.4
	Government or NGO employee	58	5.0
	Daily laborer	88	7.6
	Housewife	19	1.6
	Student	142	12.2
	Unemployed	41	3.5
Religion	Orthodox Christian	160	13.8
	Muslim	939	80.8
	Protestant	61	5.3
	Catholic	1	0.1
Residence	Urban	561	48.3
	Rural	600	51.7
Source of household income	Farming	769	66.2
	Monthly salary	59	5.1
	Private/ trading	78	6.7
	Daily payment	82	7.1
	Family/relative	152	13.1
	Prefer not to answer	21	1.8
Monthly household income in ETB	≤ 1000	584	50.3
	1001–2500	388	33.4
	2501–3500	41	3.5
	> 3500	90	7.8
	Do not have regular income	58	5.0
Previous contact with TB patient	Yes	118	10.2
	No	807	69.5
	Don't know /not sure	236	20.3
Cigarette smoking	Yes	71	6.1
	No	1090	93.9
Variables		Frequency	Percent (%)

(*Continued*)

Table 1. (Continued)

Variables		Frequency	Percent (%)
Drink alcohol	Yes	93	8.0
	No	1068	92.0
Khat chewing	Yes	599	51.6
	No	562	48.4
Previous Rx for TB	Yes	33	2.8
	No	1128	97.2
History of diabetes mellitus	Yes	12	1.0
	No	1149	99.0
Main source of information about TB	Health care providers	914	78.7
	TV/Radio	172	14.8
	Family/relative	53	4.6
	Others	22	1.9
Type of DOTS	Facility-based	774	66.7
	Community-based	387	33.3
TB classification	Smear-positive pulmonary TB	567	48.8
	Smear-negative pulmonary TB	251	21.6
	Extra pulmonary TB	343	29.5
Main mode of TB diagnosis	Bacteriological	592	51.0
	Histopathology/ Biopsy	226	19.5
	Radiological	301	25.9
	Clinical clues	42	3.6
HIV status	Reactive	38	3.3
	Non-reactive	1040	89.6
	Unknown	83	7.1

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3.4. Patient delay and total delay

The median patient delay (time from onset of symptoms until first visit to a medical provider) was 30 days [interquartile rang (IQR): 17.5, 60 days]. Whereas, the median total delay was 35 days (IQR: 25, 67 days). The total delay ranged from 4 to 732 days (Table 3).

Table 2. Districts and time to reach the nearest medical provider of the study participants at Jimma Zone, 2017 (N = 1,161).

Variables		Frequency	Percent (%)
District / town administration	*Goma*	220	18.9
	Jimma	157	13.5
	Kersa	122	10.5
	Limu kosa	144	12.4
	Mana	97	8.4
	Omo nada	102	8.8
	Seka chokorsa	120	10.3
	Sokoru	108	9.3
	Tiro afeta	91	7.8
Time to reach nearest medical provider in minutes	≤ 30	792	68.2
	31–60	278	23.9
	> 60	91	7.9
	Mean ± SD (32.86±28.52); Minimum 2; Maximum 180; Median 25 (IQR 15, 45)		

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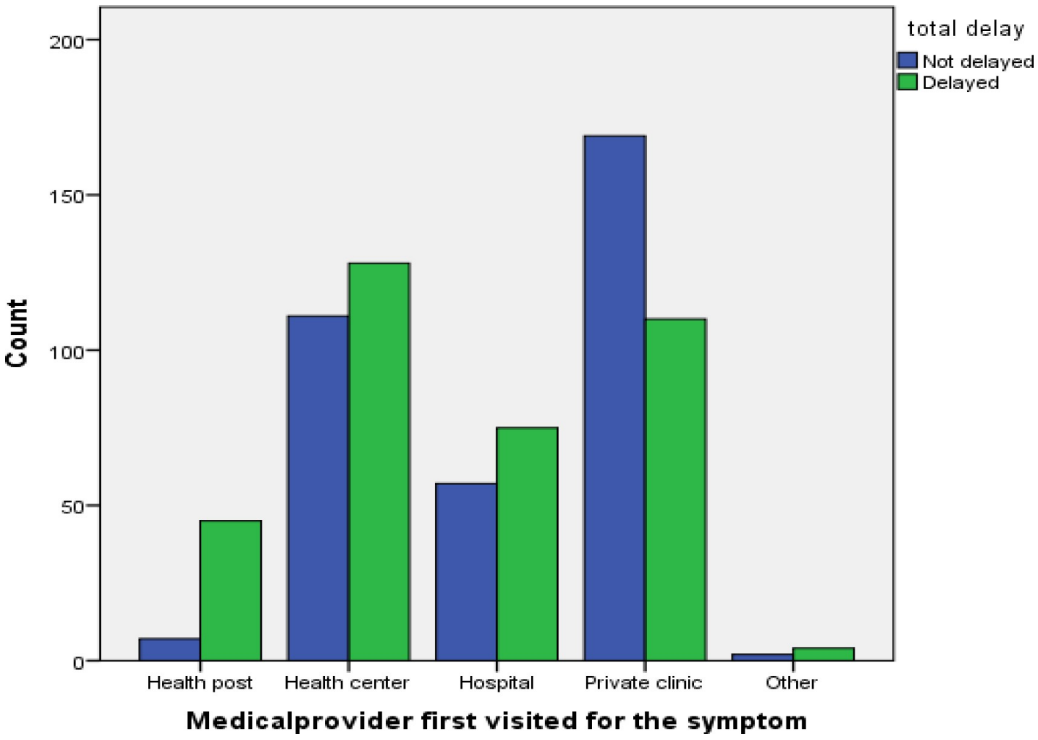

Fig 2. Medical provider first visited for the symptoms with patient delay status at Jimma Zone, 2017.

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3.5. Determinants of total delay

The median total delay was 35(IQR 25, 67 days) days, and for more than half (586) of the patients, the total delay was > 35 days. Variables such as occupation, source of household income, being a smoker, alcohol use, khat chewing, HIV status, TB classification, chest pain, and weight loss were removed from the final model even if these were statistically significant during the bivariate analysis. In the multivariate analysis, patients who had poor knowledge about TB were about four times more likely to be delayed than patients who had good knowledge about TB (AOR = 3.92, 95% CI: 2.65, 5.80). Those patients who had swelling or wound in the neck region were three times more likely to be delayed than their counterpart (AOR = 3.02, 95% CI: 1.62, 5.62). Patients who attended college or university were 72% less likely to be delayed than those patients who did not read and write (AOR = 0.28, 95% CI: 0.10, 0.81). Female patients were about 1.5 times more likely to be delayed than their counterparts (AOR = 1.46, 95% CI: 1.00, 2.14). Patients who had a monthly household income of 1001–2500 ETB had increased total delay compared to patients who earned > 3500 ETB

Table 3. Patient, health system and total delays for the study participants in Jimma Zone, 2017.

Variable	Median	IQR	Minimum	Maximum
Duration from onset of symptoms until first visit to a medical provider in days	30.00	17.5, 60	2	730
Duration from first visit to a medical provider until diagnosis of TB in days	3.00	2, 9	1	365
Duration from diagnoses of TB until treatment started in days	1.00	1, 2	1	90
Total time taken from start of TB symptoms until start of treatment	35.00	25, 67	4	732

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(AOR = 15.75, 95% CI: 2.92, 84.91). Those patients who traveled 30 or less minutes to reach the nearest medical provider were 53% less likely to be delayed than those patients who traveled more than 60 minutes (AOR = 0.47, 95% CI: 0.23, 0.94). Patients under CB-DOTS were about 1.5 times more likely to be delayed than their counterparts (AOR = 1.53, 95% CI: 1.02, 2.29). Patients who had no limitation of their day-to-day activity were less likely to be delayed than those patients who had high limitation of their day-to-day activity (AOR = 0.09, 95% CI: 0.01, 0.89) (Table 4).

4. Discussion

In this study, we assessed the length and associated factors of total delay among TB patients. A systematic review and meta-analysis conducted in low- and middle-income countries reported that the median total delay ranged from 30 to 366.5 days [7]. We observed a median total delay of 35 days which is similar to the study done in Addis Ababa, Ethiopia [35], but lower than the findings reported from earlier studies conducted in different Regions of Ethiopia [23, 25, 36–38]. The shorter total delay observed in the present study may be related to several reasons: these may include improved access to TB diagnostic and treatment facilities through decentralization of health services to the community, and health extension workers' contribution in identifying suspected TB cases and referring them to health centers for smear microscopy test [39].

Even though the observed total delay in our study was relatively lower compared to earlier study findings in Ethiopia, it is still long delay given the need for immediate diagnosis and treatment initiation for TB patients. In a recent qualitative study conducted in the study area, different barriers were identified that may have implications for increased total delay. Among these were shortage of resources including basic infrastructure and limited TB diagnostic services; and delays in the diagnostic process at the health facilities [40]. Solving these barriers through targeted interventions is crucial to reduce the observed relatively long total delay. Long delays in diagnosis and treatment initiation increase the severity and complications of disease that may result in unfavorable treatment outcome [37, 41]. It also increases the risk of developing drug resistant TB which leads to treatment failure, high mortality rates, and high transmission rate of drug resistant TB [42, 43]. These findings emphasize the importance of early diagnosis and prompt treatment of TB. Conversely, the observed median total delay in the current study is higher than the study findings in other parts of Ethiopia that reported 23 days and 33 days [8, 9]. This discrepancy might be because of differences in the study settings i.e. socio-economic status, study population, access to TB diagnostic facilities, and utilization of health care services among the population.

The analysis of socio-demographic, economic, and clinical factors revealed significant associations with increased total delay. In line with our study, low level of education [7, 25, 36, 38], long distance [19, 36], and poor knowledge about TB [23, 36, 37] were identified as predictors of total delay in former studies in Ethiopia and elsewhere. Our findings underscored that educational level is an important determinant of total delay. A former study in Ethiopia revealed that individuals with a higher level of education had better knowledge about TB compared to those who did not read and write [44]. Our study showed that the educational level of the patients may not be directly associated with the delay but do significantly affect the knowledge level of the study participants. A study from the Gambia showed an association of educational level with knowledge, attitude and health-seeking behavior regarding TB [45]. Another study from Malaysia reported that TB education program at school was an effective intervention for improvement in the mean score of knowledge, preventive practice, and perceived stigma about TB [46]. In addition, a study conducted in Ethiopia indicated that there was association

Table 4. Determinents of total delay among the study partcipants at Jimma Zone, 2017.

Variables		Total delay, No (%)		COR (95% CI)	AOR (95% CI)	P-values
		Not delayed ≤ 35 days (median)	Delayed > 35 days (median)			
Sex	Male	297 (51.7)	297 (50.7)	1	1	
	Female	278 (48.3)	289 (49.3)	0.96 [0.76,1.21]	1.46 [1.00,2.14]	0.050
Age groups in years	15–24	185 (32.2)	180 (30.7)	1	1	
	25–44	269 (46.8)	275 (46.9)	0.60 [0.33,1.09]	0.59 [0.20,1.72]	0.331
	45–64	102 (17.7)	100 (17.1)	0.63 [0.35,1.14]	0.53 [0.19,1.47]	0.220
	≥ 65	19 (3.3)	31 (5.3)	0.60 [0.32,1.13]	0.49 [0.17,1.39]	0.181
Educational level	Illiterate	177 (30.8)	282 (48.1)	1	1	
	Read and write only	63 (11.0)	35 (6.1)	1.97 [1.21,3.21]	0.74 [0.25,2.19]	0.590
	Primary school	212 (36.9)	184 (31.4)	0.69 [0.37,1.27]	0.41 [0.13,1.27]	0.122
	Secondary school	81 (14.1)	51 (8.7)	1.07 [0.66,1.76]	0.36 [0.13,1.02]	0.053
	College/University	42 (7.3)	34 (5.8)	0.78 [0.44,1.38]	0.28 [0.10,0.81]	0.019
Occupation	Farmer	365 (63.5)	374 (63.8)	1	1	
	Merchant	37 (6.4)	37 (6.3)	0.48 [0.24,0.93]	0.84 [0.18,3.97]	0.820
	Go/NGO employee	33 (5.7)	25 (4.3)	0.46 [0.21,1.03]	0.38 [0.02,7.29]	0.523
	Daily labourer	33 (5.7)	55 (9.4)	0.35 [0.15,0.81]	1.351 [0.07,27.31]	0.845
	House wife	7 (1.2)	12 (2.0)	0.77 [0.35,1.69]	0.56 [0.05,6.78]	0.652
	Student	87 (15.1)	55 (9.4)	0.80 [0.25,2.49]	1.44 [0.19,10.69]	0.722
	Unemployed	13 (2.3)	28 (4.8)	0.29 [0.14,0.62]	0.61 [0.16, 2.27]	0.457
Source of Household income	Farming	380 (66.1)	389 (66.4)	1	1	
	Monthly salary	36 (6.3)	23 (3.9)	6.14 [1.80,21.02]	0.17 [0.02,1.54]	0.114
	Private/trading	40 (7.1)	38 (6.5)	3.83 [1.01,14.49]	0.14 [0.01,1.54]	0.107
	Daily payment	28 (4.9)	54 (9.2)	5.70 [1.55,20.92]	0.37 [0.04,3.58]	0.387
	Family/relative	73 (12.7)	79 (13.5)	11.57 [3.14,42.66]	0.50 [0.05,4.95]	0.552
	Prefer not to answer	18 (3.1)	3 (0.5)	6.49 [1.84,22.96]	0.39 [0.05,3.31]	0.389
Monthly Household income in ETB	≤ 1000	301 (52.3)	283 (48.3)	5.88 [2.74,12.61]	9.51 [1.82,49.72]	0.008
	1001–2500	162 (28.2)	226 (38.6)	8.72 [4.02,18.89]	15.75 [2.92,84.91]	0.001
	2501–3500	23 (4.0)	18 (3.1)	4.89 [1.86,12.88]	6.92 [1.03,46.58]	0.047
	> 3500	39 (6.8)	51 (8.7)	1	1	
	No regular income	50 (8.7)	8 (1.4)	8.17 [3.48,19.22]	13.29 [2.27,77.65]	0.004
Time to reach nearest medical provider in minute	≤ 30	391 (68.0)	401 (68.4)	0.77[0.49,1.19]	0.47[0.23,0.94]	0.034
	31–60	145(25.2)	133(22.7)	0.69[0.43,1.12]	0.68[0.31,1.46]	0.317
	> 60	39(6.8)	52(8.9)	1	1	
Cigarette smoking	Yes	25 (4.3)	46 (7.8)	1.87 [1.14,3.09]	1.22 [0.54,2.75]	0.627
	No	550 (95.7)	540 (92.2)	1	1	
Alcohol use	Yes	36 (6.3)	57 (9.7)	1.61[1.05,2.49]	1.01 [0.49,2.08]	0.985
	No	539 (93.7)	529 (90.3)	1	1	

(*Continued*)

Table 4. (Continued)

Khat chewing	Yes	320 (55.7)	279 (47.6)	0.72 [0.58,0.91]	0.83 [0.56,1.24]	0.356
	No	255 (44.3)	307(52.4)	1	1	
HIV status	Reactive	20 (3.5)	18 (3.1)	1	1	
	Non-reactive	525 (91.3)	515 (87.9)	0.51[0.23,1.11]	0.98 [0.28,3.45]	0.970
	Unknown	30 (5.2)	53 (9.0)	0.56 [0.35,0.88]	0.96 [0.47,1.98]	0.917
Current illness status	No limitation of day-to-day activity	362 (63.0)	229 (39.1)	0.25 [0.05,1.31]	0.09 [0.01,0.89]	0.040
	Slight limitation	211(36.7)	352(60.0)	0.67 [0.13,3.47]	0.22 [0.02,2.12]	0.189
	High limitation	2(0.3)	5(0.9)	1	1	
Variables		**Total delay, No (%)**		**COR (95% CI)**	**AOR (95% CI)**	**P-values**
		Not delayed ≤ 35 days (median)	Delayed > 35 days (median)			
Type of DOTS	Facility-based	360 (62.6)	414 (70.6)	1	1	
	Community-based	215 (37.4)	172 (29.4)	1.44 [1.13,1.84]	1.53 [1.02,2.29]	0.041
TB classification	Smear-positive PTB	306 (53.2)	221 (44.5)	1	1	
	Smear-negative PTB	131(22.8)	120 (20.5)	0.57 [0.44,0.75]	0.78 [0.48,1.26]	0.309
	Extra PTB	138(24.0)	205(35.0)	0.62 [0.44,0.86]	1.07 [0.64,1.79]	0.798
Medical provider first visited for symptoms	Health post	7 (2.0)	45 (12.4)	1	1	
	Health center	111(32.1)	128 (35.4)	3.21 [0.49,20.96]	2.23 [0.25,19.50]	0.470
	Hospital	57 (16.5)	75 (20.7)	0.58 [0.10,3.21]	0.79 [0.12,5.86]	0.814
	Private clinic	169 (48.8)	110(30.4)	0.66 [0.12,3.72]	0.49 [0.07,3.77]	0.499
	Other	2 (0.6)	4 (1.1)	0.33 [0.06,1.81]	0.39 [0.05,2.89]	0.356
Chest pain	Yes	395 (68.7)	328 (56.0)	1	1	
	No	180 (31.3)	258 (44.0)	0.58 [0.46,0.74]	0.75 [0.50,1.13]	0.172
Haemoptysis	Yes	83 (14.4)	75 (12.8)	0.87 [0.62,1.22]	1.24 [0.68,2.27]	0.479
	No	492 (85.6)	511 (87.2)	1	1	
Weight loss (10%)	Yes	372 (64.7)	345 (58.9)	0.78 [0.62,0.99]	1.28 [0.86,1.91]	0.217
	No	203 (35.3)	241(41.1)	1	1	
Swelling or wound around neck region	Yes	42 (7.3)	106(18.1)	2.80[1.92,4.09]	3.02 [1.62,5.62]	< 0.001
	No	533 (92.7)	480(81.9)	1	1	
Knowledge about TB	Poor	130 (22.6)	333 (56.8)	4.51[3.49,5.81]	3.92 [2.65,5.80]	< 0.001
	Good	445 (77.4)	253 (43.2)	1	1	
Perceived to be stigmatized	No	183 (31.8)	183 (31.2)	0.97 [0.76,1.25]	1.40 [0.89,2.20]	0.143
	Yes	392 (68.2)	403 (68.8)	1	1	

AOR = adjusted odds ratio; COR = crude odds ratio; CI = confidence interval. 1 = Reference group

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between educational level and knowledge about TB in which having good knowledge of TB led to a more positive attitude and better practice in relation to TB prevention and control [47]. This was supported by findings from a qualitative meta-synthesis conducted in Nigeria which reported that low education level and poor knowledge about TB were major barriers to TB diagnosis and treatment [20]. Compared to the uneducated persons, individuals with better educational level are more likely to have access to better economic situation which consecutively improves their access to health information and care [8, 44]. Moreover, the level of their knowledge about TB influence their perceptions about TB and change their health care-seeking behaviour [8, 44].

We observed a strong association between having swelling or wound in the neck region and long total delay. Cervical TB lymphadenitis is one of the most common manifestations of

extra-pulmonary TB which contributes to diagnostic delay. The common sign and symptom is a chronic, painless swelling in the neck region (no other remarkable symptom). Thus, the diagnosis of this type of TB requires a high index of suspicion and use of different diagnostic methods. Practically, it is not possible to apply all diagnostic procedures for all symptomatic patients. In this regard, ruling out for other causes of neck mass could contribute to diagnostic delay. Because of the absence of culture and pathology services in most health centers in Ethiopia including the study area, it is difficult to early diagnose such type of TB [48, 49]. A study from Zanzibar showed that from all patients with long total delay (> 6 months), a majority (90%) were patients with TB lymphadenitis [50]. Extra-pulmonary TB cases are seldom infectious as they are considered to have less contribution in TB transmission. However, delay in starting treatment for the patients may result in disseminated TB and increased mortality [49, 50]. As peripheral health care facilities in the study area do not have the capacity to diagnose extra-pulmonary TB cases, it is important to develop diagnostic algorithms for timely referral of presumptive extra-pulmonary TB patients. Therefore, training is essential for the health extension workers so that they can screen TB lymphadenitis suspects in the community for prompt referral to the next level of health care for better diagnosis and treatment [51].

Our study revealed that women were more likely to have long total delay compared to men. This finding is consistent with former studies conducted in Ethiopia and elsewhere [36, 52, 53]. Economic status, cultural beliefs, and perceived stigma are barriers of early care seeking for most female patients [54]. In terms of cultural beliefs, women in Ethiopia give priority for their family than themselves, have main responsibility for children care, have less decision making power, and worries about preserving modesty might affect their health care seeking behavior [55]. Previous study revealed that women were more likely to suffer from TB stigma compared to men [56]. Women in high burden countries like Ethiopia experienced long delays in TB diagnosis and treatment because of challenges related to TB services [57]. Most women faced problems in accessing TB service because of resource limitations, power imbalances, and poor knowledge about TB [57]. Women who have less access to quality healthcare, and delayed to seek formal health care were prone to long delays [54]. This may partly be related to the fact that women have the main responsibility for domestic tasks and care for their family members, especially children and elders. Women often lack economic independence, have less time and are less empowered compared to men in regards to care for themselves [36]. Therefore, it is important to recognize sex differences in individual's TB care-seeking. Targeted interventions that enhance women empowerment are required to improve poor health outcomes among women. Socio-economic support interventions could change their health seeking behaviour, improve adherence and treatment outcome for TB patients who are women [58, 59]. In addition, gender-based health education and behavioural change communication (BCC) interventions focusing on early health seeking counselling are required to reduce the burden of TB among women. BCC strategies are efficient, effective, sustainable and acceptable because messages can tailored to gender- or age-based target groups [60, 61].

Monthly household income was another determinant variable that was significantly associated with total delay. This finding is in line with previous study results from Ethiopia [8, 62, 63] and Pakistan [18]. This could be due to the fact that individuals who did not have adequate monthly income could not be able to seek health care early because of several reasons such as unaffordable medical costs and transport expenses [8, 63]. Therefore, they are likely to be prone to delayed diagnosis and treatment start. In resource limited settings like Ethiopia where there are several traditional practices and low access to quality health service, patients commonly seek health care from informal medical providers, as a result the patients might get traditional treatment that could delay them from timely seeking medical care from formal medical providers. TB diagnosis and treatment services in Ethiopia is given for free, money is

mostly needed for covering costs for transportation, accommodation and food for the patient. Individuals who have low level of income may need to work long hours, as a result they may not have time to early seek health care when they get ill. Patients with inadequate income are more likely to visit formal-health care provider only when they become critically ill [8, 63]. A systematic review conducted in high TB burden settings reported that livelihood, work, and family were given priority which led them to have a long delay in health care-seeking [57]. This finding shows the importance of improving the socio-economic condition of the population for effective TB control. As per the Sustainable Development Goals (SDG), the world is committed to end poverty by 2030 [64, 65]. According to a recent World Bank report, the poverty rate in Ethiopia fell from 44 percent in 2000 to 21 percent in 2018 [66, 67]. If this trend continues, the contribution of poverty to TB disease and transmission may be significantly reduced in Ethiopia including the study area.

Time taken to reach the nearest medical provider was associated with total delay. Long distance traveling to reach the nearest health facility was also reported in previous studies conducted in Ethiopia and other countries as barrier to individuals' health-seeking behavior which leads to lengthening of patient's delay [17, 68–72]. A recent qualitative study from the study area identified that long distance traveling to get TB diagnostic services was a barrier for most TB patients from the rural settings [40]. This could also be related with patients who were under FB-DOTS travel longer distance and more delayed than those patients under FB-DOTS.

Our study showed that patients under CB-DOTS were more likely to be delayed than those patients under FB-DOTS. This could be due to the fact that patients under CB-DOTS were rural residents and most of patients under FB-DOTS were urban residents. Rural residence was reported as independent predictor of delay in a systematic review conducted in Ethiopia [11]. One of the reasons might be that rural residents had poor access to health information and TB diagnostic and treatment facilities compared to urban residents. This might be due to the scarcity of formal health care providers in rural area of Ethiopia. Thus, patients from rural areas might take long chains of care-seeking through informal health care providers [57, 73]. A previous study from Southwest Ethiopia revealed that proportion of households sought care from formal health care providers was lower among rural compared to urban households [74]. Moreover, rural residents lack regular health information about the disease and do not seek health care early compared to the urban residents [10, 11]. In addition, rural residency makes it hard to travel to diagnostic and treatment facilities due to absence of road or distance (as long distance travelling discourages initiation of tuberculosis treatment) [10, 11].

This study has strengths and limitations. The strength of the study is that we included a relatively larger sample size compared to sample sizes used in other similar studies in Ethiopia. Thus, it provides more than adequate representative population to address the research questions. With regards to potential limitations, the study was only carried out in government health facilities; hence the findings cannot be generalized to all TB patients in the study area. There are also several private health care facilities and non-formal health care providers whereby TB patients may seek health care for their symptoms. Moreover, the present study focused on adult TB patients aged $>$ 15 years who were treated at public health facilities; therefore, the results among other age groups and in other similar settings during the study period might be different. In addition, the reported duration of symptoms and first visit for treatment seeking is based on patients' ability to recall and interpretation of their symptoms. Since patients might not exactly remember the exact date of start of their symptoms and first visit to a medical provider, it is subject to a recall bias. However, we have tried to reduce the recall bias by using different techniques such as using local calendars linking to major religious and

national days to explain their perceived date of onset of TB symptoms and first visit to a medical provider.

5. Conclusion

The present study showed long total delay (the median total delay of 35 days) in diagnosis and treatment start for TB patients in the study area. The study also revealed important factors associated with total delay. Poor knowledge of TB, swelling or wound around the neck region, being women and low level of education were identified as factors associated with total delay. Several interventions are required to reduce the observed length of total delay. Efficient implementation strategies for early case detection and treatment initiation should be practiced to shorten total delay. Among others, well-crafted IEC and BCC strategies on TB need to be designed to increase awareness and health service utilization among the population in the study area. Swelling or wound around the neck region in a TB patient may be linked to TB lymphadenitis or disseminated TB. The health care facilities at peripheral level in the study area do not have the capacity to diagnose TB lymphadenitis cases. Thus, it is important to develop diagnostic algorithms for timely detection and referral of presumptive TB lymphadenitis patients to the nearest medical providers with the capacity to diagnose TB lymphadenitis. Then, the delay period among this group of patients is shortened and prompt treatment is initiated on time.

Supporting information

S1 Text. Questionnaire and information sheet with consent form English and local language versions.
(PDF)

S2 Text. STROB checklist.
(PDF)

S3 Text. PLOS' questionnaire on inclusivity in global research.
(PDF)

S1 Data. Data for current study with SPSS.
(SAV)

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Determinants of an Unfavorable Treatment Outcome among Tuberculosis Patients in the Jimma Zone, Southwest Ethiopia

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ABSTRACT

Tuberculosis (TB) is a major public health challenge in Ethiopia. The provision of standard anti-TB treatment is the primary component of the directly observed treatment, short-course strategy. The aim of this study was to assess the TB treatment outcomes and the determinants of an unfavorable treatment outcome. The study used a cross-sectional study design. A total of 1,161 TB patients were recruited from eight randomly selected districts and one town administration in the Jimma Zone, Ethiopia. Treatment outcomes were grouped into favorable and unfavorable. Of the total participants, 86.9% had a favorable treatment outcome, and 5.7% an unfavorable treatment outcome. The rest were transferred out and not recorded cases. Women were more likely to experience an unfavorable treatment outcome [adjusted odds ratio (AOR) = 1.96, 95% CI: 1.06, 3.64]. Patients who were perceived to not be stigmatized were less likely to have an unfavorable treatment outcome (AOR= 0.32, 95% CI: 0.15, 0.73). Patients who had a monthly income of > 3,500 Ethiopian *birr* were less likely to have an unfavorable outcome than patients who did not have a regular income (AOR = 0.04, 95% CI: 0.01, 0.45). Finally, the observed treatment success rate is lower than the World Health Organization's target of successfully treating >90% of detected TB cases. It is imperative to ensure that information education communication/behavior change communication strategies consider the needs of women and patients with perceived TB stigma. Furthermore, designing locally acceptable and affordable interventions may help to address the financial challenges of TB treatment adherence.

INTRODUCTION

Tuberculosis (TB) is a major public health challenge in the developing world. According to the global TB report of 2021, there were an estimated 10.0 million TB cases, and 1.5 million deaths due to TB.[1] A majority (86%) of the estimated incidence of TB cases are found in the 30 highest TB burden countries, with[2] Ethiopia being one of the high TB burden countries.[1] There was an estimated 140 per 100,000 population TB incidence rate in 2020, and 19 per 100,000 population TB mortality rate in 2019

in Ethiopia.[3] A recent national cure rate of TB in Ethiopia was 82%, which is lower than the WHO recommendation of a greater than 85% cure rate.[1,4]

The World Health Organization (WHO) has designed the End TB strategy to end the TB epidemic by 2035. The aim of the strategy is to reduce the global TB incidence and mortality rates by 90% and 95%, respectively, when compared to 2015.[5] One of the pillars of implementing the End TB strategy is treating all people with TB, including drug-resistant TB, and to enhance patient support. For the optimal treatment success rate, the WHO recommends the need to address patients and health system-related challenges affecting a successful treatment outcome.[6,7] Among others, locally acceptable and affordable interventions need to be implemented to identify and address the physical, economic and sociocultural challenges to accessing TB treatment services. Special attention is required to address the needs of the poorest and most vulnerable groups. In addition, addressing gender-related issues, improving staff attitudes and enhancing communication between the patient and the provider are equally important.[6,7]

The factors associated with unfavorable TB treatment outcome have previously been studied in different parts of the world. These factors include old age, being female, urban residence, education levels, underlying diabetes mellitus, cigarette smoking, extra-pulmonary TB, a history of previous TB treatment, HIV infection, TB relapse, being sputum-smear positive, joblessness and being a newly diagnosed TB case.[8–12] A study from 2019 conducted at the Jimma University Medical Center (one of the study sites from the present study area) indicated that 11.7% of patients had an unfavorable treatment outcome,[13] while 88.3% had a successful treatment outcome. This finding was lower than the End TB strategy target of achieving a ≥ 90% treatment success rate.[5]

Although several studies were conducted in Ethiopia and elsewhere to assess TB treatment outcomes and associated factors, there was one study from the Jimma Zone, Ethiopia that assessed the treatment outcome and associated factors of unfavorable treatment outcomes.[13] However, as this study only focused on one urban University Medical Centre located in the Zonal capital, the findings of the study were less likely to be representative of the entire Jimma Zone that comprises semi-urban and rural districts. Treatment outcomes and associated factors may vary according to the local setting, including the

socio-demographic and economic condition of the population in the study area. TB treatment outcomes monitoring and analyzing the factors affecting these outcomes are important for effective TB control program evaluation, and for providing feedback at the various levels of the health system (woreda/district, zonal, regional or national level). The aim of this study was to assess TB treatment outcomes and the associated factors of unsuccessful treatment outcome among TB patients in the Jimma Zone, Ethiopia.

MATERIALS AND METHODS

Study setting and design: The study was conducted among all forms of TB patients who started treatment from September 2016 to October 2017 in the Jimma Zone, Southwest Ethiopia. The Jimma Zone is located 354 kilometres from Addis Ababa, the capital city of Ethiopia, with a total area of 199,316.18 square kilometres (Jimma Zone health office, 2016). According to the 2017 projected population census, the Jimma Zone had an estimated population of 3,261,371, of which 49.9% were women.[14] In 2016, the Zone had 17 districts and two town administrations. A total of seven public hospitals (five were primary, one general and one specialized), 120 health centers and 494 health posts were registered in the study area during the study period. The hospitals and health centers provided TB diagnostic and treatment services, with health extension workers at health posts actively involved in case holding activities, and providing directly observed treatment short-course (DOTS). Non-governmental health facilities such as the Catholic mission and numerous private clinics also provided TB diagnostic and treatment services (the Jimma Zone health office, 2016; the Jimma Town health office, 2016). An analytic cross-sectional study design was used.

TB treatment: In the context of this study, the national guideline for TB, and DR-TB is followed to treat TB.[15] For new TB patients (drug-susceptible TB), the treatment is given for a total of six months. The regimen comprises an intensive phase of daily chemotherapy with rifampicin, isoniazid, pyrazinamide and ethambutol for two months (2RHZE), followed by a continuation phase treatment with

rifampicin and isoniazid for four months (4RH). However, patients with central nervous system and osteo-articular TB require a prolonged continuation phase treatment for 10 months (2RHZE/10RH).[15]

Study population and sampling: Eight districts and one town administration were selected from the 17 districts and two town administrations by using a simple random sampling method. Subsequently, all TB DOTS sites in the sampled districts and town administration were covered by the study. A total of 1,161 TB patients who were 15 years of age or older and started anti-TB treatment were consecutively included from the selected study sites. Patients, whose age was less than 15 years, and who could not respond to the interview questions and critically ill patients, were excluded from the study. The minimum sample size was determined by using a single population prevalence formula. A 95% confidence interval, which corresponds to a standard normal deviate of 1.96 ($Z\alpha$), and a power of 80% ($Z\beta$), which translates to a 0.84 standard normal curve, were considered. A proportion of successful treatment outcome of TB patients (p) from a previous study that showed 88.3%,[13] and a margin error of 4% (D), were taken. Thus, the minimum sample size was calculated to be 506. However, as this study is a sub-study of a larger study, it follows a recently published study that compared community-versus facility-based DOTS in a cohort of 1,161 study participants.[16] We included all of the 1,161 study participants in the current study, which was advantageous, as it provides more than an adequate representative population to assess treatment outcome. The sample size was proportionally allocated to the selected public health facilities, based on the previous one-year patient flow. The study participants were consecutively included until the required sample size was achieved.

Data collection and analysis: A structured questionnaire was developed based on the national and WHO guidelines and previous studies.[7,17–21] The questionnaire was translated to the local language (Afan Oromo) by a professional translator, whose mother tongue is the local language. It was checked for any inconsistencies between the translated version and the original English version of the questions. The translated version of the questionnaire was retranslated to English by another professional, who fluently speaks and writes the local language. It was then pre-tested to check for the clarity and applicability of the

questionnaire in the context of the study area. On the basis of the results of the pre-test, adjustments were made, such as clarifying statements. We recruited experienced data collectors and supervisors, with adequate training provided on data collection and supervision techniques. The principal investigator supervised the entire data collection process. The study participants were consecutively interviewed starting from September 2016 to October 2017. Lastly, laboratory and TB registers at the respective health facilities were used to compile data on their treatment results and other clinical information.

The collected data were checked for completeness and consistency, and then coded and entered into the EpiData entry client software, version 4.4.3.1. Next, the data were exported to the statistical package for social sciences software (SPSS) version 21 for analysis. Descriptive statistics were computed for the variables. To assess the TB knowledge, a score of one was given for the correct response and a score of zero was given for wrong responses. Subsequently, the total knowledge score and median score were computed. Those with a total score of less than the median value were categorized as having poor knowledge, while those with a total equal to, or higher than the median value, were classified as having good knowledge. Likewise, the total perceived stigma and median scores were determined. Those with a total score of less than the median value were classified as perceived to not be stigmatized, whereas those with a total equal to or higher than the median value were categorized as perceived to be stigmatized.

The different TB treatment outcomes were grouped into: 1) Favorable (treatment completed, cured), and 2) an unfavorable treatment outcome (died, treatment failure, lost to follow-up). Since the final outcome for transferred out and unrecorded cases was unknown, we did not include these as a favorable or unfavorable outcome. To help analyze the association of independent variables with the dependent variable, we used a binary logistic regression analysis. First, a bivariate analysis was performed for each independent variable against the outcome variable (treatment outcomes), and a crude odds ratio (COR) was calculated. A multivariable logistic regression analysis was conducted, including candidate variables in the bi-variable analysis (a p-value of < 0.25) with the outcome variable, and the respective AOR and 95% CI were computed. A p-value < 0.05 was considered statistically significant.

Operational Definitions: Definitions of treatment outcomes used in this study are based on the National and WHO Tuberculosis guidelines,[19,22] which are found as a supplemental table (S1 Table**)**.

Ethical considerations: Ethical clearance was obtained from the Regional Committee for Medical Research Ethics (REK Øst), Norway with the reference number 2015/2124 REK sør-øst B, and from the Institutional Review Board of Jimma University, Ethiopia, with the reference number RPGC/389/2016. Written (oral for the illiterate) informed consent was secured from each study participant before starting the data collection. The collected data were stored in a locked cabinet (hard copy) and a computer file with a password (soft copy).

RESULTS

Characteristics of the study participants

The present study assessed treatment outcomes and the associated factors of unfavorable treatment outcomes among TB patients in the Jimma Zone, Southwest Ethiopia. A total of 1,161 patients with all forms of TB participated in the study. Of these, 51.2% were male, 65.9% were married and 39.5% were illiterate. Nearly half (46.9%) the patients were 25-44 years of age. Of the total study participants, 63.7% were farmers by occupation, with 50.3% of the participants having a monthly household income of ≤ 1000 Ethiopian Birr, which is equivalent to 29 USD at the current market rate (Table 1).

171 Table 1: Socio-demographic characteristics of the study participants in the Jimma Zone, 2017 (N= 1161)

Variables		Frequency	Percentage (%)
Age in years	15–24	365	31.4
	25–44	544	46.9
	45–64	202	17.4
	≥65	50	4.3
Gender	Male	594	51.2
	Female	567	48.8
Marital status	Single	330	28.4
	Married	765	66.1
	Divorced	30	2.6
	Widowed	34	2.9
Educational status	Illiterate	459	39.5
	Read and write only	98	8.4
	Primary school	396	34.1
	Secondary school	132	11.4
	College/University	76	6.5
Occupation	Farmer	739	63.7
	Merchant	74	6.4
	Government or NGO employee	58	5.0
	Daily laborer	88	7.6
	Housewife	19	1.6
	Student	142	12.2
	Unemployed	41	3.5
Religion	Orthodox Christian	160	13.8
	Muslim	939	80.8
	Protestant	61	5.3
	Catholic	1	0.1
Source of household income	Farming	769	66.2
	Monthly salary	59	5.1
	Private/trading	78	6.7
	Daily payment	82	7.1
	Family/relative	152	13.1
	Prefer not to answer	21	1.8
Monthly household income in ETB	≤ 1,000	584	50.3
	1,001-2,500	388	33.4
	2,501–3,500	41	3.5
	> 3,500	90	7.8
	Do not have a regular income	58	5.0
	Family/relative	53	4.6
	Others	22	1.9

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Study districts and registered treatment outcome categories

Of the total 1,161 patients included in the study, 1,008 (86.9%) had a favorable treatment outcome, 66 (5.7%) had an unfavorable treatment outcome, 34 (2.9%) were transferred out, and 53(4.5%) were not recorded. A majority (18.9%) of the study participants were from the *Goma* district. The *Omo nada* district (90.2%) and the *Sokoru* district (89.8%) performed very well compared to the *Limu kosa* district (81.9%). The proportion of death was higher at the *Mana* district (6.2%) compared to *Jimma* Town (1.3%). At Limu Kosa, there were a lot of unrecorded cases (11.1%). However, the Seka Chokorsa District did not have any unrecorded instances (0.0%) (Table 2).

Table 2: Districts and number (percentage) of patients registered in the various treatment outcome categories at the Jimma Zone, Ethiopia 2017

District / town administration	**Favorable treatment outcome**			**Unfavorable treatment outcome**				**Transferred out**	**Not recorded**
	Cured	Treatment completed	Total	Died	Treatment failure	Lost to follow up	Total		
Goma (n=220)	67(30.5)	121(55.0)	188(85.5)	10(4.5)	0(0.0)	5(2.3)	15(6.8)	4(1.8)	13(5.9)
Jimma (n=157)	48(30.5)	91(58.0)	139(88.5)	2(1.3)	1(0.6)	2(1.3)	5(3.2)	11(7.0)	2(1.3)
Kersa (n=122)	36(29.5)	69(56.6)	105(86.1)	5(4.1)	0(0.0)	1(0.8)	6(4.9)	3(2.5)	8(6.5)
Limu kosa (n=144)	51(35.4)	67(46.5)	118(81.9)	5(3.5)	2(1.4)	0(0.0)	7(4.9)	3(2.1)	16(11.1)
Mana (n=97)	41(42.3)	42(43.3)	83(85.6)	6(6.2)	1(1.0)	1(1.0)	8(8.2)	3(3.1)	3(3.1)
Omo nada (n=102)	57(55.9)	35(34.3)	92(90.2)	2(2.0)	1(1.0)	2(2.0)	5(5.0)	2(2.0)	3(2.8)
Seka chokorsa (n=120)	48(40.0)	58(48.3)	106(88.3)	7(5.8)	3(2.5)	1(0.9)	11(9.2)	3(2.5)	0(0.0)
Sokoru (n=108)	43(39.8)	54(50.0)	97(89.8)	2(1.9)	1(0.9)	2(1.9)	5(4.7)	2(1.9)	4(3.6)
Tiro afeta (n=91)	44(48.4)	36(39.6)	80(88.0)	2(2.2)	1(1.1)	1(1.1)	4(4.4)	3(3.3)	4(4.3)
Total (N=1,161)	435(37.5)	573(49.4)	1008(86.9)	41(3.5)	10(0.9)	15(1.3)	66(5.7)	34(2.9)	53(4.5)

Determinants of unfavorable treatment outcome

During a bivariate analysis, gender, age groups, educational level, alcohol use, Khat chewing, history of chronic illness, HIV status, sputum result at the 2nd or 3rd month, sputum result at the end of the 5th month, and perceived to be stigmatized, were found to be associated with unfavorable treatment outcome (see Table 3).

Table 3: Association of socio-demographic and clinical factors with unfavorable treatment outcome among the study participants at the Jimma Zone, Southwest Ethiopia, 2017

Variables		Treatment outcomes, No (%)		COR (95% CI)	P-values
		Favorable	Unfavorable		
Total delay	Not delayed	505 (50.1)	32 (48.5)	1	
	Delayed	503 (49.9)	34 (51.5)	0.94 [0.57,1.54]	0.799
Gender	Male	507 (50.3)	42 (63.6)	1	
	Female	501 (49.7)	24 (36.4)	1.73 [1.03,2.89]	0.038
Age groups in years	15-24	319 (31.6)	10 (15.2)	1	
	25-44	479 (47.5)	31 (47.0)	0.14 [0.05,0.38]	< 0.001
	45-64	174 (17.3)	17 (25.8)	0.29 [0.13,0.68]	0.004
	≥ 65	36 (3.6)	8 (12.1)	0.44 [0.18,1.10]	0.078
Educational level	Illiterate	396 (39.3)	28 (42.4)	4.67 [0.62,34.88]	0.133
	Read and write only	81 (8.0)	11 (16.7)	8.96 [1.13,71.23]	0.038
	Primary school	344 (34.1)	24 (36.4)	4.61 [0.61,34.63]	0.138
	Secondary	121 (12.0)	2 (3.0)	1.09 [0.10,12.26]	0.944
	College/Uni.	66 (6.5)	1 (1.5)	1	
Monthly household income in ETB	≤ 1,000	504 (50.0)	39 (59.1)	0.91 [0.31,2.66]	0.862
	1,001-2,500	338 (33.5)	21 (31.8)	0.73 [0.24,2.22]	0.579
	2,501-3,500	37 (3.7)	1 (1.5)	0.32 [0.03,2.96]	0.314
	> 3,500	82 (8.1)	1 (1.5)	0.14 [0.02,1.32]	0.086
	No regular income	47 (4.7)	4 (6.1)	1	
Time to reach nearest medical provider min.	≤ 30	690 (68.5)	40 (60.6)	1	
	31-60	241 (23.9)	20 (30.3)	0.74 [0.31,1.81]	0.515
	> 60	77 (7.6)	6 (9.1)	1.07 [0.41,2.75]	0.896
Alcohol use	Yes	75 (7.4)	13 (19.7)	3.05 [1.59,5.85]	0.001
	No	933 (92.6)	53 (80.3)	1	
Khat chewing	Yes	505 (50.1)	44 (66.7)	1.99 [1.18,3.37]	0.010
	No	503 (49.9)	22 (33.3)	1	
History of chronic illness	Yes	36 (3.6)	9 (13.6)	4.26 [1.96,9.28]	< 0.001
	No	972 (96.4)	57 (86.4)	1	
HIV status	Reactive	27 (2.7)	8 (12.1)	3.41[1.08,10.74]	0.036
	Non-reactive	912 (90.5)	52 (78.8)	0.66 [0.27,1.58]	0.347
	Unknown	69 (6.8)	6 (9.1)	1	
TB classification	Smear-positive PTB	490 (48.6)	33 (50.0)	1	
	Smear-negative PTB	213 (21.1)	19 (28.8)	1.47 [0.77,2.79]	0.241
	Extra PTB	305 (30.3)	14 (21.2)	1.94 [0.95,3.96]	0.067

Sputum result at the 2nd or 3rd month	Negative	452 (44.8)	18 (27.3)	1	
	Positive	12 (1.2)	4 (6.1)	0.61 [0.34,1.09]	0.093
	Not done	27 (2.7)	10 (15.2)	5.07 [1.55,16.55]	0.007
	Not applicable	517 (51.3)	34 (51.5)	5.63 [2.52,12.58]	< 0.001
Sputum result at the end of 5th month	Negative	417 (41.4)	4 (6.1)	0.13 [0.05,0.36]	< 0.001
	Positive	2 (0.2)	3 (4.5)	19.92 [3.23,122.7]	0.001
	Not done	71 (7.0)	20 (30.3)	3.74 [2.07,6.77]	< 0.001
	Not applicable	518 (51.4)	39 (59.1)	1	
Knowledge about TB	Poor	410 (40.7)	26 (39.4)	0.95 [0.57,1.58]	0.837
	Good	598 (59.3)	40 (60.6)	1	
Perceived to be stigmatized	No	328 (32.5)	9 (13.6)	0.33[0.16,0.67]	0.002
	Yes	680 (67.5)	57 (86.4)	1	

Gender, monthly household income, alcohol use, sputum result at the end of the 5th month, and perceived to be stigmatized, remained significant predictors of unfavorable treatment outcome after a multivariable analysis. Female patients were about two times more likely to have an unfavorable treatment outcome compared to male patients (AOR = 1.96, 95% CI: 1.06, 3.64). Those patients who used alcohol were about three times more likely to have unfavorable treatment outcome than their counterpart (AOR = 3.16, 95% CI: 1.39, 7.15). Patients who had a monthly household income of > 3500 ETB were 96 % less likely to have an unfavorable outcome than patients who had no regular income (AOR = 0.04, 95% CI: 0.01, 0.45). Patients who perceived themselves not to be stigmatized were 68% less likely to have an unfavorable treatment outcome than their counterparts (AOR= 0.32, 95% CI: 0.15, 0.73). The median time from the onset of symptoms to the start of treatment (total delay) was 35 days. Although a higher proportion of delayed patients had an unfavorable treatment outcome, there was no statistically significant association between total delay and treatment outcomes (P=0.386). Moreover, the association of knowledge about TB and an unfavorable treatment outcome were not statistically significant (P=0.694) (see Table 4).

Table 4: Determinants of unfavorable treatment outcome among the study participants at the Jimma Zone, Southwest Ethiopia, 2017

Variables		Treatment outcomes, No (%)		AOR (95% CI)	P-value
		Favorable	Unfavorable		
Sex	Male	507 (50.3)	42 (63.6)	1	
	Female	501 (49.7)	24 (36.4)	1.96 [1.06,3.64]	0.033
Monthly household income in ETB	≤ 1,000	504 (50.0)	39 (59.1)	0.36 [0.10,1.30]	0.119
	1,001-2,500	338 (33.5)	21 (31.8)	0.30 [0.08,1.14	0.078
	2,501- 3,500	37 (3.7)	1 (1.5)	0.34 [0.03,3.67]	0.376
	> 3,500	82 (8.1)	1 (1.5)	0.04 [0.01,0.45]	0.009
	No regular income	47 (4.7)	4 (6.1)	1	
Alcohol use	Yes	75 (7.4)	13 (19.7)	3.16 [1.39,7.15]	0.006
	No	933 (92.6)	53 (80.3)	1	
Sputum result at the end of the 5th month	Negative	417 (41.4)	4 (6.1)	0.01 [0.00,0.02]	<0.001
	Positive	2 (0.2)	3 (4.5)	0.11 [0.01,3.67]	0.214
	Not done	71 (7.0)	20 (30.3)	0.04 [0.01,0.42	0.007
	Not applicable	518 (51.4)	39 (59.1)	1	
Perceived to be stigmatized	No	328 (32.5)	9 (13.6)	0.32[0.15,0.73]	0.006
	Yes	680 (67.5)	57 (86.4)	1	
Total delay	Not delayed	505 (50.1)	32 (48.5)	1	
	Delayed	503 (49.9)	34 (51.5)	0.76 [0.40,1.42]	0.386
Knowledge about TB	Poor	410 (40.7)	26 (39.4)	1.15 [0.58,2.26]	0.694
	Good	598 (59.3)	40 (60.6)	1	

AOR = adjusted odds ratio; COR = crude odds ratio; CI = confidence interval; 1= Reference group

DISCUSSION

In this study, we assessed treatment outcome and the determinants of unfavorable treatment outcome among TB patients in the Jimma Zone, Southwest Ethiopia. The study has shown that being a female patient, having a poor household income and being an alcohol consumer may decrease the chance of having TB treatment success. For the entire zone, only 86.9% of the patients had a successful treatment outcome. Our results fell short of both the WHO's and the national goal of successfully treating more than 90% of cases of TB discovered.[1,4] This difference might be due to a substantial variation of unfavorable treatment outcome observed across districts, zones and regions in Ethiopia,[23] which suggests that the Zonal TB control program has to take a variety of measures to improve the treatment success rate.

An unfavorable treatment outcome was significantly associated with socio-demographic (such as gender), economic (such as household income), and behavioral (such as alcohol use) factors, as well as stigma. Our study revealed that women were more likely to have unfavorable treatment outcome compared to men. This finding is similar to former studies conducted in Ethiopia and Nigeria.[24–26] Economic status may influence treatment outcome, as women may have less access to financial resources in the household. Cultural beliefs about the early symptoms of TB (e.g., interpreted as another illness),[27] and perceived stigma, are barriers of early care seeking and treatment adherence for a majority of female patients.[28] As reported from several countries,[28–31] the economic dependence and restriction that may be linked to religious or cultural norms may lead to a social inequality of women. This inequality results in a lack of power to decide whether to use money (e.g., for transport, medical procedures), and how to prioritize the use of time (e.g., DOTS being a time-consuming daily treatment).Other studies also show that these are factors that may reduce accessibility to medical services, and affect treatment adherence.[28–31] This finding underscores the importance of recognizing gender differences in an individual's TB treatment outcome. To help increase treatment adherence and enhance the outcomes of TB patients, it appears essential to address the specific needs of women through socioeconomic support interventions, or by modifying current barriers (excessive use of time on a daily basis, indirect/direct costs) inherent in the TB control program.[32] Furthermore, research shows that the use of adherence interventions, including patient education and counselling, reminders and digital health technologies, significantly improve TB treatment outcomes.[33] Developing well-crafted information education and communication (IEC), and behavioral change communication (BCC) interventions that target women, could be helpful for treatment adherence. Several media platforms, including local radio and text messages, can be used to address information gaps regarding both early symptoms and treatment adherence.[34,35]

However, the available evidence regarding the influence of gender in treatment outcomes has revealed inconsistent findings. Our findings differed from previous studies conducted in Ethiopia and elsewhere, which found that male patients were more likely than female patients to have unfavorable

248 treatment outcomes.[9,11,26,36,37] One reason for this could be that men are more exposed to TB infections
249 associated with behavioral factors, such as alcohol use or being a smoker (which affects treatment
250 adherence), compared to women.[38,39] In addition, men and women have different societal roles and
251 occupations (such as men often being a daily laborer), which can affect not only their risk of exposure to
252 TB, but also their access to medical care.[40,41] The observed difference in our findings might also be
253 related to differences in the study settings, study methods and socio-economic status of the population in
254 the respective studies in Ethiopia and elsewhere. It is also an established fact that the gender-based social
255 effect on decision-making related to health might differ across cultures and settings.[42]

256 Perceived stigma was identified as an independent predictor of unfavorable treatment outcome in
257 our study. TB stigma is a major barrier to early diagnosis and successful treatment completion. A
258 systematic review in low-, middle- and high-income countries showed that perceived TB stigma resulted
259 in delays in diagnosis and poor treatment compliance.[43] Previous studies from Ethiopia and elsewhere
260 revealed that the presence of TB /HIV/AIDS-related stigma (due to high co-infection rates, people tend to
261 think that TB is the first symptom of HIV/AIDS and /or that it is the same disease), and the fear of TB
262 transmission (due to misconceptions about its transmission), were found to be the primary source of TB
263 stigma.[44–48] Such misconceptions may lead patients to be afraid of disclosing themselves as TB patients.[27]
264 TB patients on treatment may avoid seeking treatment or default from treatment because of a fear of
265 discrimination by others, and a lack of support from their families and/or community.[27] The fear of
266 unemployment and isolation have also been found to affect individuals' disclosure about TB.[44,48] Thus,
267 TB stigma tends to result in poor treatment adherence, and subsequently to poor prognosis.[43,44] Earlier
268 studies from Ethiopia showed that perceived stigma was higher among TB patients than their families and
269 general population.[44,48] Because of the strong stigma attached to TB, patients could be denied housing and
270 a lack of support from their families and community.[44,48] The Oromia region (where our study area is
271 located) had the highest score of TB stigma compared to other regions of Ethiopia.[44] Studies show that,
272 for example, patients living in urban areas like Addis Ababa (capital city) have a higher knowledge about

TB, and a lower stigma score.[44,48] Hence, it is important to assess the illness perception of TB patients to identify their vulnerability to unfavorable treatment outcome. Many health-care providers disregard patients' thoughts and opinions about their illness, and do not recognize the reasons for different illness perceptions, misconceptions or rationalities that may lead to poor adherence to TB treatment.[46,49] The early recognition of a patient's illness perception will provide knowledge that is important to planning and implementing patient-centered care related to TB-related stigma, and an adherence to TB treatment in general.[46,49] Earlier studies show that organizing patient and peer support groups, TB education or support programs targeted at healthcare providers, TB patients and at-risk individuals, may reduce TB stigma.[43,50] An engagement of different stakeholders (multidisciplinary approach), such as psychologists' and/or sociologists', is suggested to reduce stigma due to TB.[43,50] As TB-related stigma contributes to a low effectiveness of the existing TB control program, understanding and addressing the local perceptions of TB is essential to increase treatment success rate.[46,48,51,52]

In this study, a poor household income was associated with an unfavorable treatment outcome. In line with our finding, several previous studies document the impact of a poor socio-economic status on TB treatment outcomes in both low- and high-income countries.[23,53–55] A low household income may affect the patients' adherence to daily treatment with DOTS because of expenses related to, for example, transport and the use of time (e.g., daily laborers not being able to meet up in the morning at regular meeting places to find a job for the day).[56,57] In addition to long treatment regimens, excessive psycho-social stress may be one possible biological reason behind an increased chance of poor treatment outcome among patients with a low household income. Studies indicate that a poor treatment outcome may result from excessive stress, as financial insecurity may negatively affect immune functions through long-term stress effects on the "Hypothalamic-Pituitary-Adrenal axis."[58,59] In addition, patients with a poor household income may not get adequate nutrition, which may result in a poor immune function.[60] As evidenced in earlier studies, proper nutrition is associated with increased immune system strength [61,62] and improved clinical outcomes among TB patients.[63]

Alcohol use was another predictor of TB treatment outcome in our study. Patients who used alcohol were more likely to have an unfavorable treatment outcome than patients who did not use alcohol. This finding is in line with previous studies' results. A systematic review and meta-analysis revealed that non-alcohol drinkers were two times more likely to have a favourable treatment outcome than their counterparts.[64] In another systematic review, alcohol use was identified as a predictor of treatment outcomes for both drug-susceptible (DS) and multi-drug resistance (MDR)-TB, whereby alcohol use was associated with a higher risk of unfavourable treatment outcome.[65] A former study in Ethiopia reported that alcohol intake was a significant risk factor for non-adherence to TB treatment, and related to poor treatment outcome.[66] Similarly, a study from Kenya found that alcohol use was significantly associated with the interruption of TB treatment.[67] This may be because patients who use alcohol on a regular basis are more likely to interrupt their TB treatment regimen, as well as more likely to forget following their treatment when they are intoxicated. Moreover, the undesirable interactions of alcohol and anti-TB drugs may cause patients to stop taking anti-TB drugs due to unwanted interactions.[67] This suggests the need for targeted psycho-social support to increase treatment adherence, and improve treatment outcomes of TB patients who use alcohol.[34]

This study has strengths and limitations. The strength of the study is that we included a relatively large sample size compared to sample sizes used in other similar studies in Ethiopia. Using a larger sample size provides a more than adequate representative population to address the research objectives. With regard to potential limitations, the study was only carried out in government health facilities; hence, the findings cannot be generalized to all TB patients in the study area. There are several private health care facilities where patients get anti-TB treatment, although the treatment outcome of patients attending private health-care facilities may be different. However, because they are fewer in number, there is little likelihood of selection bias; therefore, the current finding might not be affected.

CONCLUSION

The treatment success rate observed in this study is lower than the expected target of achieving a treatment success rate of >90 of the detected TB cases, as set by the WHO. Being a woman, alcohol use, poor household income and perceived stigma were all associated with unfavorable treatment outcome. Several interventions may improve treatment outcomes. It appears essential to address the specific needs of women and patients with a poor income through socioeconomic support interventions, or by modifying current barriers, such as the excessive use of time, which is inherent in TB control programs. Patients who use alcohol may require extra support and follow-up. Furthermore, exploring and addressing local illness perceptions; perceptions that may cause stigma and potentially delay diagnosis, or that results in poor treatment adherence seems important – both on the individual and society level. Overall, it appears important to provide individually tailored treatment-adherence counseling and follow-up, as each patient may face unique, but often interrelated barriers.

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Conflict of interest

The authors have declared that there is no financial or non-financial competing interests among the authors.

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Authors' contributions

BME initiated the study, wrote the proposal, and conducted the data collection, data analysis and the writing of this manuscript. MS contributed to the conception and proposal of the study, and contributed to the writing of this manuscript by critically reviewing it. CG contributed to the writing of this manuscript by critically reviewing it. SAY contributed to the conception and proposal of the study, and data analysis. He also contributed to the manuscript writing by critically reviewing it. All the authors read and approved the final manuscript.

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Supporting information

S1 Text: Copyright_ Authorship_ Payment agreement forms

S1 Table: Operational Definitions

S1 Table: Operational Definitions

Terms	Operational definitions
Cured	A TB patient with bacteriologically confirmed pulmonary TB at the start of treatment, who was smear- or culture-negative at the end of the treatment, and at least one previous time
Treatment completed	A TB patient who completed treatment without evidence of smear-or culture-negative at the end of treatment, and at least one previous time
Treatment failure	A TB patient whose sputum smear or culture is positive at the fifth month or later during the course of treatment
Lost to follow-up	TB patient who has been on treatment for at least four weeks, and who discontinued the treatment for eight or more consecutive weeks
Died	A patients who dies from any cause during the course of TB treatment
Favorable treatment outcome	Include cured and treatment-completed
Unfavorable treatment outcome	Include deaths, treatment failures and lost to follow-up outcomes
Medical provider	Include hospitals, health centres, health posts, private clinics and drug-retail-outlets
Woreda	It is the third level of the administrative division after "zone" and "region" in Ethiopia. It has a defined geographic area, and the population size may range between 50,000 to 200,000
Zone	It is defined as the second level of the administrative division in Ethiopia, below "region" and above *woredas* or districts. It has a defined geographic area, and the population size may range between 500,000 to 3 million
Urban	Refers to the capital of a zone, a district as well as a town
Rural	Any areas outside of the "Urban" areas
Not applicable	Examination of sputum was not required either because the patient was not a pulmonary-TB positive, or the outcome was known at this stage (died, transferred-out)

Appendix 2: Information sheets and consent forms English version

I. Request for participation in a research project for local and regional health office program managers/coordinators

"Performance and Quality of Tuberculosis Directly Observed Treatment Short Course (DOTS) Strategy in Jimma Zone, Southwest Ethiopia*"*

Introduction

My name is _____I am PhD student at the University of Oslo, Norway. I am kindly inviting you, to participate in a research study because you have been implementing tuberculosis prevention and control program and have experience in the area. The details of the research plan are described in this document. It is important that you understand why the research is being done and what it will involve. Please take your time to read through and consider this information carefully before you decide to participate in the proposed study. Please, ask if anything is unclear or if you would like to get more information.

Background and purpose

Tuberculosis (TB) is an infectious disease, responsible for serious illness and death globally, affecting both sexes of all age groups. TB is a common problem in Ethiopia including Jimma Zone. It is important to control the disease with feasible, cost effective, and acceptable approaches. The research project intends to assess the overall performance and quality of tuberculosis directly observed treatment short course (TB DOTS) strategy in Jimma Zone, Ethiopia.The knowledge obtained from this study will provide relevant information that may help you to improve the performance and quality of the program. Due to your position as a health office program manager/coordinator you have participated in many of the overall tuberculosis program related activities and we believe that you have ample knowledge in regards to how the program is implemented. You are therefore selected purposefully as we consider that you can provide relevant knowledge for our study.

What does the study entail?

In this study I would like to interview you about your experience and views of tuberculosis directly observed treatment short course. The interview will last about an hour and take place at a time/place convenient for you. If you are willing to participate, the interview will be tape recorded. I would like to ask you a few questions about the TB control program to explore potential barriers and facilitators during the implementation of this program. Whether you participate or not will not in any way affect your position.

Potential advantages and disadvantages

You may spend about an hour providing us information regarding to TB DOTS strategy which may consume your precious time. There may not be any direct benefit as a result of your participation in the study, however your honest and genuine response will contribute to generate information that can be used to improve performance and quality of services related to tuberculosis.

What will happen to information about you?
The data that are registered about you will only be used in accordance with the purpose of the study. All the data will be processed without name, ID number or other directly recognisable type of information. A code number that links you to your data will be used, and the information you provide us will therefore be confidential. All data will be kept in a locked cabinet and pass word protected computers. In addition, your information will only be used during report writing and not after completing the project.

Voluntary participation
Participation in the study is voluntary. You can withdraw your consent to participate in the study at any time and without stating any particular reason. This will not have any consequences for your further position. If you wish to participate, sign the declaration of consent on the final page.

If you agree to participate at this time, you may later on withdraw your consent without your position being affected in any way. If you later on wish to withdraw your consent or have questions concerning the study, you may contact:
Berhane Megerssa Ereso
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2. Solomon Yimer (PhD, Postdoc)
Email address yimsolo@yahoo.com
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Releasing material and data to other parties
If you agree to participate in the study, you also consent de-identified data being released to local and regional health offices in Ethiopia.

Right to access and right to delete your data
If you agree to participate in the study, you are entitled to have access to what information is registered about you. You are further entitled to correct any mistakes in the information we have registered. If you withdraw from the study, you are entitled to demand that the collected data are deleted, unless the data have already been incorporated in analyses or used in scientific publications.

Funding and the role of Strategic and Collaborative Capacity Development in Ethiopia and Africa (SACCADE) Project

The study will be funded by research grants from Strategic and Collaborative Capacity Development in an Ethiopian and African (SACCADE) project. The SACCADE project will cover expenses related with personal, materials/ supplies and transportation. It does not have any conflict of interest with any other project.

Information about the outcome of the study

You are fully entitled to receive information about the result and outcome of this study.

. **Consent for participation in the study**

I am willing to participate in the study

(Signature of the study participant, date)

I confirm that I have given information about the study.

(Signature of the data collector, date)

Request for participation in a research project for tuberculosis directly observed treatment short course (DOTS) providers

"Performance and Quality of Tuberculosis Directly Observed Treatment Short Course (DOTS) Strategy in Jimma Zone, Southwest Ethiopia*"*

Introduction

My name is _____I am PhD student at the University ofOslo, Norway. I am kindly inviting you, to participate in a research study because you have been implementing tuberculosis prevention and control program and have experience in the area. The details of the research plan are described in this document. It is important that you understand why the research is being done and what it will involve. Please take your time to read through and consider this information carefully before you decide to participate in the proposed study. Please, ask if anything is unclear or if you would like to get more information.

Background and purpose

Tuberculosis (TB) is an infectious disease, responsible for serious illness and death globally, affecting both sexes of all age groups. TB is a common problem in Ethiopia including Jimma Zone. It is important to control the disease with feasible, cost effective, and acceptable approaches. The research project intends to assess the overall performance and quality of tuberculosis directly observed treatment short course (TB DOTS) strategy in Jimma Zone, Ethiopia. The knowledge obtained from this study will provide relevant information that will help you to improve the performance and quality of the program. Due to your position as a DOTS provider, you have participated in many of the overall tuberculosis program related activities and we believe that you have ample knowledge in regards to how the program is implemented. You are therefore selected purposefully as we consider that you can provide relevant knowledge for our study

What does the study entail?

In this study I would like to interview you about your experience and views of tuberculosis directly observed treatment short course. The interview will last about an hour and take place at a time/place convenient for you. If you are willing to participate, the interview will be tape recorded. I would like to ask you a few questions about the TB control program to explore potential barriers and facilitators during the implementation of this program. Whether you participate or not will not in any way affect your position.

Potential advantages and disadvantages

You may spend about an hour providing us information regarding to TB DOTS strategy which may consume your precious time. There may not be any direct benefit as a result of your participation in the study, however your honest and genuine response will contribute to generate information that can be used to improve performance and quality of services related to tuberculosis.

What will happen to information about you?
The data that are registered about you will only be used in accordance with the purpose of the study. All the data will be processed without name, ID number or other directly recognisable type of information. A code number that links you to your data will be used, and the information you provide us will therefore be confidential. All data will be kept in a locked cabinet and password protected computers. In addition, your information will only be used during report writing and not after completing the project.

Voluntary participation
Participation in the study is voluntary. You can withdraw your consent to participate in the study at any time and without stating any particular reason. This will not have any consequences for your further career. If you wish to participate, sign the declaration of consent on the final page. If you agree to participate at this time, you may later on withdraw your consent without any consequence. If you later on wish to withdraw your consent or have questions concerning the study, you may contact:

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Jimma University, Ethiopia

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Information about the outcome of the study

You are fully entitled to receive information about the result and outcome of this study.

Consent for participation in the study

I am willing to participate in the study

(Signature of the study participant, date)

I confirm that I have given information about the study.

(Signature of the data collector, date)

Request for participation in a research project for tuberculosis patients (for in-depth interview)

"Performance and Quality of Tuberculosis Directly Observed Treatment Short Course (DOTS) Strategy in Jimma Zone, Southwest Ethiopia*"*

Introduction

My name is _____I am PhD student at the University ofOslo, Norway.

I am kindly inviting you, to participate in a research study because you have been diagnosed to have a disease called tuberculosis (TB). The details of the research plan are described in this document. It is important that you understand why the research is being done and what it will involve. Please take your time to read through and consider this information carefully before you decide to participate in the proposed study. Please, ask if anything is unclear or if you would like to get more information.

Background and purpose

Tuberculosis (TB) is an infectious disease, responsible for serious illness and death globally, affecting both sexes of all age groups. TB is a common problem in Ethiopia including Jimma Zone. It is important to control the disease with feasible, cost effective, and acceptable approaches. The research project intends to assess the overall performance and quality of tuberculosis directly observed treatment short course (TB DOTS) strategy in Jimma Zone, Ethiopia. The knowledge obtained from this study will help us to provide useful information for decision makers so that the program performance and quality can be improved and the community members get better services. To be able to do this, learning about your experience and your knowledge as being a TB patient under treatment is very important. You are therefore selected purposefully as we consider that you can provide relevant knowledge for our study

What does the study entail?

In this study I would like to interview you about tuberculosis directly observed treatment short course since you have been receiving the treatment. I would like to ask you a few questions about your experience and views of tuberculosis care to identify barriers and facilitators during receiving tuberculosis care. The interview will last about an hour and take place at a time/place convenient for you.If you are willing to participate, the interview will tape recorded. This study does not affect your treatment and you can receive your usual treatment whether you have participated in the study or not.

Potential advantages and disadvantages

You may spend about an hour providing us information about tuberculosis diagnosis & treatment which may consume your precious time and energy. There may not be any direct benefit as a result of your participation in the study, however your honest and genuine response will contribute to generate information that can be used to improve performance and quality of services related to tuberculosis.

What will happen to information about you?

The data that are registered about you will only be used in accordance with the purpose of the study. All the data will be processed without name, ID number or other directly recognisable type of information. A code number that links you to your data will be used, and the information you provide us will therefore be confidential. All data will be kept in a locked cabinet and password protected computers. In addition, your information will only be used during report writing and not after completing the project.

Voluntary participation

Participation in the study is voluntary. You can withdraw your consent to participate in the study at any time and without stating any particular reason. This will not have any consequences for your further treatment. If you wish to participate, sign the declaration of consent on the final page. If you agree to participate at this time, you may later on withdraw your consent without your treatment being affected in any way. If you later on wish to withdraw your consent or have questions concerning the study, you may contact:

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Mobile phone number +4741576964

2. Solomon Yimer (PhD, Postdoc)

Email address yimsolo@yahoo.com
Mobile phone number +4747687670

Releasing material and data to other parties

If you agree to participate in the study, you also consent de-identified data being released to local and regional health offices in Ethiopia.

Right to access and right to delete your data

If you agree to participate in the study, you are entitled to have access to what information is registered about you. You are further entitled to correct any mistakes in the information we have registered. If you withdraw from the study, you are entitled to demand that the collected data are deleted, unless the data have already been incorporated in analyses or used in scientific publications.

Funding and the role of Strategic and Collaborative Capacity Development in Ethiopia and Africa (SACCADE) Project

The study will be funded by research grants from Strategic and Collaborative Capacity Development in an Ethiopian and African (SACCADE) project. The SACCADE project will

cover expenses related with personal, materials/ supplies and transportation. It does not have any conflict of interest with any other project

Information about the outcome of the study

You are fully entitled to receive information about the result and outcome of this study.

Consent for participation in the study

I am willing to participate in the study.

(Signature of the study participant, date)

I confirm that I have given information about the study.

(Signature of the data collector, date)

I. Request for participation in a research project for tuberculosis patient

"Performance and Quality of Tuberculosis Directly Observed Treatment Short Course (DOTS) Strategy in Jimma Zone, Southwest Ethiopia*"*

Introduction

My name is _____I am working at _____ health facility. I am kindly inviting you, to participate in a research study because you have been diagnosed to have a disease called tuberculosis (TB). The details of the research plan are described in this document. It is important that you understand why the research is being done and what it will involve. Please take your time to read through and consider this information carefully before you decide to participate in the proposed study. Please, ask if anything is unclear or if you would like to get more information.

Background and purpose

Tuberculosis (TB) is an infectious disease, responsible for serious illness and death globally, affecting both sexes of all age groups. TB is a common problem in Ethiopia including Jimma Zone. It is important to control the disease with feasible, cost effective, and acceptable approaches. The research project intends to assess the overall performance and quality of tuberculosis directly observed treatment short course (TB DOTS) strategy in Jimma Zone, Ethiopia. The knowledge obtained from this study will help us to provide useful information for decision makers so that the program performance and quality can be improved and the community members get better services. To be able to do this, learning about your experience and your knowledge as being a TB patient under treatment is very important. You are selected for the study from randomly selected Woredas (Districts).

What does the study entail?

In this study I would like to ask you some questions about the diagnostic process and your daily visits to this treatment site. The interview will last for about 50 to 60 minutes and take place at a time/place convenient for you. In addition, we would like to follow your treatment outcome until you complete the treatment and obtain information related with tuberculosis treatment as well as your treatment outcome status from TB registration book. This study does not affect your treatment and you will get your usual treatment whether you have participated in the study or not.

Potential advantages and disadvantages

You may spend about 50 to 60 minutes in providing us information about your background and process of tuberculosis diagnosis & treatment which may consume your precious time. There may not be any direct benefit as a result of your participation in the study, however your honest and genuine response will contribute to generate information that can be used to improve performance and quality of services related to tuberculosis.

What will happen to information about you?
The data that are registered about you will only be used in accordance with the purpose of the study. All the data will be processed without name, ID number or other directly recognisable type of information. A code number that links you to your data will be used, and the information you provide us will therefore be confidential. All data will be kept in a locked cabinet and password protected computers. In addition, your information will only be used during report writing and not after completing the project.

Voluntary participation
Participation in the study is voluntary. You can withdraw your consent to participate in the study at any time and without stating any particular reason. This will not have any consequences for your further treatment. If you wish to participate, sign the declaration of consent on the final page. If you agree to participate at this time, you may later on withdraw your consent without your treatment being affected in any way. If you later on wish to withdraw your consent or have questions concerning the study, you may contact:
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Releasing material and data to other parties
If you agree to participate in the study, you also consent de-identified data being released to local and regional health offices in Ethiopia.

Right to access and right to delete your data
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Information about the outcome of the study

You are fully entitled to receive information about the result and outcome of this study.

Consent for participation in the study

I am willing to participate in the study

(Signature of the study participant, date)

Proxy consent (when necessary).

(Signature of guardian, date)

I confirm that I have given information about the study.

(Signature of data collector, date)

Appendix 3: Information sheets and consent forms Afan Oromo (local language) version

Gaaffii hirmaannaa qorannoo pirojektii qindeessitoota/hojii gaggeesitoota sagantaa w/ra fayyaa naannoo fi godinaa

Raawwannaa fi qulqullina Tarsiimoo Koorsii gabaabaa yaaliinsa daawwannaa kallaattii dhukkuba "Tiibii'' (DOTS) godina jimmaa, kibba lixa itiyoophiyaa.

Seensa

Maqaan koo---------- ----------Yunivarstii osloo,Noorwayitti ani barataa PhD ti.

Sababa raawwatiinsa naannoo sagantaa to'achuufi Ittisuu Tiibii irraatti muuxxaannoo qabdaniifi qo'annaa qorannoo irraatti akka hirmaattan kabajaan isin affeerreera.Tarreen karoora qorannoo kanaa ragaa kana irraatti tarreeffameera.Qorannoon kun maaliifi akka gaggeeffamu,maal of keessaa akka qabu, baruun isiniif barbaachisaa dha. Wixinee qorannoo irraatti hirmaachuuf murteessuu keessaaniin dura odeeffannoo kana of eeggannoon hubachuu fi waliigala isaa dubbisuuf adaraa yeroo kennaa! Wanti ifa isiniif hin taane yoo jiraate ykn Odeeffannoo dabalataa argachuuf gaafa dhaa.

Faayidaafi duub jalee

Dhikkubni "Tiibii dhukkuba daddarboo dha,akka waliigalaatti umrii kamiyyuu irraatti saala lamaanuu du'aafis ta'e dhukkuba cimaafi kan nama saaxilu dha.Dhukkubni "Tiibii godina jimmaa dabalatee itiyoophiyaa keessaatti beekamaa dha. Haala fudhatama,danda'amaafi baasii xiqqaa ta'een dhukkubicha to'achuun barbaachisaa dha. Yaadni piroojektii qorannoo kanaas;- itiyoophiyaa keessaa godina jimmaatti raawwii fi qulqullina waliigalaa tarsiimoo koorsii gabaabaa yaalinsa daawwannaa kallattii/'Tiibii'-DOTS/ sakattaa'uu dha. Beekumsi qorannoo kana irraa argamu raawwiifi qulqullina sagantichaa foyyeessuuf odeeffaannoo gahaa kennuuf kan isin gargaaru dha. Aangeeffamaa Qindeessaa ykn hojii gaggeessaa w/ra fayyaa ta'uu keessaniin sochiiwwan sagantaa 'Tiibii'waliigalaa baayyee irraatti waan hirmaattaniifi saganticha haala itti raawwatu irraatti beekumsa hedduu akka qabdanu ni amanna.Kanaafi qorannocha keenyaaf beekumsa barbaachisaa kennuu akka dadeessanu hubannee itti yaaduun isin filanneerra.

Qorannochi Maal qabata?

Qorannoo kana keessaatti waa'ee koorsii gabaabaa yaalinsa daawwannaa kallaattii 'Tiibii' muuxannoofi ilaalcha qabdanu irraatti ani gaaffii isin gaafadha. Gaaffifi deebiichi sa'aatii tokko kan fudhatu yoo ta'u yeroonifi bakki isiniif mijaa'aa ta'etti kan ta'u dha. Hirmaachuufi eeyyamaa yoo taatan gaaffifi deebichi Teeppiidhaan kan waraabamu ta'a. Waa'ee sagantaa to'annoo ''Tiibii'' fi sagantaa kana yeroo raawwachistan jiraachuu wantoota mijeessitootaafi danqarsoota addaan baasuu irraatti gaaffii muraasa isin gaafachuu nan barbaada.Yoo hirmaattanis ta'e dhiistan haala kamiinuu aageeffama keessan irraatti dhiibbaa hin qabu.

Jiraachuu Faayidaa fi miidhaa

Waa'ee Tarsiimoo 'Tiibii'DOTS odeffaannoo nuuf kennitanu gara sa'aatii tokko isin jalaa gubuu ni danda'a. Qorannoo kana irraatti hirmaachuu keessaaniifi kallattidhaan faayidaan isin argattan hin jiru ta'a garuu amanamummaafi bilisaan deebiin kennitan foyya'insa raawwii fi qulqullina tajaajila 'Tiibii'wojin walqabateef odeeffannoo gabbifachuufi gahee qaba.

Odeeffaannoo kennitan maal ta'uu danda'a?

Ragaan waa'ee keessan galmaa'ee kun faayidaa qorannoo kanaafi qofa oola. Ragaan kun kan raawwatu maqaafi lakkofsa eenyummaa kallaattiin haala odeeffaannoo hin beekamneeni dha. Lakkofsa addaa ragaa keessan isiniin wal qabsiisu ni fayyadamna,akkasumas odeeffaannoon isin nuuf kennitanu icitiin ni qabama,Ragaan hundu saanduqa keessatti furtuun kan qabamuufi lakkofsa icitii kompuratan ni eegama. Dabalataanis odeeffaannoon keessan kan fayyadamnu piroojektii eega xumurree booda osoo hin ta'in yeroo gabaasni barreeffamu qofa dha.

Hirmaannaa Fedhiinii

Hirmaanaan qorannoo kana keessaatti gaggeffamu fedhii irraatti kan hundaa'ee dha.Sababa dhuunfaa kamiyyuu osoo hin dhiheessin yeroo barbaaddan keessaatti fedhii keessan haquu ni dandeessu.Kunis yaalinsa itti fufu irraatti miidhaa wanta tokko isin irraatti hin qaqqabsiisu.hirmaachuu kan barbaaddan yoo ta'e fuula xumuraa waliigaltee irraatti mallateessaa.Yeroo kana keessaatti hirmaachuufi yoo waliigaltan, karaa kamiinuu yaalinsa keessan haala hin miineen booda irraatti waliigaltee keessan haquu ni dandeessu. Booda irraatti waliigaltee keessan haquu yoo barbaaddan ykn gaaffii qorannocha ilaallatu yoo qabaattan:

Birhaanee Magarsaa Irreessoo

Lakkofsa mobaayilii 0917804469

Teessoo imeelii berhanemegerssa2004@gmail.com, Yunivarstii jimmaa, itiyoophiyaa

Supparvaayizaroota

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Argachu ykn dubbisu dandeessu

Miseensota kan birootiif ragaafi meeshaalee dabarsuu

Qorannoocha irraatti hirmaachuufi hanga waliigaltanitti ragaa eenyummaa hin ibsine itiyoophiyaatti w/ra fayyaa naannoofi godina keessaatti ragaa darbuufi eeyyamtanittu jechuu dha.

Mirga argachuufi haquu ragaa

Qorannocha irraatti hirmaachuuf hanga waliigaltanitti waa'ee keessanii odeeffannoo galmaa'ee argachuu ni dandeessu. Odeeffaannoo nuti galmeessine keessaatti dogongora kamiyyuu dabalataan sirreessuu ni dandeessu.Qorannocha keessaa bahuu yoo barbaaddan; hanga ragichi hin qindoofnetti ykn tajaajila maxxansaafi hin galleetti ragaa sassaabame haquu ni dandeessu.

Maallaqaafi gahee pirojektii tarsiimoo walgargaarsaa misooma dandeetti itiyoophiyaafi afriikaa (SACCADE)

Qo'annochi maallaqaan kan gargaaramu pirojektii tarsiimoo walgargaarsaa misooma dandeetti itiyoophiyaafi afriikaa (SACCADE) irraa qorannoofi kan argameetiini dha.Pirojektiin SACCADE baasiiwwan geejjibaa, namaafi dhiheessa meeshaaleetiin walqabatu ni aguuga.pirojektichi pirojektii kamiyyuu waliin walitti bu'iinsa faayidaa hin qabu.

Odeeffaannoo waa'ee bu'aa qo'annoochaa

Waa'ee xumuraafi bu'aa qo'annochaa odeeffaannoo fudhachuuf mirga guutuu qabdu.

Qo'annocha irraatti hirmaachuufi eeyyamaa ta'u

Ani qo'annocha irraatti hirmaachuufi eeyyameera.

(Mallaattoo hirmaataa qo'annichaa fi guyyaa)

Waa'ee qo'annochaa odeeffaannoo kennuu koo nan mirkaneessa.

Mallaattoo sassaabaa Ragaa fi guyyaa

Gaaffii hirmaannaa qorannoo pirojektii kennitoota Koorsii gabaabaa yaaliinsa daawwannaa kallaattii dhukkuba "Tiibii'' (DOTS)

Raawwannaa fi qulqullina Tarsiimoo Koorsii gabaabaa yaaliinsa daawwannaa kallaattii dhukkuba "Tiibii'' (DOTS) godina jimmaa, kibba lixa itiyoophiyaa.

Seensa

Maqaan koo---------- ----------Yunivarstii osloo,Noorwayitti ani baratatu PhD ti.

Sababa raawwatiinsa naannoo sagantaa to'achuufi Ittisuu Tiibii irraatti muuxxaannoo qabdaniifi qo'annaa qorannoo irraatti akka hirmaattan kabajaan isin affeerreera.Tarreen karoora qorannoo kanaa ragaa kana irraatti tarreeffameera.Qorannoon kun maaliifi akka gaggeeffamu,maal of keessaa akka qabu, baruun isiniif barbaachisaa dha. Wixinee qorannoo irraatti hirmaachuuf murteessuu keessaaniin dura odeeffannoo kana of eeggannoon hubachuu fi waliigala isaa dubbisuuf adaraa yeroo kennaa! Wanti ifa isiniif hin taane yoo jiraate ykn Odeeffannoo dabalataa argachuuf gaafa dhaa.

Faayidaafi duub jalee

Dhikkubni "Tiibii dhukkuba daddarboo dha,akka waliigalaatti umrii kamiyyuu irraatti saala lamaanuu du'aafis ta'e dhukkuba cimaafi kan nama saaxilu dha.Dhukkubni "Tiibii godina jimmaa dabalatee itiyoophiyaa keessaatti beekamaa dha. Haala fudhatama,danda'amaafi baasii xiqqaa ta'een dhukkubicha to'achuun barbaachisaa dha. Yaadni piroojektii qorannoo kanaas;- itiyoophiyaa keessaa godina jimmaatti raawwii fi qulqullina waliigalaa tarsiimoo koorsii gabaabaa yaalinsa daawwannaa kallattii/'Tiibii'-DOTS/ sakattaa'uu dha. Beekumsi qorannoo kana irraa argamu raawwiifi qulqullina sagantichaa foyyeessuuf odeeffaannoo gahaa kennuuf kan isin gargaaru dha. Aangeeffamaa Qindeessaa ykn hojii gaggeessaa w/ra fayyaa ta'uu keessaniin sochiiwwan sagantaa 'Tiibii'waliigalaa baayyee irraatti waan hirmaattaniifi saganticha haala itti raawwatu irraatti beekumsa hedduu akka qabdanu ni amanna.Kanaafi qorannocha keenyaafi beekumsa barbaachisaa kennuu akka dadeessanu hubannee itti yaaduun isin filanneerra.

Qorannochi Maal qabata?

Qorannoo kana keessaatti waa'ee koorsii gabaabaa yaalinsa daawwannaa kallaattii 'Tiibii' muuxannoofi ilaalcha qabdanu irraatti ani gaaffii isin gaafadha. Gaaffifi deebiichi sa'aatii tokko kan fudhatu yoo ta'u yeroonifi bakki isiniif mijaa'aa ta'etti kan ta'u dha. Hirmaachuufi eeyyamaa yoo taatan gaaffifi deebichi Teeppiidhaan kan waraabamu ta'a. Waa'ee sagantaa to'annoo ''Tiibii'' fi sagantaa kana yeroo raawwachistan jiraachuu wantoota mijeessitootaafi danqarsoota addaan baasuu irraatti gaaffii muraasa isin gaafachuu nan barbaada. Yoo hirmaattanis ta'e dhiistan haala kamiinuu aageeffama keessan irraatti dhiibbaa hin qabu.

Jiraachuu Faayidaa fi miidhaa

Waa'ee Tarsiimoo 'Tiibii'DOTS odeffaannoo nuuf kennitanu gara sa'aatii tokko isin jalaa gubuu ni danda'a. Qorannoo kana irraatti hirmaachuu keessaaniifi kallattidhaan faayidaan isin argattan hin jiru ta'a garuu amanamummaafi bilisaan deebiin kennitan foyya'insa raawwii fi qulqullina tajaajila 'Tiibii'wojin walqabateef odeeffannoo gabbifachuufi gahee qaba.

Odeeffaannoo kennitan maal ta'uu danda'a?

Ragaan waa'ee keessan galmaa'ee kun faayidaa qorannoo kanaafi qofa oola. Ragaan kun kan raawwatu maqaafi lakkofsa eenyummaa kallaattiin haala odeeffaannoo hin beekamneeni dha. Lakkofsa addaa ragaa keessan isiniin wal qabsiisu ni fayyadamna, akkasumas odeeffaannoon isin nuuf kennitanu icitiin ni qabama,Ragaan hundu saanduqa keessatti furtuun kan qabamuufi lakkofsa icitii kompurataan ni eegama. Dabalataanis odeeffaannoon keessan kan fayyadamnu piroojektii eega xumurree booda osoo hin ta'in yeroo gabaasni barreeffamu qofa dha.

Hirmaannaa Fedhiinii

Hirmaanaan qorannoo kana keessaatti gaggeffamu fedhii irraatti kan hundaa'ee dha.Sababa dhuunfaa kamiyyuu osoo hin dhiheessin yeroo barbaaddan keessaatti fedhii keessan haquu ni dandeessu.Kunis yaalinsa itti fufu irraatti miidhaa wanta tokko isin irraatti hin qaqqabsiisu.hirmaachuu kan barbaaddan yoo ta'e fuula xumuraa waliigaltee irraatti mallateessaa.Yeroo kana keessaatti hirmaachuufi yoo waliigaltan, karaa kamiinuu yaalinsa keessan haala hin miineen booda irraatti waliigaltee keessan haquu ni dandeessu. Booda irraatti waliigaltee keessan haquu yoo barbaaddan ykn gaaffii qorannocha ilaallatu yoo qabaattan:

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   Argachu ykn dubbisu dandeessu.

Miseensota kan birootiif ragaafi meeshaalee dabarsuu

Qorannoocha irraatti hirmaachuufi hanga waliigaltanitti ragaa eenyummaa hin ibsine itiyoophiyaatti w/ra fayyaa naannoofi godina keessaatti ragaa darbuufi eeyyamtanittu jechuu dha.

Mirga argachuufi haquu ragaa

Qorannocha irraatti hirmaachuuf hanga waliigaltanitti waa'ee keessanii odeeffannoo galmaa'ee argachuu ni dandeessu. Odeeffaannoo nuti galmeessine keessaatti dogongora kamiyyuu dabalataan sirreessuu ni dandeessu.Qorannocha keessaa bahuu yoo barbaaddan; hanga ragichi hin qindoofnetti ykn tajaajila maxxansaafi hin galleetti ragaa sassaabame haquu ni dandeessu.

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Odeeffaannoo waa'ee bu'aa qo'annoochaa

Waa'ee xumuraafi bu'aa qo'annochaa odeeffaannoo fudhachuuf mirga guutuu qabdu.

Qo'annocha irraatti hirmaachuufi eeyyamaa ta'u

Ani qo'annocha irraatti hirmaachuufi eeyyameera.

(Mallaattoo hirmaataa qo'annichaa fi guyyaa)

Waa'ee qo'annochaa odeeffaannoo kennuu koo nan mirkaneessa.

Mallaattoo sassaabaa Ragaa fi guyyaa

Gaaffii hirmaannaa qorannoo pirojektii dhukubsattoota 'Tiibiitiif' gaaffiifi deebii gadi fageenyaatiif)

Raawwannaa fi qulqullina Tarsiimoo Koorsii gabaabaa yaaliinsa daawwannaa kallaattii dhukkuba "Tiibii'' (DOTS) godina jimmaa, kibba lixa itiyoophiyaa.

Seensa

Maqaan koo---------- ----------Yunivarstii osloo,Noorwayitti ani baratuPhD ti.

Sababa dhukkuba 'Tiibii' jedhamee beekamu isin irratti waan argameefi hirmaannaa qo'annaa qorannoo irraatti akka hirmaattan kabajaan isin affeerreera.

Tarreen karoora qorannoo kanaa ragaa kana irraatti tarreeffameera.Qorannoon kun maaliifi akka gaggeeffamu, maal of keessaa akka qabu, baruun isiniif barbaachisaa dha. Wixinee qorannoo irraatti hirmaachuuf murteessuu keessaaniin dura odeeffannoo kana of eeggannoon hubachuu fi waliigala isaa dubbisuuf adaraa yeroo kennaa! Wanti ifa isiniif hin taane yoo jiraate ykn Odeeffannoo dabalataa argachuuf gaafa dhaa.

Faayidaafi duub jalee

Dhikkubni "Tiibii dhukkuba daddarboo dha,akka waliigalaatti umrii kamiyyuu irraatti saala lamaanuu du'aafis ta'e dhukkuba cimaafi kan nama saaxilu dha.Dhukkubni "Tiibii godina jimmaa dabalatee itiyoophiyaa keessaatti beekamaa dha. Haala fudhatama,danda'amaafi baasii xiqqaa ta'een dhukkubicha to'achuun barbaachisaa dha. Yaadni piroojektii qorannoo kanaas;- itiyoophiyaa keessaa godina jimmaatti raawwii fi qulqullina waliigalaa tarsiimoo koorsii gabaabaa yaalinsa daawwannaa kallattii/'Tiibii'-DOTS/ sakattaa'uu dha.

Miseensotni hawaasaa tajaajila gaarii akka argataniifi raawwiin fi qulqullina sagantichaa foyyeessuufi jecha qorannaa kana irraa beekumsi argamu odeeffannoo faayidaa qabeessa ta'e akka murtii kennitootaafi kenninu kan nu gargaaru dha.

Kana hojjachuu akka dandeenyuufi waa'ee dhukkubsattoota 'Tiibii' yaalinsa irra jiranii muuxxaannoofi beekumsa keessaan argachuun baayyee barbaachisaa dha. Kanaafi qorannocha keenyaafi beekumsa barbaachisaa kennuu akka dandeessanu hubannee itti yaaduun isin filanneerra.

Qorannochi Maal qabata?

Yaalinsa fudhataa hanga taatanitti qorannoo kana keessaatti waa'ee koorsii gabaabaa yaalinsa daawwannaa kallaattii 'Tiibii' gaaffifi deebii isniif gochuu nan barbaada. Muuxannoof ilaalcha kunuunsa 'Tiibii' irraatti qabdanu fi yeroo kunuunsa 'Tiibii' mijeessitootaafi jiraachuu rakkoo addaan baasuuf gaaffii muraasa isin gaafachuu nan barbaada. Gaaffifi deebiichi sa'aatii tokko kan fudhatu yoo ta'u yeroonifi bakki isiniif mijaa'aa ta'etti kan ta'u dha. Hirmaachuufi eeyyamaa yoo taatan gaaffifi deebichi Teeppiidhaan kan waraabamu ta'a. Qorannoo kana irraatti

hirmaattanis dhiistanis yaalinsa argattan irraatti dhibbaa kamuu hin qabu.Yaalinsa Kanaan dura argattan itti fufaan ni fudhattu.

Jiraachuu Faayidaa fi miidhaa

Odeeffaannoo waa'ee argannoo 'Tiibii' fi yaalinsa isaa nuuf kennitan humnaafi yeroo keessan isa mi'awaa sa'aa tokko kan ta'u isin jalaa gubuu ni danda'a. Qorannoo kana irraatti hirmaachuu keessaaniifi kallattidhaan faayidaan isin argattan hin jiru ta'a garuu amanamummaafi bilisaan deebiin kennitan foyya'insa raawwii fi qulqullina tajaajila 'Tiibii'wojin walqabateef odeeffannoo gabbifachuufi gahee qaba.

Odeeffaannoo kennitan maal ta'uu danda'a?

Ragaan waa'ee keessan galmaa'ee kun faayidaa qorannoo kanaafi qofa oola. Ragaan kun kan raawwatu maqaafi lakkofsa eenyummaa kallaattiin haala odeeffaannoo hin beekamneeni dha. Lakkofsa addaa ragaa keessan isiniin wal qabsiisu ni fayyadamna, akkasumas odeeffaannoon isin nuuf kennitanu icitiin ni qabama,Ragaan hundu saanduqa keessatti furtuun kan qabamuufi lakkofsa icitii kompurataan ni eegama. Dabalataanis odeeffaannoon keessan kan fayyadamnu piroojektii eega xumurree booda osoo hin ta'in yeroo gabaasni barreeffamu qofa dha.

Hirmaannaa Fedhiinii

Hirmaanaan qorannoo kana keessaatti gaggeffamu fedhii irraatti kan hundaa'ee dha.Sababa dhuunfaa kamiyyuu osoo hin dhiheessin yeroo barbaaddan keessaatti fedhii keessan haquu ni dandeessu.Kunis yaalinsa itti fufu irraatti miidhaa wanta tokko isin irraatti hin qaqqabsiisu.hirmaachuu kan barbaaddan yoo ta'e fuula xumuraa waliigaltee irraatti mallateessaa.Yeroo kana keessaatti hirmaachuufi yoo waliigaltan, karaa kamiinuu yaalinsa keessan haala hin miineen booda irraatti waliigaltee keessan haquu ni dandeessu. Booda irraatti waliigaltee keessan haquu yoo barbaaddan ykn gaaffii qorannocha ilaallatu yoo qabaattan:

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   Argachu ykn dubbisu dandeessu.

Miseensota kan birootiif ragaafi meeshaalee dabarsuu

Qorannoocha irraatti hirmaachuufi hanga waliigaltanitti ragaa eenyummaa hin ibsine itiyoophiyaatti w/ra fayyaa naannoofi godina keessaatti ragaa darbuufi eeyyamtanittu jechuu dha.

Mirga argachuufi haquu ragaa

Qorannocha irraatti hirmaachuuf hanga waliigaltanitti waa'ee keessanii odeeffannoo galmaa'ee argachuu ni dandeessu. Odeeffaannoo nuti galmeessine keessaatti dogongora kamiyyuu dabalataan sirreessuu ni dandeessu.Qorannocha keessaa bahuu yoo barbaaddan; hanga ragichi hin qindoofnetti ykn tajaajila maxxansaafi hin galleetti ragaa sassaabame haquu ni dandeessu.

Maallaqaafi gahee pirojektii tarsiimoo walgargaarsaa misooma dandeetti itiyoophiyaafi afriikaa (SACCADE)

Qo'annochi maallaqaan kan gargaaramu pirojektii tarsiimoo walgargaarsaa misooma dandeetti itiyoophiyaafi afriikaa (SACCADE) irraa qorannoofi kan argameetiini dha.Pirojektiin SACCADE baasiiwwan geejjibaa,namaafi dhiheessa meeshaaleetiin walqabatu ni aguuga.pirojektichi pirojektii kamiyyuu waliin walitti bu'iinsa faayidaa hin qabu.

Odeeffaannoo waa'ee bu'aa qo'annoochaa

Waa'ee xumuraafi bu'aa qo'annochaa odeeffaannoo fudhachuuf mirga guutuu qabdu.

Qo'annocha irraatti hirmaachuufi eeyyamaa ta'u

Ani qo'annocha irraatti hirmaachuufi eeyyameera.

(Mallaattoo hirmaataa qo'annichaa fi guyyaa)

Waa'ee qo'annochaa odeeffaannoo kennuu koo nan mirkaneessa.

Mallaattoo sassaabaa Ragaa fi guyyaa

1. Gaaffii hirmaannaa qorannoo pirojektii Dhukkubsattoota “Tiibii’ tiif dhiyaate

Raawwannaa fi qulqullina Tarsiimoo Koorsii gabaabaa yaaliinsa daawwannaa kallaattii dhukkuba “Tiibii’’ (DOTS) Godina Jimmaa, kibba lixa itiyoophiyaa

Seensa

Maqaan koo---------- ----------kani hojjadhu dhaabbatu fayyaa ----------

Sababa dhukkuba ‘Tiibii’ jedhamee beekamu isin irratti waan argameefi hirmaannaa qo’annaa qorannoo irraatti akka hirmaattan kabajaan isin affeerreera. Tarreen karoora qorannoo kanaa ragaa kana irraatti tarreeffameera.Qorannoon kun maaliifi akka gaggeeffamu,maal of keessaa akka qabu, baruun isiniif barbaachisaa dha. Wixinee qorannoo irraatti hirmaachuuf murteessuu keessaaniin dura odeeffannoo kana of eeggannoon hubachuu fi waliigala isaa dubbisuuf adaraa yeroo kennaa! Wanti ifa isiniif hin taane yoo jiraate ykn Odeeffannoo dabalataa argachuuf gaafa dhaa.

Faayidaafi duub jalee

Dhikkubni “Tiibii dhukkuba daddarboo dha,akka waliigalaatti umrii kamiyyuu irraatti saala lamaanuu du’aafis ta’e dhukkuba cimaafi kan nama saaxilu dha.Dhukkubni “Tiibii’’ godina jimmaa dabalatee itiyoophiyaa keessaatti beekamaa dha. Haala fudhatama,danda’amaafi baasii xiqqaa ta’een dhukkubicha to’achuun barbaachisaa dha. Yaadni piroojektii qorannoo kanaas;- itiyoophiyaa keessaa godina jimmaatti raawwii fi qulqullina waliigalaa tarsiimoo koorsii gabaabaa yaalinsa daawwannaa kallattii/’Tiibii’-DOTS/ sakattaa’uu dha. Miseensotni hawaasaa tajaajila gaarii akka argataniifi raawwiin fi qulqullina sagantichaa foyyeessuufi jecha qorannaa kana irraa beekumsi argamu odeeffannoo faayidaa qabeessa ta’e akka murtii kennitootaafi kenninu kan nu gargaaru dha. Kana hojjachuu akka dandeenyuufi waa’ee dhukkubsattoota ‘Tiibii’ yaalinsa irra jiranii muuxxaannoofi beekumsa keessaan argachuun baayyee barbaachisaa dha. Aanaalee tasaan filataman keessaa isin qorannoo kanaafi filatamtaniittu.

Qorannochi Maal qabata?

Qorannoo kana keessaatti ani gaaffiilee muraasa waa’ee adeemsa argannaa dhukkubichaafi kallaattii daawwannaa yaalinsaa guyyaa guyaanii keessan isin gaafadha. Gaaffifi deebiichi daqiiqaa 50 hanga 60 kan fudhatu yoo ta’u yeroofi bakkicha isiniif mijaa’aa ta’etti kan ta’u dha. Dabalataanis bu’aa yaalinsa keessanii hanga yaalisicha xumurtanitti ni hordofna, odeeffaannoo yaalinsa ‘Tiibii’wojjiniin walqabate fi sadarkaa bu’ichaa galmee galmeessa ‘Tiibii’irraa ni arganna. Qorannoo kana irraatti hirmaattanis dhiistanis yaalinsa argattan irraatti dhibbaa kamuu hin qabu.Yaalinsa Kanaan dura argattan itti fufa.

Jiraachuu Faayidaa fi miidhaa

Odeeffaannoo waa'ee eenyummaa keessanniifi adeemsa argannoofi yaalinsa 'Tiibii'nuuf kennitan yeroo keessan irraa daqiiqaa 50 hanga 60 ta'uu isin duraa gubachuu danda'a. Qorannoo kana irraatti hirmaachuu keessaaniifi kallattidhaan faayidaan isin argattan hin jiru ta'a garuu amanamummaafi bilisaan deebiin kennitan foyya'insa raawwii fi qulqullina tajaajila 'Tiibii'wojin walqabateef odeeffannoo gabbifachuufi gahee qaba.

Odeeffaannoo kennitan maal ta'uu danda'a?

Ragaan waa'ee keessan galmaa'ee kun faayidaa qorannoo kanaafi qofa oola. Ragaan kun kan raawwatu maqaafi lakkofsa eenyummaa kallaattiin haala odeeffaannoo hin beekamneeni dha. Lakkofsa addaa ragaa keessan isiniin wal qabsiisu ni fayyadamna,akkasumas odeeffaannoon isin nuuf kennitanu icitiin ni qabama,Ragaan hundu saanduqa keessatti furtuun kan qabamuufi lakkofsa icitii kompurataan ni eegama. Dabalataanis odeeffaannoon keessan kan fayyadamnu piroojektii eega xumurree booda osoo hin ta'in yeroo gabaasni barreeffamu qofa dha.

Hirmaannaa Fedhiinii

Hirmaanaan qorannoo kana keessaatti gaggeffamu fedhii irraatti kan hundaa'ee dha.Sababa dhuunfaa kamiyyuu osoo hin dhiheessin yeroo barbaaddan keessaatti fedhii keessan haquu ni dandeessu.Kunis yaalinsa itti fufu irraatti miidhaa wanta tokko isin irraatti hin qaqqabsiisu.hirmaachuu kan barbaaddan yoo ta'e fuula xumuraa waliigaltee irraatti mallateessaa.Yeroo kana keessaatti hirmaachuufi yoo waliigaltan, karaa kamiinuu yaalinsa keessan haala hin miineen booda irraatti waliigaltee keessan haquu ni dandeessu. Booda irraatti waliigaltee keessan haquu yoo barbaaddan ykn gaaffii qorannocha ilaallatu yoo qabaattan:

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   Argachu ykn dubbisu dandeessu.

Miseensota kan birootiif ragaafi meeshaalee dabarsuu

Qorannoocha irraatti hirmaachuufi hanga waliigaltanitti ragaa eenyummaa hin ibsine itiyoophiyaatti w/ra fayyaa naannoofi godina keessaatti ragaa darbuufi eeyyamtanittu jechuu dha.

Mirga argachuufi haquu ragaa

Qorannocha irraatti hirmaachuuf hanga waliigaltanitti waa'ee keessanii odeeffannoo galmaa'ee argachuu ni dandeessu. Odeeffaannoo nuti galmeessine keessaatti dogongora kamiyyuu dabalataan sirreessuu ni dandeessu.Qorannocha keessaa bahuu yoo barbaaddan; hanga ragichi hin qindoofnetti ykn tajaajila maxxansaafi hin galleetti ragaa sassaabame haquu ni dandeessu.

Maallaqaafi gahee pirojektii tarsiimoo walgargaarsaa misooma dandeetti itiyoophiyaafi afriikaa (SACCADE)

Qo'annochi maallaqaan kan gargaaramu pirojektii tarsiimoo walgargaarsaa misooma dandeetti itiyoophiyaafi afriikaa (SACCADE) irraa qorannoofi kan argameetiini dha.Pirojektiin SACCADE baasiiwwan geejjibaa,namaafi dhiheessa meeshaaleetiin walqabatu ni aguuga.pirojektichi pirojektii kamiyyuu waliin walitti bu'iinsa faayidaa hin qabu.

Odeeffaannoo waa'ee bu'aa qo'annoochaa

Waa'ee xumuraafi bu'aa qo'annochaa odeeffaannoo fudhachuuf mirga guutuu qabdu.

Qo'annocha irraatti hirmaachuufi eeyyamaa ta'u

Ani qo'annocha irraatti hirmaachuufi eeyyameera.

(Mallaattoo hirmaataa qo'annichaa fi guyyaa)

Mallaattoo guddisaa fi guyyaa(yeroo barbaachisaa ta'e)

Waa'ee qo'annochaa odeeffaannoo kennuu koo nan mirkaneessa.

Mallaattoo sassaabaa Ragaa fi guyyaa

Appendix 4: Data collection tool:

In-depth interview guides, Checklist, and Questionnaire English version

Interview guide for Regional Health Bureau Head/ Program manager

Background information

Sex ---------- Age ---------- Profession ----------

Responsibility on the program ----------

Training on TB DOTS ---------- If yes, how long? ----------

Introductory /open question:

1. Would you please tell me about your experience in regards to the national TB control program?

Theme I. Infrastructure and other resources

2. What do you think about the availability of necessary infrastructure and other resources for implementation of TB DOTS in Oromia region?

Probing questions

- How did you see the distribution pattern for all Zones under Oromia region?
- Would you please tell me about the source for fund/resources?
- Would you please mention which infrastructure/resource are absent while necessary for the program?
- What are the facilitators in relation to infrastructure and other resources?
- What are the barriers in relation to infrastructure and other resources?
- How do you see the utilization of allocated resources for DOTS in different Zones? What about Jimma Zone in particular?

Theme II. Compliance to national guideline

3. How do you see the general performance of DOTS in Oromia Region? What about in Jimma Zone?

Probing questions

- Do you think that health personal are performing as per national guideline/as expected? (timely, complete, accurate reporting, etc)
- What do you think are the possible barriers for compliance to the national guideline?
- What do you think are the possible facilitators for compliance to the national guideline?
- Have you conducted supportive supervision this year? How frequent? Was feedback provided in written/orally?

Theme III. DOTS outcome

4. What do you think about the overall performance and outcome of DOTS in Oromia Region? What about in Jimma Zone?

Probing questions

- How did you see the overall performance?
- How do you see the outcome of DOTS? Is it as expected?
- What are the possible explanations/causes for this outcome?
- What do you think are the possible facilitators and barriers for favorable outcome?

5. What do you think about facility based versus community based DOTS in Oromia? Are both implemented?
6. In your experience, are there any differences in regards to e.g. quality or effectiveness between these? If yes, can you explain why such differences exists?
7. What suggestions would you give to improve the existing TB control program?
8. Do you have any other information or comments you would like to provide regarding the DOTS strategy?

Interview guide for Zonal /Woreda health office head and TB program coordinator/supervisors of health extension workers

Background information

Sex ---------- Age ---------- Profession ----------
Responsibility on the program ----------

Training on TB DOTS ---------- If yes, how long? ----------

Introductory/open questions:

1. Would you please tell me about your experience with the national TB control program?

2. Can you please tell me what resources or elements of the treatment program that has to be present to ensure good quality in implementing DOTS?

Theme I. Infrastructure and other resources

3. Do you think that this Zone/Woreda has the necessary infrastructure and other resources to deliver quality DOTS for the community?

Probing questions

- Would you please mention which infrastructure/resource are absent while necessary for the program?
- What are the facilitators in relation to infrastructure and other resources?
- What are the barriers in relation to infrastructure and other resources?
- Has there been an interruption of service due to absence of drug and/or reagents? If so, what measures were taken to solve the interruption?
- In what way do you check the quality of the available resource?

Theme II. Compliance to national guideline

4. What are your thoughts on the process/activities performed by health care providers in delivering DOTS for the community in this Zone/ Woreda?

Probing questions

- Do you think that health personnel are performing as per national guideline? (During diagnosis, treatment, follow up, reporting)
- What are possible barriers for compliance of health care providers to the national guideline?
- What are possible facilitators for compliance of health care providers to the national guideline?
- How do you check the quality of the health care providers' performance?
- Have you conducted 'supportive supervision' in this year? How frequent? Was feedback provided in written/orally?

Theme III. Treatment adherence and outcome

5. Can you please tell me about your thoughts and experience in regards to TB treatment adherence in general in this Zone/Woreda?

6. Can you please tell me about your thoughts and experience in regards to the treatment outcome in this Zone/Woreda?

Probing questions

- What are possible explanations/causes for patients' not adhering to treatment?
- What are possible facilitators for patients in completing their treatment?
- What are possible barriers for patients in completing their treatment?
- What are the possible causes for the present (poor/good) TB treatment outcomes?
- What are the possible facilitators and barriers for favorable treatment outcomes?

7. What do you think about facility based versus community based DOTS in this Zone/Woreda? Are both implemented?

8. In your experience, are there any differences in regards to e.g. quality or effectiveness between these? Would you please explain? What suggestions would you give to improve the existing TB control program?

9. Do you have any other information or comments you would like to provide regarding the DOTS strategy?

Interview guide for DOTS provider

DOTS site _____

Background information

Sex ---------- Age ---------- Profession ----------
Responsibility in the program ----------

Training on TB DOTS ---------- If yes, how long? ----------

Introductory /open questions:

1. Would you please tell me about your experience in regards to the national TB control program?

2. Can you please tell me what resources or elements of the treatment program have to be present to ensure good quality in implementing DOTS?

Theme I. Infrastructure and other resources

3. Do you think that this Zone/Woreda has the necessary infrastructure and other resources to deliver quality DOTS for the community?

Probing questions

- Would you please mention which infrastructure/resource are absent while necessary for the program?
- What are the facilitators in relation to infrastructure and other resources?
- What are the barriers in relation to infrastructure and other resources?
- Has there been an interruption of service due to absence of drug and/or reagents? If so, what measures were taken to solve the interruption?

Theme II. Compliance to national guideline

4. What are your thoughts on the process/activities that you have been providing for the community in this DOTS site?

Probing questions

- Do you think that you and your colleagues are performing according to the national guideline? (During diagnosis, treatment, follow up, reporting). Why? Why not?
- What are possible barriers for you to provide DOTS according to the national guidelines?
- What are possible facilitators for you to provide DOTS according to the national guidelines?
- Have you received any type of supervisionfor performing TB activities? How frequent? Have you received feedback in written/orally? Was it useful?

Theme III. Treatment adherence and outcome

5. Can you please tell me about your thoughts and experience in regards to TB treatment adherence in general in this Zone/Woreda?

6. Can you please tell me about your thoughts and experience in regards to the treatment outcome in this Zone/Woreda?

Probing questions

- What are possible explanations/causes for patients' not adhering to treatment?
- What are possible facilitators for patients in completing their treatment?
- What are possible barriers for patients in completing their treatment?
- What are the possible causes for the present (poor/good) TB treatment outcomes?
- What are the possible facilitators and barriers for favorable treatment outcomes?

7. What do you think about facility based versus community based DOTS in this Zone/Woreda? Are both implemented?

8.In your experience, are there any differences in regards to e.g. quality or effectiveness between these? Would you please explain? What suggestions would you give to improve the existing TB control program?

9. Do you have any other information or comments you would like to provide regarding the DOTS strategy?

Interview guide for TB patient

Background information of the respondent

Age ---------- Sex ---------- Educational status ----------

Occupational status ---------- Residence ----------

DOTS site ---------- Duration of treatment ----------

Introductory /open question:

1. Can you tell me about your experience being a TB patient at this treatment site? (The diagnostic process, the daily visits to the treatment site)

Theme I. Infrastructure and other resources

2. What is your impression in regards to how the daily TB treatment is performed?

3. Do you think that there are enough resources? (e.g. human power, equipment for diagnostics tests, supplies and TB medicines)

Probing questions

- Where do you receive treatment? Is it difficult for you to come daily for the treatment? If so, in what way?
- Please tell me more about the organization of treatment and care provided for you (waiting hours, queues, physical condition of DOTS site, walking distance, transport)
- Do you have suggestions regarding how this treatment arrangement (DOTS) could be done to help in improving TB control in the community?
- What changes could be made to help patients getting diagnosed and receiving treatment?
- What changes could be made to help patients complete their TB treatment?
- Do you think that your daily life has been affected? If so, how does this treatment affect your daily life? (Expense, time, work, family/social-life)

Theme II. Compliance to national guideline

4. Are you familiar with how the TB treatment is supposed to be conducted (the national guidelines)

5. Did you think that you have been receiving TB care as recommended in the national guideline?

Probing questions

- Was this DOTS site your first choice when you wanted help? If so, why? If not, where?
- Did you discuss your choice of treatment site with health care provider? If no, why not?
- Does the health care provider/treatment supporter observe you daily when you swallow your drugs? If not, why not?
- Can you tell me about the daily meeting with the health personnel? (Communication, friendly? Room for asking questions? follow-up, mal-treatment)
- Have you learned more about TB, causes of TB, treatment and prevention of TB after you started the treatment? Who/ what are your source of information?
- So far what are the major problems you have been faced in receiving TB care?

Theme III. Treatment adherence and outcome

6. What do you think is the first symptoms of TB?

7. Do you think that the treatment you are offered here is the right (sufficient) treatment for TB?

8. At what point would you think that you have recovered from TB?

Probing questions

- What can you say about your daily TB treatment? Have you ever interrupted your treatment? If so, why? For how long?
- What do you think about the consequence of interrupting the TB treatment?
- Would you please explain the possible facilitators and barriers for favorable outcome of TB treatment?

9. What do you think about TB treatment being offered in the health facility versus being offered in the community? (Researcher must provide examples of these types of organization)

10. Do you think there could be important differences and similarities between these ways of organizing treatment?

11. What suggestions would you give to improve the existing TB treatment?

12. Do you have any other information or comments regarding the existing TB care?

Checklist for availability of infrastructure and other resources

Instruction: This checklist should be completed by observing DOTS sites and asking persons in charge. The presence and absence should be verified through observation.

Permission for observation and interview

Dear Sir/Madam

My name is _____ I am a member of a study team conducting research on performance and quality of Tuberculosis Directly Observed Treatment Short course (TB DOTS) strategy in Jimma Zone. The aim of this study is to assess the over performance and quality of TB DOTS strategy and compare community versus facility based DOTS approaches. Then to provide important information which will help for program improvement. The knowledge provided from this study will help us to provide useful information for decision makers so that the program performance and quality can be improved and the community members may get better services. Your Woreda is randomly selected for this study. I will ask you to provide some information about the program resources. The information you will provide for us will be handled straightly in a confidential manner and will not be shared with anyone with your identity or identify you as the source. I would like to ask you your permission so that I can observe the infrastructure and other resources related to TB DOTS strategy. Also the information collected through this observation will be kept strictly confidential.

The project is approved by the Regional Ethical Committee, South-East, in Norway, and the Ethical Committee in Jimma University, Ethiopia.

Can I get your cooperation in providing necessary information and documents?

1. Yes ---------- 2. No ----------

Name and signature of data collector _____ Date _____

Name and signature of data supervisor _____ Date _____

DOTS site/ Health office ----------

Over all infrastructure and patient environment	Yes	No	NA*	Remark
Does the facility have full time DOTS provider?				
Does the facility have trained laboratory personnel? (on AFB techniques)				
Is there waiting area for patient?				
Does the facility have separate and equipped room for TB clinic?				
Does the health facility have safe water supply?				
Does the health facility have electricity?				
Is appropriate sign posted to locate TB clinic?				
Are there information education and Communication (IEC) materials posted at patient waiting area and OPD room at visible place in local language				
Outpatient departments (OPDs)for availability of the following				
National TB control program guideline				
Laboratory AFB request paper				
Drug prescription paper				
Usable OPD abstract				
Laboratory unit for availability of the following				
National TB control program guideline				
Standard operating procedures of AFB (SOPs)				
IEC material posted on visible place in local Language?				
Laboratory AFB register				
Carbon fuchsine				
Acid alcohol				
Methylene blue				
Functional Microscope (Write type of microscope as remark)				

Over all infrastructure and patient environment	Yes	No	NA*	Remark
Sink with running water				
Alarm clock				
Staining rack				
Drying rack				
Spirit lamp				
Forceps				
Slides (Write type of slides as remark)				
Sputum cups				
Immersion oil				
Lens tissue				
Disinfectant (either 5% phenol or 10% sodium hypo chloride)				
Filter paper				
Applicator stick /wire loop				
Glove				
TB clinic (check for expiry date for the drugs)				
Is TB consultation room clean?				
Is there adequate light in TB room?				
Is there adequate ventilation in TB room?				
Are there IEC materials with local language posted at visible spaces?				
Is there NTCP manual?				
Is there reporting formats				
Is there functional standard unit register?				
Is there functional weighting scale?				
Is there RHZE (Rifampicin,Isoniazid, Pyrazinamid, Ethambutol)				

Over all infrastructure and patient environment	Yes	No	NA*	Remark
RHZ (Rifampicin,Isoniazid, Pyrazinamid				
Is there RH (Rifampicin,Isoniazid)				
Is there Streptomycin (S)				
Does TB room provide privacy?				
Is there Masks				
Is there appropriate safety box				
Pharmacy Store for availability of the following (check for expiry date for the reagents and drugs)				
RHZE				
RHZ				
RH				
Streptomycin (S)				
Sputum cup				
Slides				
Carbol fuchsine				
Methylene blue				
Acid alcohol				
Immersion oil				
Applicator stick				
Review stock card for the following if stock out for the last three months				
RHZE				
RHZ				
RH				
Streptomycin (S)				

Over all infrastructure and patient environment	Yes	No	NA*	Remark
Sputum cup				
Slides				
Carbol fuchsine				
Methylene blue				
Immersion oil				
Applicator stick				
Check availability of stock for at least the next two months				
RHZE				
RH				
Streptomycin (S)				
Sputum cup				
Slides				
Carbol fuchsine				
Methylene blue				
Acid alcohol				
Immersion oil				
Applicator stick				

NA* - Not applicable

Description of Health facility /DOTS site and rooms

_____

Other interesting observations (environment)

_____

_____

_____

1. Questionnaire for Tuberculoses patient

Name of hospital/health center/health post _____
Date of data collection_____
Unit TB number (Code number) _____
Woreda registry number_____
Permanent address of the patient: Zone____ Woreda ___ Kebele___House no._____Phone no._____
Name of data collector_____
Signature_____

I. **Socio-demographic characteristics of the respondent**
First, I would like to ask you a few questions about yourself
For interviewer: please tick the box for the selected answer/s number/s additionally, write short answer in the blank space.

S.No	Questions	Response category	Skip
1	Sex of respondent	1. Male ----------☐ 2. Female----------☐	
2	How old are you?	----------	
3	What is your current marital status	1. Single ----------☐ 2. Married ----------☐ 3. Divorced ---------- ☐ 4. Widowed ----------☐ 5. Not applicable--------☐	
4	What is the highest level of education you have completed?	----------	
5	What is your occupation?	1. Farmer ----------☐ 2. Merchant ----------☐ 3. Government employee -☐ 4. Daily laborer ----------☐ 5. Others, please specify------	

S.No	Questions	Response category	Skip
6	What is your ethnic group?	1. Oromo ----------☐ 2. Amhara---------- -- ☐ 3.Tigre----------☐ 4.Yem ----------☐ 5. Dawuro ---------- ☐ 6. Other please specify ----------	
7	What is your religion	1. Orthodox Christian------ ☐ 2. Muslim ----------☐ 3. Protestant ----------☐ 4. Catholic ----------☐ 5.Other(specify) ----------	
8	Where do you currently live? Please describe the name of your residence area	----------	
9	How far do you live from the nearest health facility that provides you tuberculosis treatment?	In kilometers ---------- or in hours/minutes ----------	
10	What is your means of transportation to visit the health facility for tuberculosis treatment?	1. On foot ---------- ☐ 2. By car/ Bajaj ----------☐ 3. Using horse/mule ------☐ 4. By bus ----------☐ 5. Others (specify) --------	
11	Did you incur any cost for your daily visits to the clinic?	1. Yes ----------☐ 2. No ----------☐	If 2,go to 14

S.No	Question	Response category	Skip
12	If yes, for Q 11, please mention the reason for payment?	1. For transport ----------☐ 2. For laboratory services -------☐ 3. For food & accommodation --☐ 4. Other (specify)----------	
13	Would you please tell me total amount of money you have paid in relation to this illness?	----------	
14	How many family members are living in your household?	----------	
15	Would you please tell me the number of rooms in the house that you are currently live in?	----------	
16	What is/are your means of income? Please describe	---------- ----------	
17	How much do you approximately earn per year?	In cash ---------- In kind ---------- ---------- ----------	

II. Questions for assessing diagnostic delay among TB patients

I would like to ask you some questions to understand your experiences with your illness

S.No	Questions	Response category	Skip
18	When did you first experience to have cough?	----------	
19	Before you come to the current health facility, did you visit any medical provider to get treatment for the cough?	1. Yes ----------☐ 2. No ----------☐	If 2, go to 21
20	If yes for Q 19, which of the following medical providers did you first visit when you first had cough?	1. Health post ---------- ☐ 2. Health centre ----------☐ 3. Hospital ----------☐ 4. Private clinic ----------☐ 5. Other, please describe --------	
21	Have you ever been in contact with a patient who has been taking drugs for treatment of tuberculosis?	1.Yes ----------☐ 2. No ----------☐ 3. I do not know/ I am not sure ☐	

22. Which of the following symptoms are you have been suffering from?

No	**Symptoms**	**Yes**	**No**	**Duration of symptoms**	**Remark**
22. 1	Dry cough				
22.2	Cough with whitish or yellowish sputum				
22.3	Cough with bloody sputum				
22.4	Chest pain				
22.5	Fever				
22.6	Night sweating				
22.7	Weight loss (10%)				
22.8	Loss of appetite				
22.9	Difficulty in breathing				
22.10	Other symptoms (specify)_____				

For interviewer, for questions 24 and 25 please cross check patient information with laboratory and TB registration books data

S.No	**Questions**	**Response category**	**Skip**
23	How long did it take from onset of the above symptoms until your first visit to a medical provider?	Days ---------- Weeks ---------- Months ---------- Years ----------	
24	How long time passed between your first visit to a medical provider until first diagnosis of tuberculosis was made?	Hours ---------- Days ---------- Weeks ---------- Months ----------	
25	How long time passed between the first diagnoses of tuberculosis until you first started treatment?	Hours ---------- Days ---------- Weeks ----------Months -------	

S.No	Questions	Response category	Skip
26	**For the interviewer**: please fill the total time taken from patient's first start of TB symptoms until first start of treatment (Questions 23 + 24 + 25)	Days ---------- Weeks ---------- Months ----------	
27	How do you describe your current illness status?	1. No limitation of day to day activity ---------- -----☐ 2. Slight limitation of day to day activity ---------- ☐ 3. Bed-ridden ----------☐	
28	Are you or have you ever been a smoker?	1. Yes ----------☐ 2. No ----------☐	If 2, go to 30
29	If yes for Q 28, what type?	1. Shisha ---------- ☐ (Duration ----------) 2.Cigarette ----------☐ (Duration ----------)	
30	Do you drink alcohol at all?	1. Yes ---------- ☐ 2. No ----------☐	If 2, go to 32
31	If yes for Q 30, please mention the following:	Type of alcohol ---------- Amount of alcohol consumed in millilitre per day ---------- Duration of alcohol consumption----------	
32	Do you use or have you ever used khat?	1. Yes ---------- ☐ 2. No ----------☐	If 2, go to 34
33	If yes for Q 32, for how long?	----------	
34	Have you evere lived or worked on a regular/temporary basis in a prison or camp?	1. Yes ----------☐ 2. No ----------☐	If 2, go to 37
35	If "Yes" for Q 34, please specify	1. Prison ----------☐ 2. Camp ----------☐	

S.No	Questions	Response category	Skip
36	If "Yes" for Q 34, for how long?	----------	
37	Have you ever been told by a doctor that you have diabetes mellitus?	1. Yes ---------- ☐ 2. No ----------☐	
38	Have you ever been told by a doctor that you have other chronic diseases?	1. Yes ---------- ☐ 2. No ----------☐	If 2, go to Q 40
39	If yes for Q 38 , please specify	----------	
40	Have you ever taken any previous anti-TB treatment?	1. Yes ----------☐ 2. No ----------☐	
41	If yes for Q 40, how long did you take the treatment?	----------	

III. Tuberculosis knowledge and practice related questions

In the following, I would like to ask you some questions related to your opinion about tuberculosis disease and experience about TB care

S.No	Questions	Response category	Skip
42	In your opinion, who can be infected with TB?	1. Anybody ---------- ☐ 2. Only poor people ------ ☐ 3. Only people who consume much alcohol----------☐ 4. Only people with HIV/AIDS -- ---------- ----------☐ 5. Only people who have been in prison ---------- ☐ 6. Others, please explain --------	
43	What do you think are the signs and symptoms of tuberculosis? Please list	---------- ----------	
44	Would you please tell me how a person can get tuberculosis?	----------	
45	Is tuberculosis curable?	1.Yes ----------☐ 2. No ----------☐	

S.No	Questions	Response category	Skip
46	How can a person with TB be cured?	1. With herbal remedies -------☐ 2. With pain killer ---------- ☐ 3. With TB drugs through directly observed treatment short course☐ 4. Do not know ----------☐ 5. Other (please explain) -------	
47	How long do you have to take TB treatment to become cured?	----------	
48	What/who is/are your source of information about tuberculosis and its treatment?	1. Health care providers ---- ☐ 2. TV/Radio ----------☐ 3. Family/relative ----------☐ 4. Other (specify) ----------	
49	Have you ever faced any problem/ challenges in relation to the TB services provided for you?	1. Yes ----------☐ 2. No ----------☐	If 2, go to 51
50	If yes to question No. 49, what is/are the problem/s you have faced yet?	1. Shortage of drugs -------☐ 2. Absence of laboratory service - ----------☐ 3. Unwanted effect of drugs -☐ 4. Bad/impolite treatment by health personnel ---------- ☐ 5. Poor information about the treatment ----------☐ 6. Other (specify) ----------	
IV. Tuberculosis stigma related questions In the following, I would like to ask you some questions in relation to how you as a patient and other people in your community perceive TB			
51	Do you perceive yourself to be at risk of negative reactions due to your disease?	1. Yes ----------☐ 2. No ----------☐	If 2, go to 53

S.No	Questions	Response category	Skip
52	If yes, for Q 51, from whom?	1. Myself ----------☐ 2. My family ----------☐ 3. Community ----------☐ 4. Health workers ----------☐ 5. Other (please specify) ------	
53	Will you continue to take your anti-TB drugs in this health facility/post until completion of treatment?	1.Yes ----------☐ 2. No ----------☐	If 1, go to 55
54	If "no" for Q 53, please indicate the name of the health facility that you will be taking your medications until the end of treatment	----------	

55. Being a tuberculosis patient, which of the following conditions or feelings have you felt/ experienced?

S. No	Feeling /experience	Yes	No	Explanation/justification
55.1	Considering myself as of less value			
55.2	Desire to keep others from knowing about my disease			
55.3	Hide my illness from my family			
55.4	Others think less of me			
55.5	Others have avoided me (Specify)			
55.6	I have isolated myself			
55.7	I have been asked to stay away from work			
55.8	I have lost job and/or reduced income			
55.9	Others have refused to visit me			
55.10	I think it may affect my marriage prospects			
55.11	I fear discrimination			
55.12	I have stayed away from work and/ or groups			
55.13	Other (specify)			

V. TB treatment and its outcome (to be filled by data collectors)

S.No	Questions	Response category	Skip
56	Type of DOTS	1. Facility based ----------☐ 2. Community based --- ☐	
57	TB classification	1. Smear-positive pulmonary TB (PTB +ve) -☐ 2. Smear-negative pulmonary TB (PTB–ve) -☐ 3. Extra pulmonary TB (EPTB) ----------☐	
58	TB diagnostic category	1. Bacteriological ----------☐ 2. Histo-pathological ----------☐ 3. Radiological ----------☐ 4. Other (specify)----------	
59	TB treatment category	1. New ----------☐ 2. Relapse ----------☐ 3. Failure ----------☐ 4. Return after default ----------☐ 5. Other (specify) ----------	
60	Is there a contact person for follow-up registered with an address?	1. Yes ----------☐ 2. No ----------☐	
61	HIV status of the patient	1. Reactive ----------☐ 2. Non-reactive ----------☐ 3. Unknown ----------☐	If 2or 3, go to 64
62	If Q No 61 is reactive, was ART stared before TB treatment?	1. Yes ----------☐ 2. No ----------☐	

S.No	Questions	Response category	Skip
63	If yes for Q 62, when was ART started (please indicate the date of start)	_____	
Phase two (**To be filled at the end of the treatment**)			
64	For smear-positive PTB patient, sputum result at end of 2nd or 3rd month	1. Negative ----------☐ 2. Positive ----------☐ 3. Not done ----------☐	
65	For smear-positive PTB patient, sputum result at end of 5th month	1. Negative ---------- ------☐ 2. Positive ----------☐ 3. Not done ----------☐	
66	For smear-positive PTB patient, sputum result at end of the treatment	1. Negative ----------☐ 2. Positive ----------☐ 3. Not done ----------☐	
67	Treatment outcomes	1. Cured ---------- ☐ 2. Treatment completed --------☐ 3. Died ----------☐ 4. Treatment failure----------☐ 5. Default/lost to follow-up-----☐ 6. Transferred-out ----------☐ 7. Other (specify) ----------	

Date treatment started ____/___/____ Date treatment completed ____/___/_____

Name of data collector _____Date_____/_____/_____

Name of data supervisor _____Date_____/_____/_____

Thank you so much for your participation!

Appendix 5: Data collection tool:

In-depth interview guides and Questionnaire Afan Oromo (local language) version

Agarsiisa Gaaffii fi deebii hojii gageessaa sagantaa /gaggeessa biiroo fayyaa naannoo

Odeeffannoo Dub jalee

Saalaa ----------umurii ----------ogummaa ----------sanganticha irratti- itti gaafatamummaa ----------leenjii 'Tiibii' DOTS----------yoo eeyyee ta'e , yeroo hangamiif?----------

Seensaa/Gaaffii galumsaa

1. Maaloo, sagantaa to'annaa biyyooleessaa 'Tiibii' ilalchisee muuxannoo keessaan natti himuu dandeessuu?

Dhimma 1. Bu`uuralee misoomaa fi qabeenyaa biroo

2. Naannoo oromiyaa keessaatti 'Tiibii' DOTS raawwachiisuudhaafi waa'ee jiraachuu bu'uuralee misoomaa fi qabeenya biroo barbaachisaa ta'an maal yaadduu?

Gaaffilee kaka'umsaa

- Naannoo oromiyaa jalatti godinaalee jiran hundumaafi haala tamsaasaa akkamitti ilaaltu?
- Waa'ee madda galii/qabeenyotaa natti himuu dandeessuu?
- Sagantichaafi barbaachisaa ta'ee osoo jiruu dhabame misooma bu'uuraa /qabeenyaa biroo naaf ibsuu dandeessuu?
- Bu`uuralee misoomaa fi qabeenyaa biroon walqabate wantoota mijeessitoota kam faadha?
- Bu`uraalee misoomaa fi qabeenya biroon walqabtan wantoota danqarsoota kam faadha?
- Qabeenyawwan godinaalee adda addaatti DOTS iif ramadaman itti fayyadama isaani akkamitti ilaaltu? Keessattuu kan godina jimmaa ?

Dhimma 2. Akkaataa agarsiisa biyyooleessaan hojjachuu

3. Naannoo oromiyaatti raawwatiinsa waliigalaa DOTS akkamitti ilaaltu? Kan godina jimmaa akkamitti ilaaltu?

Gaffilee kaka'umsaa

- Namoonni fayyaa irratti hojjatan akkaata agarsiisa biyooleessaatiin hojjataa jiru jettani yaadduu? (yerootti,guutiinsaa,sirrummaan gabaasuu, kkf)
- Akkaataa agarsiisa biyyoolessaattin DOTS kennuuf wantoota danqarsoota jiran maal faadha?
- Akkaataa agarsiisa biyyoolessaattin DOTS kennuuf wantoota mijeessitoota maalfaa dha?

- Bara kana supparviizyinii gargaarsaa rawwattan beektu? yeroo hagamiif? Dub-deebiin bareeffamaan/afaaniin kenamee turee?

Dhimmaa 3ffaa Bu`aa DOTS

4. Naannoo oromiyaatti waa'ee raawwatiinsa waliigalaafi Bu'aa DOTS maal yaaddu? Godina jimmaattoo?

Gaaffilee kaka`umsaa

- Raawwatiinsa waliigalaa akkamitti ilaaltu?
- Bu'aa DOTS akkamitti ilaaltu? Akka eegamuu?
- Bu'aa kanaafi sababootni/ibsamni maalfaadha
- Bu'aa mijaawaa ta'eefi wantoota danqarsoota fi mijeessooteta ta'uu danda`a maali dha jettanii yaaddu?

5. Naannoo oromiyaatti 'DOTS'iin haawaasa bu`uureeffatee fi dhaabbata bu`ureeffate jidduu garaagarummaan isaanii maal yaaddu? Lamaanuu hojiiatamaa jiruu?

6. Muxannoo keessaan keessatti garaagarummaa ilaalachisee fakkeenyaaf Qulqullina yookiin milkaa'inaa jidduu jaraa? Eeyyee yoo ta'e, garaagarummaan kun maaliif akka jiraate ibsuu dandeessu?

7. Sagantaa To'annaa 'Tiibii' amma jiru foyyeessuuf yaadota maali kennitu?

8. Tarsiimoo 'DOTS' ilaachisee yaadawwan ykn odeeffaannoo biroo kamiyyuu kennuu barbaaddan qabduu?

Agarsiisa Gaaffii fi deebii godinaa,gaggeessaa waajjira fayyaa aanaa, qindeessaa sagantaa 'Tiibii'/supparvaayizarii hojjataa eksiteeshinii Fayyaa

Odeeffannoo Dub jalee

Saalaa ----------umurii ---------- ogummaa ----------sanganticha irratti-itti gaafatamummaa ----------leenjii 'Tiibii' DOTS----------yoo eeyyee ta'e , yeroo hangamiif?----------

Seensaa/Gaaffii galumsaa

1. Maaloo, sagantaa to'annaa biyyooleessaa 'Tiibii' Muuxannoo keessaan natti himtu?

2. Qulqullinaan hojii irra ooluu DOTS haal gaariin mirkaneessuuf saganataa yaalinsaafi qabeenya ykn wantoota barbaachisan dhiyaachuu qaban natti himuu dandeessuu?

Dhimma 1. Bu`uuralee misoomaa fi qabeenyaa biroo

3. Godinni/aanaan kun 'DOTS' qulqullina qabu haawaasaaf kennuf bu'uuralee misoomaa fi qabeenya biroo barbaachisaa ta'anii qaba jettanii yaadduu?

Gaaffilee kaka'umsaa

- Bu'uuralee misoomaa/ qabeenya sagantichaaf barbaachisaa ta'anii amma kan hin jirre maaloo kami akka ta'e tarreessuu dandeessuu?
- Bu`uuralee misoomaa fi qabeenyaa biroon walqabate wantoota mijeessitootni kam faadha?
- Bu`uraalee misoomaa fi qabeenya biroon walqabtan wantoota danqarsoota kam faadha?
- Sababa dhabamuu qorichaatiin yookiin keemikaala laabiraatooriitiin tajaajilli dhaabbatee jiraa? Eeyyee yoo ta'e, rakkoo tajaajila addan kute hiikuuf tarkaanfilee maaltu fudhatame?
- Qulqullina qabeenya jiranii haala kamiin mirkaneessitu?

Dhimma 2. Akkaataa agarsiisa biyyooleessaan hojjachuu

4. Hawaasaa godinaa /aanaa kanaaf kenninsa 'DOTS ' irratti adeemsa /gochaalee kennitoota kunuunsa fayyaan hojjatame ilaalchisee yaadni keessaan maali?

Gaffilee kaka'umsaa

- Namoonni fayyaa irratti hojjatan akkaata agarsiisa biyooleessaatiin hojjataa jiru jettani yaadduu? (yeroo argama dhukkubaa ,yaalinsa,hordoffii ,gabaasa)

- Kunuunsa fayyaa kennitootn aka agarsiisa biyyooleessaatiin hinhojenee wantoota danqarsoota jiran maal faadha?
- Kunuunsa fayyaa kennitootn aka agarsiisa biyyooleessaatiin hojeetan wantoota mijeessitoota kamfaa dhaa?
- Raawwatiinsa qulqullina keenitoota kunuunsa Fayyaa akkamiin mirkaneessitu?
- Bara kana to`annoo gargaarsaa rawwataanii beektu? yeroo hagamiif? Dub-deebiin bareeffamaan/afaaniin keenamee turee?

Dhimmaa 3ffaa Yaalinsa waliirra hin cinnee fi bu`aa

5. Godinaa/aanaa kana keessaatti Yaalinsa 'Tiibii' walirraa hin cinne ilaalchisee walumaagalan muuxannoo fi yaada keessan maaloo natti himuu dandeessuu?

6. Godinaa/aanaa kana keessaatti bu'aa yaalinsa 'Tiibii' ilaalchisee muuxannoo fi yaada keessan maaloo natti himuu dandeessuu?

Gaaffilee kaka`umsaa

- Sababni /ibsamni dhukkabsattootni yaalinsa hordofanii akka hin fudhanne maalfaa ta`u danda`a?
- Dhukkubsattootni yaalinsa isaanii akka xumurraniif wantoota mijeessiitoota maal fa'i ta'uu danda'uu ?
- Dhukkubsattootni yaalinsa isaanii akka hin xumurreef wantoota danqarsoota jiran maalfaa ta'uu danda'uu?
- Sababooleen bu'aalee yaalinsaa 'Tiibii' yeroo amma (gaarii/yaraa/ maal ta`u danda`u?
- Bu'aalee Yaalinsaa mijaawaafi wantoota mijeessitoota fi danqarsoota maal faa'i ta`uu danda`a ?

7. Godina /aanaa kanatti 'DOTS'iin haawaasa bu`uureeffatee fi dhaabbata bu`ureeffate jidduu garaagarummaan isaanii maal yaaddu ? Lamaanuu hojiiatamaa jiruu?

8. Muxannoo keessaan keessatti garaagarummaa ilaalachisee fakkeenyaaf Qulqullina yookiin milkaa'inaa jidduu jaraa? Maloo ibisa, Sagantaa To'annaa 'Tiibii' amma jiru foyyeessuuf yaadota maali kennitu?

9. Tarsiimoo 'DOTS' ilaachisee yaadawwan ykn odeeffaannoo biroo kamiyyuu kennuu barbaaddan qabduu?

Agarsiisa Gaaffii fi deebii kennitoota DOTS iif

Iddoo 'DOTS' ----------

Odeeffannoo Dub jalee

Saalaa ----------umurii ----------ogummaa ----------sanganticha irratti- itti gaafatamummaa ----------leenjii 'Tiibii' DOTS----------yoo eeyyee ta'e , yeroo hangamiif?----------

Seensaa/Gaaffii galumsaa

1. Maaloo, sagantaa to'annaa biyyooleessaa 'Tiibii' ilalichisee muuxannoo keessaan natti himtuu ?

2. Qulqullinaan hojii irra ooluu DOTS haal gaariin mirkaneessuuf saganataa yaalinsaafi qabeenya ykn wantoota barbaachisan dhiyaachuu qaban natti himuu dandeessuu?

Dhimma 1. Bu`uuralee misoomaa fi qabeenyaa biroo

3. Godinni/aanaan kun 'DOTS' qulqullina qabu haawaasaaf kennuf bu'uuralee misoomaa fi qabeenya biroo barbaachisaa qaba jettanii yaadduu ?

Gaaffilee kaka'umsaa

- Bu'uuralee misoomaa/ qabeenya biroo sagantichaaf barbaachisaa ta'anii amma kan hin jirre maaloo kami akka ta'e tarreessuu dandeessuu?
- Bu`uuralee misoomaa fi qabeenyaa biroon walqabate wantoota mijeessitoota kam faadha?
- Bu`uraalee misoomaa fi qabeenya biroon walqabtan wantoota danqarsoota kam faadha?
- Sababa dhabamuu qorichaatiin yookiin keemikaala laabiraatooriitiin tajaajilli dhaabbatee jiraa? Eeyyee yoo ta'e, rakkoo tajaajila addan kute hiikuuf tarkaanfilee maaltu fudhatame?

Dhimma 2.Akkaataa agarsiisa biyyooleessaan hojjachuu

4. Iddoo 'DOTS ' kana irratti adeemsa /gochaalee hawaasaaf kennaa turtan ilaalchisee yaadni keessaan maali?

Gaffilee kaka'umsaa

- Isiniifi hiriyootni keessan akkaata agarsiisa biyooleessaatiin hojjataa jirra jettani yaadduu? (yeroo argama dhukkubaa ,yaalinsa,hordoffii ,gabaasa)maaliif/maaliif hin taane?

- Akkaataa agarsiisa biyyoolessaattin DOTS kennuuf wantoota danqarsoota jiran maal faadha?
- Akkaataa agarsiisa biyyoolessaattin DOTS kennuuf wantoota mijeessitoota maalfaa dha ?
- Raawwachiisa gochaalee Tiibiitiif supparviizyinii gosa kamiyyuu fudhattan jiraatu ?yeroo hagamiifi?duub deebii barreeffamaa/afaaniin fudhattaniittuu ? isin fayyadee turee?

Dhimmaa 3ffaa Yaalinsa waliirra hin cinnee fi bu`aa

5. Godinaa/aanaa kana keessaatti Yaalinsa 'Tiibii' walirraa hin cinne ilaalchisee waliigalan muuxannoo fi yaada keessan maaloo natti himuu dandeessuu?

6. Godinaa/aanaa kana keessaatti bu'aa yaalinsa 'Tiibii' ilaalchisee muuxannoo fi yaada keessan maaloo natti himuu dandeessuu?

Gaaffilee kaka`umsaa

- Sababni /ibsamni dhukkabsattootni yaalinsa hordofanii akka hin fudhanne maalfaa ta`u danda`a?
- Dhukkubsattootni yaalinsa isaanii akka xumurraniif wantoota mijeessiitoota maal fa'i ta'uu danda'uu ?
- Dhukkubsattootni yaalinsa isaanii akka hin xumurreef wantoota danqarsoota jiran maalfaa ta'uu danda'uu?
- Sababooleen Bu'aalee yaalinsaa 'Tiibii' yeroo amma (gaarii/yaraa/ maal ta`u danda`u?
- Bu'aalee Yaalinsaa mijaawaafi wantoota danqarsoota fi mijeessitootni maal faa'i ta`uu danda`a ?

7. Godina /aanaa kanatti 'DOTS'iin haawaasa bu`uureeffatee fi dhaabbata bu`ureeffate jidduu garaagarummaan isaanii maal yaaddu ? Lamaanuu hojiiatamaa jiruu?

8. Muxannoo keessaan keessatti garaagarummaa ilaalachisee fakkeenyaaf Qulqullina yookiin milkaa'inaa jidduu jaraa? Maloo ibsaa, Sagantaa To'annaa 'Tiibii' amma jiru fayyeessuuf yaadota maali kennitu?

9. Tarsiimoo 'DOTS' ilaachisee yaadawwan ykn odeeffaannoo biroo kamiyyuu kennuu barbaaddan qabduu?

Agarsiisa Gaaffii fi deebii dhukkubsattoota 'Tiibii'tiif

Odeeffannoo Dub jalee

Saalaa ----------umurii ----------haala barumsaa ----------

Haala hojii----------iddoo jireenyaa ----------

iddoo DOTS----------hanga yeroo yaalinsaa ----------

Seensaa/Gaaffii galumsaa

1. Akka dhukkubsataa Tiibii iddoo yaalinsa kanaa taatanitti muuxannoo keessaan natti himuu dandeessuu? (adeemsa argannoo ,deddeebi'iinsa guyyaanii ,iddoo yaalinsaa)

Dhimma 1. Bu`uuralee misoomaa fi qabeenyaa biroo

2. Haala raawwii yaalinsa Tiibii guyyaa guyyaanii ilaalchisee ilaalchi keessan maali?

3. Qabeenyawwan gahaa jira jettanii yaadduu ?(fakkeenyaafi,humna namaa,meeshaa qorannoo argachuu dhukkubaa,meeshaalee yaalinsaa dabalataa fi qorichaalee ' Tiibii')

Gaaffii kaka'umsaa

- Yaalinsa eessati fudhattu? Guyyaa guyyaan yaalinsaaf dhufuun isin rakkisaa? Yoo ta'e haala kamiin?
- Haala qindeessa kunuunsaafi yaalinsaa siniif kennamaa ture dabalataan maaloo natti himaa (sa`atii eegumsaa,dabaree, haala qabatama iddoo DOTS, fageenya deemsaan,geejjiba)
- To'annaa 'Tiibii' hawaasa keessaa foyyeessuuf kan gargaaru sirni yaalinsaa (DOTS) hojjatame ilaalchisee yaanni keessaan maali?
- Dhukkubsattota dhukkubni isaanii argameefi fi yaalinsa fudhataa jiran gargaruuf jijjiramoota maaliitu raawwatamee qaba?
- Dhukkubsattota yaalinsa isaanii akka xumuraniif gargaruuf jijjiramoota maaliitu raawwatamu qaba?
- Jireenyi guyyaa guyyaa kesan irraatti dhiibbaa uumeera jettani yaadduu? Yoo ta`e akkamitti yaalinsi kun jieenya guyyaa guyyaa keesan diibe?(baasii,yeroo,hojii, maatii/jireenya hawaasummaa)

Dhimma 2.Akkaataa agarsiisa biyyooleessaan hojjachuu

4. Yaalinsi 'Tiibii' akkamiin akka kennamuu qabu hubannoo gahaa qabduu? (agarsiisaa biyyoolessaa)

5. Kunuunsa ‘Tiibii’ akkaataa qajeelfama agarsiisa biyyooleessaatiin fudhachaan jira jettanii yaadduu?

Gaffilee kaka’umsaa

- Iddoon DOTS kun filannoo keessaan jalqabaa yeroo isin gargarsa barbaaddaniitii? Yoo ta’e maaliif? Yoo hin taane, eessa turee?
- Kunuunsa fayyaa kennitoota waliin iddoo yaalinsa filannoo keessan mariyattanittuu? Yoo lakki, maaliif hin taane?
- Kunuunsa fayyaa kennitootni/gargaartoonni yaalinsaa guyyaa guyyaan yeroo qoricha liqimstanu isin ilaaluu? yoo miti ta`e? maaliif hin taanee ?
- Namoota fayyaa irraatti hojjatan waliin guyya guyyaa walitta dhufeenya keessan natti himuu dandeessu? (walitti haasa’uu,hiriyyummaan?gaaffii gaafachuufi carraa argachuu ? hordoffii , yaalinsa sirrii hin taane)
- Erga yaalinsa jalqqabdani; waa’ee ‘Tiibii’, sababoota ‘Tiibii’, yaalinsa fi ittisa ‘Tiibii’caalaatti waan barattan jiraa? Maddi odeeffannoo keessan eenyu /maalii?
- Kunuunsa Tiibii fudhachuu irraatti rakkoowwan gurguddoo hanga yoonaa isin qunname maal fa’I dha?

Dhimmaa 3ffaa Yaalinsa waliirra hin cinnee fi bu`aa

1. Mallattoon dhukkubaa TB inni jalqabaa maali jettanii yaaddu?
2. Yaalinsi ‘Tiibii’ asitti sinii kenname sirrii yookin gahaadha jettanii yaadduu?
3. ‘Tiibii’ irraa fayyeera jettanii kan yaaddanu sadarkaa kami irraatti ?

Gaaffilee kaka`umsaa

- Waa’ee yaalisa ‘Tiibii’ guyyaa guyyaa maal jechuu dandeessu? Yaalinsa keesan giddutti kuttaani beektu? Yoo eeyyee ta’e maaliif? yeroo hagamiif?
- Yaalinsa ‘Tiibii’ addaan kutuun maal fida jettanii yaaddu?
- Bu’aalee Yaalinsaa mijaawaafi wantoota danqarsoota fi mijeessitootni maal faa’i ta`uu aka danda`an nafi ibisitu?

9. Yaalinsi ‘Tiibii’ kilinika fayyaa keessatti kennamaa jiruu fi hawaasa keessatti kennamaa jiru jidduu garagarummaan jiru maal jettanii yaaddu? (**haal qindeessichaa qorataan fakkeenya kennuu qaba**.)

10. Akkaataa yaaliinsa itti qindeessan irratti gargaarumaa fi walfakkeenyi barbaachisaa jira jettanii yaadduu?

11. Yaalinsa Tiibii amma jiru foyyeessufi yaadota akkamii kennitu?

12. Kunuunsa Tiibii jiru ilaalchisee yaada ykn odeeffaannoo biroo qabduu?

1. Gaaffii Dhukkubsataa 'Tiibiitiif'

Maqaa hospitaalaa/ buufata fayyaa/keellaa fayyaa_____

Guyyaa sassaabbii raga_____

Lakkoofsa yuniitii "Tiibii" /lakkoofsa koodii/ (unit TB No)_____

Lakkoofsa galmee Aanaa, _____

Teessoo dhaabbataa dhukkubsataa: Godina _____ Aanaa _____ Ganda _____ Lakk.Manaa _____ Lakk.Bilbilaa_____

Maqaa raga sassaabaa _____mallaattoo ----------

I. Amaloota deebii kennaa walitti dhufeenya waa'ee ummataa

Duraan dursee, waa'ee keessan gaaffii muraasa isin gaafachuu nan barbaada.
Gaafataaf: Maloo sanduqaa kessaati deebii kessan mallaattoon agarsiisaa akkasumas, bakka duwwaa irraatti deebii gabaabaa kennaa.

Lakk.s	**Gaaffilee**	**Tarree deebii**	**Irraa darbu**
1	Saala deebii kennaa	1.Dhiira----------☐ 2.Dubara----------☐	
2	Umriin keessan meeqa?	----------	
3	Haalli gaa'ila keessanii yeroo ammaa maali?	1.Hin fuune/heerumne----------☐ 2.Fuudheera/heerumteetti----------☐ 3.Hiikeera/hikteetti----------☐ 4.kan jalaa du'e/duute ----------☐	
4	Sadarka barnoota isa ol'aanaa isin xumurtan kami?	_____	
5	Hojiin keessan maali?	1.Qotee bulaa----------☐ 2. Daldalaa----------☐ 3.Hojjata mootummaa----------☐ 4. Hojjataa guyyaa----------☐ 5. kan biroo, (addaa baasaa) ----------	

Lakk.s	Gaaffilee	Tarree deebii	Irraa darbu
6	Sabin keessan maali	1.Oromoo----------☐ 2.Amaaraa----------☐ 3.Tigiree----------☐ 4.Yeem----------☐ 5.Dawuroo----------☐ 6.Kan biroo maaloo adda baasaa------☐	
7	Amantiin keessan maali?	1.Kiristaana Orthoodooksii----------☐ 2.Musiliima----------☐ 3.Pirooteestaantii----------☐ 4.Kaatoolikii----------☐ 5. Kan biro, maaloo adda baasaa-----☐	
8	Yeroo ammaa eessa jiraattu? maaloo maqaa iddoo jiraattnii ibsaa.	----------	
9	Dhaabbatni fayyaa yaalinsa Tiibii isiniifi keennu irraa iddoon jiraattan hangam fagaata?	Kiloomeetiraan---------- Sa`atiidhaan/daqiiqaa dhaan ----------	
10	Yaalinsa Tiibiitiifi dhaabbata Fayyaa yeroo dhaqxanu maaliin deemtu?	1.Miilaan----------☐ 2.Konkolaataa/bajaajii----------☐ 3.Fardaan/gaangeen----------☐ 4.Awwutoobisii ----------☐ 5.kan biroo, adda baasi----------☐	
11	Kilinika guyyaa guyyaan deemuuf baasiin isin baastanu jiraa?	1.Eeyyee----------☐ 2.Lakkii----------☐	Yoo 2 ta'e, gara 14
12	Gaaffii 11 f "eeyyee" yoo ta'e, sababa kaffaltii ibsa maaloo?	1.Geejjibaafi----------☐ 2.Tajaajila laaboraatoaarfi----------☐ 3.Nyaataa fi ciisichaaf----------☐ 4. Kan biroo ibsii maaloo----------☐	

Lakk.s	Gaaffilee	Kutaa Deebii	Irraa darbu
13	Dhukkuba kanaan walqabatee hanga qarshii waliigalaa kaffaltan natti himuu dandeessuu?	----------	
14	Miseensa maatii meeqatu mana keessan keessa jiraata?	----------	
15	Mana amma keessa jiraattan keessa kutaalee meeqa akka qabu natti himuu dandeessuu?	----------	
16	Haalli galii keessanii maali/maalfaa dha maaloo ibsaa?	----------	
17.	Waggaatti tilmaamaan hangam argatta?	Qarshii caallan---------- Gosaan ----------	

II. Gaaffilee sakattaa'iinsaa dhukkubsattota Tiibii jidduu boodeessuu argama dhukkubichaa Dhukkubbii irraatti muuxxaannoo keessan hubachuufi gaaffilee muraasa isin gaafachuu barbaadna.

Lakk.s	Gaaffilee	Kutaa Deebii	Irraa darbu
18	Qufaan yeroo duraaf yoom isin jalqabee?	----------	
19	Dhaabbata fayyaa kana dhufuu keessaniin dura yaalinsa qufaa argachuuf wal'aansaa kennaa kamiyyuu bira deemtanii beektuu?	1.Eeyyee ----------☐ 2.Lakki----------☐	Yoo 2 ta'e, gara 21
20	Yoo gaaffiin 19 eeyyee ta`e yeroo dura isin qufaasisu wal'aansa kennaa isa kam bira dhaqxan?	1. Keella fayyaa ----------☐ 2. Buufata fayyaa ----------☐ 3.hospitaala----------☐ 4. kilinika dhuunfaa----------☐ 5. kan biroo,maaloo ibsaa-----☐	

Lakk.s	Gaaffilee	Kutaa Deebii	Irraa darbu
21	Dhukkubsataa qoricha "Tiibii" fudhachaa ture waliin walitti dhufeenyaa qabdu tureeyii?	1.Eeyyee----------☐ 2 Lakki ----------☐ 3. Hin beeku /sirritti hin beeku/-☐	

22. Mallattoolee armaan gadii keessaa hanga ammatti isa kamtu isin rakkisaa jira?

Lakk	Mallattoolee	Eeyyee	Lakki	Turtii mallattoolee	Yaada
22.1	Qufaa gogaa				
22.2	Qufaa hakkee adii yookiin keelloo qabu				
22.3	Qufaa hakkee dhiiga qabu				
22.4	Waraansa laphee				
22.5	Ho`ina qaama				
22.6	Halkaan dafqisiisuu				
22.7	Hir`ina ulfaatina (10/%)				
22.8	Fedhii nyaataa dhabuu				
22.9	Rakkoo afuura baafachuu				
22.10	Mallaattoo kan biroo/ibssa/----------				

Gaaffii dhiyeessaaf, Gaaffiilee 24 fi 25 maaloo odeeffannoo dhukkubsaticha isa laabiraatoorii fi galmeessa ragaa 'Tiibii' waliin mirkaneessa.

Lakk.s	Gaaffilee	Kutaa deebii	Irraa darbu
23	Mallattoo dhukkuba armaan olii eega isin mudate yeroo hangamitti waldhaansa kennitootaa bira dhaqxan?	Guyyoota ---------- Torbanoota ---------- Ji'oota ---------- Waggoota----------	
24	Yeroo duraafi waldhaansaa 'Tiibii' kennitoota bira dhaquufi argamuu 'Tiibii' jidduu yeroo hangam ture?	Sa'atii---------- Guyyoota---------- Torbanoota---------- Ji'oota ----------	
25	Yeroo duraa fi mu'lachuu 'Tiibii' fi jalqabuu yaalinsa jidduu yeroo hangamtu ture?	Sa'atii---------- Guyyoota---------- Torbanoota---------- Ji'oota ----------	

Lakk.s	Gaaffilee	Kutaa Deebii	Irraa darbu
26	**Gaaffii dhiyeessaaf :** Maaloo jalqabuu mallaattoo 'Tiibii'fi jalqabuu yaalinsaa 'Tiibii' jidduu yeroo hangam akka fudhate guutaa (gaaffii 23 + 24 + 25)	Torbanoota ---------- Guyyoota---------- Ji'oota ----------	
27	Haala/sadarkaa/ dhukkuba keesan yeroo ammaa akkamiitti ibsitu?	1.Sochii guyyaa guyyaatiin garaagarummaa hin qabu----------☐ 2.Sochii guyyaa guyyaatiin hanga tokko ana daangeesseera.---------- ☐ 3.Siree irraatti hafeera ----------☐	
28	Ni xuuxxuu turee ykn xuuxaa jirtuu?	1.Eyyee ----------☐ 2.Lakki ----------☐	Yoo ta'e, gara 30 2
29	Gaaffii 28 ffafi "eeyyee": yoo ta'e , gosa kami?	1. Shiishaa ----------☐ (turtii) --------- 2.Tamboo ----------☐ (turtii) ---------	
30	Dhugaatii alkoolii ni dhugduu?	1.Eyyee ----------☐ 2.Lakki ----------☐	Yoo ta'e, gara 32 2
31	Yoo gaaffiin 30ffaa "eeyyee" yoo ta`e, maaloo kan itiannu ibssa?	Gosa alkoolii ---------- Hanga alkoolii guyyatti mililitraan fudhattan ---------- Yeroo hangamiif fudhattan ----------	
32	Caatii ni fayyadamtuu ykn fayyadamtanii beektuu?	1.Eeyyee ----------☐ 2.Lakkii----------☐	Yoo ta'e, gara 34 2
33	Yoo gaaffiin 32 eeyyee ta'e, yeroo hagamiif?	----------	
34	Mana sirreessa ykn kaampii dhaabbataan/yeroof jiraattanittuu ykn hojjattanittuu?	1.Eyyee ----------☐ 2.lakkii ----------☐	Yoo ta'e, gara 37 2

Lakk.s	Gaaffilee	Kutaa Deebii	Irraa darbu
35	Yoo gaaffiin 34ffaa “eeyyee” ta’e Maaloo ibsaa---	1.Mana sirreessa----------☐ 2. Kaampii ----------☐	
36	Yoo gaaffiin 34 “eeyyee” ta’e, yeroo hangamiif?	----------	
37	Akka dhukkuba sukkaaraa isin keessa jiru haakimiin isinitti himee beekaa?	1. Eeyyee----------☐ 2. Lakki ----------☐	
38	Akka dhukkuboota nama irra turanii isin keessa jiru haakimiin isinitti himee beekaa?	1. Eeyyee----------☐ 2. Lakki ----------☐	Yoo 2 ta’e, gara 40
39	Gaaffii 38 “eeyyee” yoo ta’e maaloo ibsaa ----------	----------	
40	Yaaliinsa qoricha ‘Tiibii’ kamuu kanan dura fudhattanii beektuu?	1.Eeyyee----------☐ 2. Lakkii.----------☐	Yoo 2 ta’e, gara 42
41	Gaaffii 40ffaaf “eeyyee” yoo ta’e yaalinsicha yeroo hangamiif fudhattan?	----------	

III. Gaaffilee Beekumsaa fi gochaa ‘Tiibii’ waliin walqabtee

Waa’ee kunuunsa ‘Tiibii’muuxxaannoo qabdanu fi waa’ee dhukkuba ‘Tiibii’ Yaada qabdanu gaaffii muraasa haala armaan gadiin isin gaafachuu barbaanna.

Lakk.s	Gaaffilee	Kutaa Deebii	Irraa darbu
42	Akka yaada keessaniitti eenyutu dhukkuba ‘Tiibii’dhaan qabamuu danda’a?	1. Nama kamiyyuu----------☐ 2.Hiyyeessoota qofa----------☐ 3.Nama dhugaatii alkooli baayyee fudhatu qofa----☐ 4. Nama HIV /AIDS qabu qofa----------☐ 5.Nama mana sirreessa ture qofa----------☐ 6. ka biroo, ibsa ----------	
43	Mallattoolee dhukkuba‘Tibii’ maalifaa dha jeetani yaaddu?	---------- ---------- ----------	

Lakk.s	Gaaffilee	Kutaa Deebii	Irraa darbu
44	Namni Tiibii'n qabamuu akkamitti akka danda`u natti himu ni dandeessuu?	----------	
45	'Tiibii'n kan fayyudhaa?	1.Eeyyee ----------☐ 2.Lakki----------☐	
46	Namni Tibii qabu akkamiin fayyuu danda`aa?	1.Wal'aansa naannootiin /herbal remedies/ --------☐ 2. Dhukkubbii tasgabbeessatiin ----------☐ 3.Qoricha 'Tiibii'koorsii gabaabaa yaalinsa hordoffii kallaattiin kennamuutiin ---------- ☐ 4. Hin beeku ----------☐ 5. Kan biroo /maaloo ibsa ----------	
47	'Tiibii' irraa fayyuufi yeroo hangamiifi yaalinsicha fudhachuu qabdu?	_____	
48	Maddi odeeffannoo waa'ee Tiibiifi yaalinsa isaa eenyuu irraa/maalfaa dha?	1. Kennitoota kunuunsa fayyaa ----------☐ 2. TV/Reediyoo----------☐ 3. Maatii/fira----------☐ 4. Kan biroo/ibsaa ----------	
49	Tajaajiloota'Tibii' wojjiniin walqabatan yeroo isinii kennamu rakkoon isin qunnamee beekaa?	1.Eeyyee ---------- ☐ 2.Lakkii----------☐	Yoo 2 ta'e, gara 51
50	Yoo gaaffii 49ffaaf "eeyyee" ta'e rakkoo/lee hanga yoonaa isn qunname maalidha/maalfadha?	1. Hanqina qorichootaa ----------☐ 2. Dhabiinsa tajaajila laabiraatoorii ----------☐ 3. Bu'aa qorichaa kan hin barbaadamne----------☐ 4.Yaalinsa amala badaa ogeessa fayyaatiin ----------☐ 5. Waa`ee yaalinsaa odeeffaannoon dadhabaa ta'uu ☐ 6. Kan biroo/ibsi----------	

IV. Gaaffilee dhiibbaa hawaasa 'Tiibii' waliin walqabate

Haala armaan gadiitiin isin akka dhukkubsataa tokkoo fi namoota biroo hawaasa keessaatti 'Tiibii'akkmitti akka hubatanu isin gaafachuu nan barbaada.

Lakk.s	Gaaffilee	Kutaa Deebii	Irraa darbu
51	Dhukkuba keessan kana ilaalchisee dhibbaaf saaxilameera jettani of hubattani beektu?	1. Eeyyee ----------☐ 2. Lakkii ----------☐	Yoo 2 ta'e, gara 53
52	Gaaffii 51ffafi eeyyee yoo ta'e gama kamiini dha?	1. Ofii kootiin ----------☐ 2. Maatii koo irraa----------☐ 3. Hawaasa irraa ----------☐ 4. Hojjataa fayyaa irraa----------☐ 5. Kan biroo/maaloo ibsaa ----------	
53	Hanga yaalinsichi xumuramutti dhaabbata fayyaa/ kellaa fayyaa kanatti qoricha 'Tiibii'fudhachuu itti fuftuu?	1.Eeyyee ----------☐ 2.Lakki ----------☐	Yoo 1 ta'e, gara 55
54	Gaaffii 59 f Yoo "Lakki" ta'e hanga yaalinsichi xumuramutti maqaa dhaabbata fayyaa qorcha itti fudhattan maaloo ibsa.	_____	

55. Akkuma dhukkubsataa 'Tiibii' taatanitti haalawwan/mirawwan armaan gadii keessaa isa kamtu isnitti dhagahame/ isin qunname ture?

Lakk.	mudannoo/wanta itti dhagahamu	Eeyyee	lakkii	Ibsama
55.1.	Akka gadi aanaati ofi ilaaluu			
55.2.	Namootni biroo waa'ee dhukkuba koo akka hin beekne barbaadu			
55.3.	Dhukkuba koo maatii koo dhoksuu			

Lakk.	mudannoo/wanta itti dhagahamu	Eeyyee	lakkii	Ibsama
55.4.	Namootni biroo ana gadi qabani ilaaluu			
55.5	Namootni biroo anan fageesuu/ibsa			
55.6.	Ofii koo of addaan fo'uu			
55.7.	Hojiin ala turuufi gaafadheen ture			
55.8.	Hojii koo dhiiseera fi/ykn galiin koo xiqqaateera			
55.9.	Namootni biroo ana gaafachuu dhisaaniru			
55.10	Fudhatama ga'ila koo irraatti dhiibbaa uumeera natti fakkaataa?			
55.11	Qoqoodinsa nan sodaadha.			
55.12	Hojii koo irraa fi/ykn hiriyoota koo irraa fagaadheera.			
55.13	Kan biroo/ibsi			

V. Yaalinsa 'Tiibii' fi bu'aa isaa /sassaabaa ragaatiin kan guutamu/

Lakk.s	Gaaffilee	Kutaa Deebii	Irraa darbu
56	Gosa 'DOTS'	1. Dhaabbata kan bu'uureeffate ---------☐ 2. Hawaasa kan bu'ureeffate ----------☐	
57	Kutaalee 'Tiibii'	1.'Tiibii' sombaa hakkee irraatti argame/PTB+ve ----------☐ 2.'Tiibii' sombaa hakkeen hin argamne (PTB-ve)---------- ☐ 3.'Tiibii'sombaa kan hin taane (EPTB)-- ☐	
58	Kutaalee argama dhukkuba 'Tiibii'	1. Baakteeriyaadhaan ----------☐ 2. Histoo-paatooloojiidhaan----------☐ 3. Raajiidhaan/Raadiyooloojiidhaan/☐ 4. Kan biroo, ibsaa ----------	
59	Kutaalee yaaliinsa 'Tiibii'	1. Haaraa ----------☐ 2. Kan itti Deebi'ee/relapse/ ----------☐ 3. Milkaa'uu hafuu/failure/----------☐ 4. Addaan kutanii deebi'uu----------☐ 5. Kan biroo ibsaa ----------	

Lakk.s	Gaaffilee	Kutaa Deebii	Irraa darbu
60	Hordoffifi namni waamamuu danda'u teessoo waliin galmaa'ee jiraa?	1. Eeyyee ----------☐ 2. Lakkii----------☐	
61	HIV qabaachuuf dhabuu dhukkubsattoota	1. Qaba ----------☐ 2. Hin qabu----------☐ 3. hin beekamne----------☐	Yoo 2 ykn 3 ta'e, gara 64
62	Gaaffii 61ffaa yoo 'qaba' ta'e yaalinsi 'Tiibii' osoo hin jalqabmin dura qorichi isaa/ART/jalqabameeraa?	1. Eeyyee ----------☐ 2. Lakki ----------☐	
63	Gaaffii 62ffafi yoo eeyyee ta'ee qorichi (ART) yoomi jalqabame(maaloo guyyaa jalqabamee ibsaa)	----------	
Marsaa lamaffaa (xumura yaalinsaa irraatti kan guutamu)			
64	Dhukubsattoota Tiibii sombaa hakkeedhaan pozatiivii ta'an Ji'a xumura 2ffaa ykn 3faa irraatti bu'aan hakkee isaanii maali dha?	1. Nagatiivii----------☐ 2. Pozatiivii----------☐ 3. Hin hojjatamne----------☐	
65	Dhukubsattoota Tiibii sombaa hakkeedhaan pozatiivii ta'an Ji'a xumura 5ffaa irraatti bu'aan hakkee isaanii maali dha?	1.Nagatiivii----------☐ 2.Pozatiivii----------☐ 3.Hin hojjatamne----------☐	
66	Dhukubsattoota Tiibii sombaa hakkeedhaan pozatiivii ta'an yaalinsa xumura irraatti bu'aan hakkee isaanii maali dha?	1.Nagatiivii----------☐ 2.Pozatiivii----------☐ 3.Hin hojjatamne----------☐	
67	Bu'aa yaalinsaa	1. Fayyeera. ----------☐ 2. Yaalinsi xumurameera.---------☐ 3. Du'eera. ----------☐ 4. Yaalinsi hin milkoofne.------- ☐	

		5. Hordoffiin addaan citeera.----- ☐ 6. Gadhiiseera/transferred out/----☐ 7. Kan biroo/ibsi/----------	

Guyyaa yaalinsi jalqabe ----------/------/------- guyyaa yaalinsi xumurame -------/----------/---------

Maqaa ragaa sassaabaa ----------guyyaa --------/----------/----------

Maqaa supparvaayizarii ragaa ----------guyyaa ---------/----------/----------

Hirmaannaa keessaaniif baayyee isin galateeffadha!

Appendix 6: Ethical clearance and permission letters

REK
REGIONALE KOMITEER FOR MEDISINSK OG HELSEFAGLIG FORSKNINGSETIKK

Region:	Adviser:	Telephone nr.:	Our date:	Our ref.:
REC South East Norway	Mariann Glenna Davidsen	22845526	17.12.2015	2015/2124 REK sør-øst B
			Your date: 27.10.2015	

Christoph Gradmann
University of Oslo, Institute of Health and Society

2015/2124 Gjennomføring og kvalitet in Dots i Jimma, Ethiopia

Institution Responsible for Research: University of Oslo, Institute of Health and Society
Project Manager: Christoph Gradmann

We are writing in reference to your Application for Preliminary Approval for the above-mentioned Research Project. The Regional Committee for Medical and Health Research Ethics, Section B, South East Norway, reviewed your Application during its meeting on the 25th of November 2015. The Project was assessed in accordance to the Norwegian Research Ethics Act § 4 2006, and the Health Research Act § 10 2008, for Regional Committees for Medical and Health Research Ethics.

Project description
"*Tuberculosis (TB) is still a common cause of illness and death in many countries. To control the disease, Directly Observed Treatment Short course (DOTS) was launched as a universal strategy by WHO in 1994. This implies that patients must take their daily treatment under direct observation of healthcare providers. Though studies reveal that community based DOTS is more cost effective than clinic based DOTS, it is not yet scaled up in Jimma, Ethiopia. Further, little is known about the difference between the approaches. This study will be conducted to assess the overall performance and quality of TB DOTS strategy and compare the two approaches. A case study and prospective cohort study design will be employed using both qualitative & quantitative data collection methods. Nine districts will be selected with simple random sampling technique & all DOTS sites in sampled districts will be included. Retrospective record review, observations & interviews will be employed to produce data*"

Review
The observational part of the study is briefly described. The project will need to ensure that participants are provided with sufficient information when giving their consent, in terms of what the observations entail and during which period, especially in relation to accessing their personal health data records.

The Committee presumes that, only personal health data records for patients who have given their consent to participating in the study, will be accessed. The approval does not apply/cover the collection of personal health data from different health data registries, other types of registries, or from patients who have not given their consent.

Further, the Committee presupposes that any communication with participants will take place in the language that the participant is fluent in.

It appears that some of the Participant Information Sheets and Consent Forms are missing the research team's contact information. Contact information for the research team should be made available on the Consent Form.

Information which is irrelevant to the study, for example biobanks, should be removed from the forms.

The Committee have set the following conditions for approval of the research project:

1. The Participant Information Sheet and Consent form will need to be amended with more detailed information about what the study entails. The contact information for the research team will also need to be updated on the form. The amended Information Sheet and Consent Form will need to be sent to the Committee for their records.

Decision
The project is approved in accordance to the Health Research Act § 9 and § 33 2008 on the basis that the conditions, as mentioned above, are fulfilled. In addition to these conditions, approval is given under the provision that the project is implemented as described on the Application Form and the Research Protocol.

The approval is valid until 31.07.2018. For documentation and follow-up purposes, the data will need to be kept until 01.01.2023. The data must be stored as de-identified data, i.e. a file with key identifiable information stored separately from the file containing other data. The data must, either be deleted or anonymised within 6 months after this date.

Appeals process
The decision of the Committee may be appealed to the National Committee for Research Ethics in Norway. The appeal will need to be sent to the Regional Committee for Research Ethics, Section B, South East Norway, The deadline for appeal is three weeks from the date on which you receive this letter.

The Committee's decision was unanimous.

With Kind regards,

Grete Dyb
Chair of the Regional Committee for Medical &
Health Research Ethics of South East Norway, Section B

Mariann Glenna Davidsen
Adviser

CC:
- *Professor Jeanette Magnus, University of Oslo*
- *Project admnistrator Line Marie Løw, Institute of Health and Society, University of Oslo*
- *Management of Administration, University of Oslo*
- *Faculty of Medicine, University of Oslo*

JIMMA UNIVERSITY

Ref.No: PPGC/389/2016

Date: 22/04/2016

To Mrs. Berhane Megerssa Ereso

Subject: Ethical clearance of your research protocol

The IRB of College of Health Sciences has reviewed your research protocol during its regular meeting on April 20, 2016:

"Performance and quality of TB directly observed treatment short course strategy in Jimma Zone"

This is to notify that this research protocol as presented to the IRB meets the ethical and scientific standards outlined in the national and international guidelines. Hence, we are pleased to inform you that your protocol is *ethically cleared*.

We strongly recommend that any significant deviation from the methodological details indicated in the approved protocol must be communicated to the IRB before they are implemented.

With regards,

[redacted]

Research & Coordinator

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JIMMA, ETHIOPIA
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BIIROO EEGUMSA FAYYAA
OROMIYAA

OROMIA HEALTH BUREAU
የኦሮሚያ ጤና ጥበቃ ቢሮ

Lakk/Ref. No. BEFO/ARTFH/1-8/2026

Guyyaa /Date 8/4/2018

Waajjira Eegumsa Fayyaa Godina Jimmaa tiif
Jimmaa

Dhimmi: **Xalayaa deeggarsaa ilaala**

Akkuma beekamu biiroon keenya ogeeyyii, dhaabbilee akkasumas namoota qorannoo gaggeessuuf piroppoozaala dhiyeeffatan piroppoozaala isaanii madaaluun akkanumas iddoo biraatti ilaalchisanii fudhatama argatee (approved) dhiyaateef, piroppoozaala isaanii ilaaludhaan waraqaa deeggarsaa ni-kenna. Haaluma kanaan mata-duree **"Performance and Quality of Tuberculosis Directly Observed Treatment Short Course Strategy in Jimma Zone, South West Ethiopia"** jedhurratti **Addee Birhaanee Magarsaa** qorannoo godinalee keessan keessatti hojjachuuf piroppoozaalii isaanii koree "Health Research Ethical Review Committee" biiroo keenyaatti dhiyeesaniiru.

Haaluma kanaan koreen "Health Research Ethical Review Committee" biiroo keenyaas piroppoozaala kana ilaaluun fudhatee qorannoon kun akka hojiirra oolu murteessee jira.

Waan kana ta'eef hojii qorannoo kanarratti deeggarsa barbaachisaa akka gootaniif; akkasumas nama tokko kan adeemsa qorannoo kanaa hordofuu akka ramaddanii hordoftan jechaa, **Aaddee Birhaanee Magarsaa,** qaamni qorannoo hojjatu, wayitii qorannoon kun qaacceffamee xummurame fiiriisaa Biiroo Eegumsa Fayyaa Oromiyaa fi iddoowwan qorannoon irratti adeemsifameef kooppii tokko tokko akka galii godhan garagalchaa xalayaa kanaatiin isaan beeksifna.

Ani **Aaddee Birhaanee Magarsaa,** qorattuu kan ta'e, wayitii qorannoon kun qaacceffamee xumurame fiiriisaa kooppii tokko tokko Biiroo Eegumsa Fayyaa Oromiyaa fi iddoowwan qorannoon irratti adeemsifameef akkan galii godhu mallattoo kiyyaan nan mirkaneessa.

Nagaalwaiiin

[redacted]

Mallattoo_____
Maqaa _____

Guyyaa ----------
Lakk. Bilbilaa ----------
G/G
Aaddee Birhaanee Magarsaa tiif
Bakka jiranitti

Biiroo Eegumsa Fayyaa Oromiyaatti Adeemsa Hojii Ijoo Balaa Qorannoo fi Qorannoo Fayyaa Hawaasaa, Qo'annoo Fayyaa (BSc, MPH) Daani'eel Kabaa

Teessoo: Tel:+251-011-369-01-49 Fax: +251-011-361-01-27 P.O.Box 24341 E-mail: oihbhead@telecom.net.et Address:
ADDIS ABABA/FINFINNE-ETHIOPIA

Lakk: WEFBS/0-11/1206/08
Guyyaa: 16/09/2008

Wajjira Eeg.Fayyaa Aanaa Omo Naddaaf
Wajjira Eeg.Fayyaa Aanaa Xiiroo Afataaf
Wajjira Eeg.Fayyaa Aanaa Maanaaf
Wajjira Eeg.Fayyaa Aanaa Gommaaf
Wajjira Eeg.Fayyaa Aanaa Limmu-Kossaaf
Wajjira Eeg.Fayyaa Aanaa Qarsaaf
Wajjira Eeg.Fayyaa Aanaa S.Caqorsaaf
Wajjira Eeg.Fayyaa Aanaa Sokorruuf
Waljira Eeg.Fayyaa Magaalaa Aggarooof
Bakka jiranutti

Dhimma isaa:- Deggersa hojii gaafachuu ta'a.

Akkuma mata duree irratti ibsamee BEFO xalayaa BEFO/Amk/1111/8/2026 gaafa Guyyaa 8/9/2008 barreeffameen namoota qorannoo fayyaa gaggeeuf propoozaalaa dhiyeeffataniif propoozalaa isanii ilaaludhaan, waraqaa deggarsa kennuu isaa ibsanii haaluma kanaan Addee Birhaanee Magarsaa mata duree "Performance and quality of Tuberculosis Directly Observed Treaatment Short Course Strategy in Jimmaa Zone, South West ETHIOPIA" jedhamu irratti Propozaala dhiyeefatani 'Ethical Committee' BEFOtiin ilaalee akka qorannoo kun hojii irra oolu murtessu isaa ibsanii qorannoo xana irratti deggarsa baarbachisa ta'e akka godhamuuf isa beeksisaniru.

Kanafuu Addee Birhaanee Magarsaa fi namoota raga isaabanuu hojii kanaf gara aanaa keessan waan dhufanii deggersa hojii kanaf barbachisa ta'e akka goodhamuf ni gaafana.

Nagaa Waliin !

[redacted]

C.C.

- Ad.Hoj.Dhuk.Dadarbaaf
  WEF-Godina Jimmaa