Prevalence and Associated Risk Factors of Pulmonary Tuberculosis among Prisoners in Eastern Ethiopia

Dawit Shawel Abebe

Supervisor:

Professor Gunnar Bjune

Co-supervisors:

Researcher Fekadu Abebe

Associate Professor Gobena Ameni

University of Oslo

Faculty of Medicine

Institute of General Practice and Community Medicine

Section for International Health

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Abbreviations

AFB	Acid Fast Bacilli
AIDS	Acquired Immuno Deficiency Syndrome
ALIPB	Aklilu Lemma Institute of Pathobiology
BCG	Bacillus Calmette-Guérin
BMI	Body Mass Index
DOTS	Direct Observed Treatment, Short-course
EPTB	Extra-Pulmonary Tuberculosis
FMOH	Federal Ministry of Health
HIV	Human Immunodeficiency virus
HSDP	Health Sector Development Program
ICRC	International Committee for Red Cross
LJ	Löwenstein-Jensen
MDG	Millennium Development Goal
MDR	Multi-Drug Resistance
N	Number
NTCP	National Tuberculosis Control Program
PTB	Pulmonary Tuberculosis
RHB	Regional Health Bureau
SSA	Sub-Saharan Africa
TB	Tuberculosis
WHO	World Health Organization

Abstract

Background: Information on prevalence of tuberculosis (TB) in Ethiopian prisons is non-existent, despite its highly endemic nature. So, the aim of this study was to determine prevalence and associated risk factors for pulmonary TB (PTB) in three large prisons of Eastern Ethiopia.

Methodology: A cross-sectional study was performed on 382 sampled prisoners (44 PTB cases and 338 PTB suspects) from July to November, 2008. A structured questionnaire was administered to prisoners who had ≥ 2 weeks of cough. Sputum samples were analyzed by direct smear microscopy and culture on Löwenstein-Jensen medium. Data were analyzed using logistic regression model. The analysis was evaluated using goodness-of-fit tests.

Result: Using an active screening strategy, 371 PTB suspects were identified; out of which, 33(8.9%) were smear- or culture-positive PTB. Eleven (25%) newly diagnosed PTB cases were sharing a cell with already known TB cases. Including 11 PTB cases on anti-TB treatment (passively identified), the point prevalence of PTB was 1913/100,000 (95%CI=1410-2580); about seven times higher than it's prevalence in the general population. Three previously undetected PTB cases were found for every 1 case that was identified passively. Risk factors for PTB included being an urban resident (AOR=2.79, 95%CI=1.26-6.17), having > 3 visits to clinics for TB symptoms (AOR=3.33, 95%CI=1.15-9.60), cough > 4 weeks (AOR=2.69, 95%CI=1.20-5.98), sharing a cell with a TB patient (AOR=2.82, 95%CI=1.33-6.00) or a prisoner with chronic cough (AOR=3.61, 95%CI=1.68-7.76). Also, high proportion (40.4%) of prisoners had low level of biomedical knowledge of TB. Independent predictors for low knowledge of TB included being an illiterate (AOR=2.22, 95%CI 1.29-3.82), not able to visit health institution for TB symptoms (AOR=2.52, 95%CI 1.41-4.49), had longer duration of cough (> 4 weeks) (AOR=1.77, 95%CI 0.99-3.12), and imprisoned in C (AOR=15.62, 95%CI 7.47-33.54) and B (AOR=2.67 and 95%CI 1.38-5.16) prisons.

Conclusion: The present study indicates high prevalence of PTB and associated risk factors that favor the transmission of the causative agent and the acquisition of new cases, and hence dangerous for the prison population and surrounding community. Therefore, active surveillance of TB and implementing specific prevention and control guidelines are highly recommended.

1 CHAPTER I. INTRODUCTION

1.1 Ethiopia: Country profile

1.1.1 History

Ethiopia is an ancient country with a rich diversity of peoples and cultures and a unique alphabet that has existed for more than 3,000 years. It is one of the few African countries to escape colonialism. Palaeontological studies have identified Ethiopia as the likely cradle of mankind. Ethiopia's geographical and historical factors have had a great influence on the distribution of its peoples and languages. The country embraces a complex variety of nations, nationalities and peoples, and linguistic groups. Its peoples altogether speak over 80 different languages constituting 12 Semitic, 22 Cushitic, 18 Omotic and 18 Nilo-Saharan languages. The capital city, Addis Ababa, has been a seat for the head quarter of African Union since its establishment. The country has rock hewn churches, historic towns, obelisks and valleys registered under the world heritage list (1) .

1.1.2 Geography and Climate

Ethiopia is a landlocked country located in the Horn of Africa, lies between 3 and 15 degrees north latitude and 33 and 48 degrees east longitude. With a total area of around 1.1 million square kilometers, it borders with five countries; Eritrea in the north, Djibouti in the east, Sudan in the west, Kenya in the south and Somalia in the southeast. The size of the country and its location has accorded it with diverse topography, geographic and climatic zones and resources. The Great East African Rift Valley divides the highland into two: the western and northern highlands and the south-Eastern. There are three principal climatic groups, namely the tropical rainy ('*Dega'*), dry ('*Kolla'*), and warm temperate ('*Weyna Dega'*) climates. In general, the highlands receive more rain than the lowlands with annual rainfalls of 500 mm to over 2000 mm for the former and 300 mm to 700 mm in the latter. In addition, irregularity of rainfall is a characteristic of climates that prone the country to recurrent droughts and famines (1;2).

1.1.3 Administrative setup

The government is made up of two tiers of parliament, the House of Peoples' Representatives and the House of the Federation. Administratively structured into nine regional states, namely: Tigray; Afar; Amhara; Oromiya; Somali; Benishangul-Gumuz; Southern Nations Nationalities and Peoples; Gambela and Harari Regional States and two city administrations, i.e. Addis Ababa and Dire Dawa Administration Council (1).

The national regional states and city administrations are further divided into 68 Zones and 611 '*Woredas'*. Zone is the second administrative level in the regional states, but *woreda* is the basic decentralized administrative unit that has an administrative council composed of elected members. *Woredas* are further divided into roughly 15,000 '*Kebeles'* (10,000 rural and 5000 urban); it is the lowest administrative unit (1;2).

1.1.4 Economy

Ethiopia is an agrarian country and agriculture accounts for 54% of the Gross Domestic Product. Agriculture employs about 80% of the population and accounts for about 90% of the exports. The country is one of the least developed in the world, with a per capita gross national income of US$110 in 2004. Poverty is persistent with 47% of the population estimated to live below the poverty line (< US$2/day). The Ethiopian currency is called '*Birr*', and at present, 1 US$ is equivalent to about 11 *birr*. Coffee has remained the main export of the country; however, other agricultural products are currently being introduced on the international market. It is one of the seven priority countries selected by the Millennium Project to prepare a scaled-up investment plan that would allow the country to meet the Millennium Development Goal (MDG) targets. The country is implementing a poverty reduction strategy, which is referred to as the "Plan for Accelerated and Sustained Development to End Poverty" (1;2).

1.1.5 Demography

According to the first draft report of 2007 census, the total population is estimated to be 73,918,505. Ethiopia has become the second most populous country in Africa, following Nigeria. Its population has been growing rapidly in recent years, at a rate of 2.7% per annum since 2000, which means increment by 2 million persons annually: with such a rate, the population is expected to reach 82.1 million by the year 2009. Nearly half of the population (49.5%) is female. The average household size is 4.8 (2;3).

About 85% of the total population lives in rural areas, making Ethiopia one of the least urbanized countries in the world. As in many other developing countries, the rate of growth of the urban population (4.1%) is higher than that of the total population (2.7%). This rapid population growth exacerbates critical gaps in basic health services. Moreover, settlement pattern of the population and its density greatly affect the provision of health care, including the accessibility and utilization of existing health care facilities (2;3).

The structure of the population shows the dominance of the young age group. It is the typical demographical structure of many developing countries. Children (0-14 years) and youth (15-24 years) together accounted for almost 64 percent of the total. About 43.5% of the population comprises those under the age of 15 years, 51.9% between the ages of 15 and 59 years, and only 4.6% aged 60 years and above. A large proportion of women (24%) are in the reproductive age (15-49 years). Total Fertility Rate (TFR) for the country is high with 5.4 children per woman. The overall dependency ratio for the country is estimated as 84.3 dependents per 100 people in the working age group (15-64). The impact of HIV/AIDS has also been exacerbating the dependency ratio by depleting the productive group of the population (2;3).

1.1.6 Education

In Ethiopia, the literacy status of the population is low; where the total adult literacy rate is 36% (46% for males and 25% for females). The gross enrolment ratio in primary schools at national level is 68.4% (59.1% for girls). Although more than tripled from the 20% enrolment level of 1994, it is still much lower than the Sub Saharan Africa (SSA) average. The urban-rural differential in literacy among men is smaller compared with women, suggesting that men in the rural areas have much greater opportunity for learning than women. So this low level of education has marked influence on the spread of diseases, the acceptability of health practices and utilization of modern health services (2;4).

1.1.7 Prison System

The Ministry of Federal Affairs and Justice is responsible for overall executive activities of prisons in Ethiopia. While the federal and state (regional) prison authorities are governing body of the prison administration. Each state and city administration has a full pledge right in the management of their respective prisons. In 2003, a total number of establishments were 114 (2 federal prisons and 112 state prisons). Among these prisons, federal and some of state prisons, particularly those found in the capital cities of states, are functioning as central prisons that usually receives sentenced individuals from the surrounding *woredas*. In almost all of the *woredas*, there are police stations that usually serve as pre-trial prisons. In 2007, about 80,000 pre-trial detainees and remand prisoners were estimated to be held in the prisons. The rate of prison population is about 98 per 100,000 of the national population (5).

1.2 Health profile of Ethiopia

1.2.1 Health service status

Historically, the health system was centralized and the services were being delivered in a fragmented manner with a reliance on vertical programs. The administrative arrangements were also highly centralized until 1991. In 1992, this was evaluated in accordance to the status of health services, to identify major problems and develop a health policy within the framework of the overall government policy of good governance and decentralization. The Federal Government approved Ethiopia's Health Policy and Strategy in 1993 (4).

The country is following a federal structure with resulting high level decision-making at regional levels. The decision making processes in the development and implementation of the health system are shared between the Federal Ministry of Health (FMOH), the Regional Health Bureaus (RHB) and the *woreda* health offices; it is a four tier health service system. The FMOH and RHB are made to function more on policy matters and technical support, while the *woreda* health offices have been made to play the pivotal roles of managing and coordinating the operation of the primary health care services at the *woreda* levels. The primary health care service includes preventive, promotive and basic curative services (2;4).

In response to prevailing and newly emerging health problems, the government has set up the Health Sector Development Program (HSDP), which incorporates a 20-year health development strategy, through a series of five-year rolling programs. The country is implementing the third phase of this program, HSDP III. It focuses on poverty-related health conditions, communicable diseases such as HIV, tuberculosis (TB), malaria and diarrhea, and other health problems that affect mothers and children with particular attention to rural areas (2;4).

The potential health service coverage[1] was estimated 71.2% in 2005. However, this varies substantially among the regions depending on their topographic, demographic and socio-economic characteristics. There is also a big disparity between urban and rural. The per capita health service utilization that was 27% until 2000 had increased to 30% in 2004. The population per primary health care facility is 27,456, which is three times higher than in the other SSA countries. The total number of hospital beds is 13,922; there is only one bed for a population of about 5,300 that is about five times lower than the SSA average. The proportion of physician is estimated, one physician to about 40,000 populations and for nurse, 1:4000. Similar to the health facilities, health professionals are also poorly distributed among regions, and disparity between urban and rural areas is considerable (2;4;6).

[1] The population covered in percentage based on the existing health centers and health stations in catchment's area

1.2.2 Health status of the population

Ethiopian population has a poor health status relative to other low-income countries; even within the SSA. This is largely attributed to preventable infectious diseases and nutritional deficiencies. Infectious diseases account for about 60-80% of the health problems in the country. This high burden of ill-health has attributed to multiple factors, such as widespread poverty, low education levels (especially among women), inadequate access to clean water and sanitation facilities and poor access to health services. The situation is further aggravated by a high population growth. The average life expectancy at birth is relatively low at 53.4 for male and 55.4 for female, and is further expected to decline if present HIV infection rates continue (2;4).

Poor nutritional status, infections and high fertility rate, together with low levels of access to reproductive health and emergency obstetric services, contribute to one of the highest maternal mortality rate (MMR) in the world, 871/100,000 live births. Infant mortality rate (IMR) is 77/1000 live births, and under five child mortality rate (U5MR) is 123/1000. Nutritional disorders rank among the top problems affecting the population in general, most notably children and mothers. In 2004, 46.9% of children under the age of five years were stunted, 8.3% were wasted, and 36.1% were underweight (2;4).

The HIV epidemic has taken off rapidly over the last two decades and the prevalence was estimated at 3.5% of the adult population (3% among male and 4% among female) in 2005. The estimated prevalence in urban areas was 10.5% (9.1% among males and 11.9% among females) and 1.9% in rural areas (1.7% among males and 2.2% among females). It was also estimated that 1.32 million people are living with HIV/AIDS. This is a staggering number to cope with the resource-poor country (7) (See Table 1).

Table 1 Health status and some disease control indicators (2001-2004/05), Ethiopia

Indicator	Baseline value 2001/02	HSDP II Target 2004/05	HSDP II Result 2004/05	HSDP III Target	MDGs Target by 2015
Life expectancy	NA	58	54	NA	NA
Infant mortality rate	113	85	77	45	38
U5 mortality rate	166	NA	123	85	55
Maternal mortality rate	871	450	871	600	450
Total fertility rate	5.5	NA	5.4	4	NA
HIV prevalence	7.3%	NA	4.6%	4.4%	2.2%
TB case detection rate	44%	NA	34%	50%	NA
Malaria prevalence	NA	NA	22%	10%	NA
Proportion of children < 5 years underweight	47%	NA	38%	NA	NA
Proportion of children < 5 years underweight	52%	NA	47%	NA	NA

Source: Tuberculosis, TB/HIV and Leprosy prevention and control strategic plan, 2007-2010, NA: not available

1.3 Tuberculosis

1.3.1 Basic facts about tuberculosis

1.3.1.1 Aetiology

TB is a bacterial disease caused by *Mycobacterium* (M). The genus *Mycobacterium* is divided in to two main groups: *M.tuberculosis* complex and environmental Mycobacteria or non tuberculosis Mycobacteria (NTM).The *M.tuberculosis* complex comprises the closely related species *M.tuberculosis, M.bovis, M.africanum, M.microti and M.canettii*. These species are the causative agents of TB in humans and animals. *M.tuberculosis* is the major cause of human TB all over the world (8;9).

1.3.1.2 Mode of transmission of tuberculosis

M.tuberculosis infection occurs through inhaling an aerosol droplet that is generated when patient with PTB coughs, talks, sneezes, spits and sings. For *M. bovis*, it can be transmitted through drinking of raw milk that may infect the tonsils presenting as scrofula (cervical lymphadenitis), or the intestinal tract, causing abdominal TB (8;10). In case of PTB, once the organism enters the alveolar region, alveolar macrophages engulf and control multiplication of bacillus in most of the exposed individuals. This primary infection leads to an active disease in about 10% of individuals only. In the remaining 90% of cases, individuals remain asymptomatic and non-infectious, i.e. latent infection stage. However, in some circumstances where the immune response is weakened, reactivation of latent infection can result (10;11).

1.3.1.3 Clinical manifestation of tuberculosis

Once a person develops the disease, PTB, there will be several suggestive clinical features, especially 2 weeks' or above duration of cough, sputum production and weight loss are important for the diagnosis of PTB. Others respiratory symptoms like chest pain, haemoptysis, breathlessness and/or constitutional symptoms like fever, night sweats, tiredness, loss of appetite can also occur (10).

1.3.1.4 Diagnosis of tuberculosis

The diagnosis of PTB in adult is mainly done by collecting a sputum sample. Due to the nature of the waxy coat of *Mycobacterium* cell wall, it retains an aniline dye (e.g. carbol fuchsin) even after decolorization with acid and alcohol; they are thus named Acid Fast Bacilli (AFB). This characteristic enables us to detect them by microscopy. Although this method has low sensitivity; it is widely applied and used globally, because it is simple, rapid and cost-effective. In resource limited settings, culture is used for a definitive diagnosis of TB. However, it is much more costly than microscopy, requiring a long incubation period and facilities for media preparation as well as skilled staff. The other diagnostic method is chest x-ray (CXR). It is less applicable in low resource countries (10;12;13).

1.3.1.5 Treatment and management of tuberculosis

The treatment of TB is targeting five objectives:–preventing death from active TB or its late effects; preventing TB relapse or recurrent disease; preventing the development of drug resistance and decreasing TB transmission to others. The drugs that are used for first line treatment of TB are safe and effective if properly used. In Ethiopia, these include rifampicin, ethambutol, isoniazid, pyrazinamide and sterptomycin. The administration of chemotherapy has two phases. First, the intensive (initial) phase that consists of 3 or more drugs (rifampicin, ethambutol, isoniazid, and pyrazinamide) for first the 8 weeks for new cases and 12 weeks for re-treatment cases. In this phase, drugs must be collected daily and swallowed under direct observation of a health worker. Secondly, the continuation phase has at least 2 drugs (ethambutol, and isoniazid) that will be taken for 4-6 months. In this phase, drugs must be collected every month and self-administered by the patient, except for some conditions (10;14). The strategy of TB treatment is called Directly Observed Treatment, Short-course (DOTS). It was adopted for the control of TB and formulated global targets for the year 2000, namely to detect 70% of infectious new cases and to cure 85% of the detected infectious cases at the World Health assembly in 1991. WHO TB global report indicated that DOTS was being implemented in 184 countries that accounted for 99% of all estimated TB cases and 93% of the world's population in 2006 (15).

1.3.2 Global burden of tuberculosis

TB is still a priority in the global public health agenda, despite efforts and interventions that lasts several decades. It is the second most common cause of death due to an infectious disease. Current trends suggest that TB will remain among the top leading causes of global disease burden over the next decades (16).

It was estimated that 9.2 million new cases of TB (139 per 100,000 population), including 4.1 million (62 per 100,000 population) new smear-positive cases occurred globally during 2006. About 95% the new cases and 98% deaths due to TB occur annually in the developing world. Asia and Africa account for 55% and 32% of cases globally, respectively. The SSA countries have the highest rates, with an average rate of about 300 per 100,000 population. Of the 9.2 million TB cases, 7.7% were estimated to be co-infected with HIV. The African region accounts for the majority of co-infected cases worldwide, about 85% in 2006 (15;17;18).

The burden of TB is predominately accounted by men; reported as the disease of men. For instance, countries (2004) reported 1.4 million smear-positive cases in men, but only 775,000 in women. This epidemiological difference is suggested to be due to gender differences in access to TB services, exposure to infection and susceptibility to develop an active disease. For many years, TB cases occurred predominantly among young adults, where approximately 6-8 million cases in the economically most productive age groups (15-49 years old). However, in Western Europe and North America countries, which have low incidence rate, TB cases tend to be in the old indigenous population, whereas patients who are immigrants from high-incidence countries tend to be young adults (18;19).

In the 20th century, morbidity and mortality due to TB steadily dropped in the developed world. This was aided by better public health measures, improving living standards and widespread use of BCG vaccine as well as the development of antibiotics in the 1950s. This downward trend ended and the number of new cases started to increase in the mid 1980s. The major causes were risk of reactivation of latent TB by increased life expectancy, poor compliance with anti-TB treatment, and increased risk of exposure through HIV, urbanization, migration and destitution. But, using

massive expenditure of funds and human resources, the epidemic has been well controlled and reversed in Western Europe and United States. In most Western Europe and North America countries, TB is often attributable to immigrants from high-incidence countries; they remain at increased risk of active TB (17;18;20;21). For instance, a study in Norway showed that immigrant had 7 up to 90 times higher than the crude incidence of TB in the country (22).

The global increase in TB burden has sizeable contribution from Eastern Europe countries (mainly the former Soviet Union) since 1990 and SSA since mid 1980s. The resurgence of TB in the Eastern Europe countries is due to dramatically worsened living conditions, poor nutrition, economic decline during break down of the former Soviet Union, substandard TB treatment, inadequate TB control program, emergence of MDR-TB, and increased prison population (19;23;24). The epidemic in this region is also strongly linked to the emerging of successful strains, W-Beijing strains, that are highly virulent and drug resistant, and has higher degree of transmission (25).

In Africa, the increasing of TB morbidity and mortality is caused by multiple factors, such as widespread poverty, poor political commitment to TB control, civil strife, inadequate donor support and the HIV epidemic. Predominantly, HIV epidemic has made a momentous contribution since 1980s (18;19;21). The rate of TB among HIV/AIDS patients is documented ranging from 20-44%. TB is known as the primary cause for death among HIV infected patients. So, HIV infection has profoundly lead on the epidemiology of TB (21). The African continent as a whole is out of a track in achieving MDG 6; to have halted and begun to reverse the incidence of TB in 2015 (15).

1.3.3 Tuberculosis in Ethiopia

1.3.3.1 Tuberculosis epidemiology in Ethiopia

Ethiopia ranks 7th among the 22 high burden countries and 15th among the MDR-TB priority countries in 2006. It is one of the top three in Africa, with regard to a number of TB patients. According to the FMOH hospital statistics data, PTB was the third leading cause of hospital admission (7.8%), and the first leading cause of in-patient deaths (10.1%) in 2001. Due to poorly developed health information system and absence of a national prevalence study, the actual magnitude of TB in the country has not been accurately determined. However, WHO has estimated the burden of TB as presented in Table 2 (4;15;26).

Table 2 WHO (2007) estimates of TB burden in Ethiopia

	Rate
Incidence ratio of all forms of TB	341 per 100,000
Incidence ratio of smear-positive TB	152 per 100,000
Prevalence of TB infection	546 per 100,000
Mortality rate due to TB	73 per 100,000
HIV among TB patients	41.00%

Source - Tuberculosis, TB/HIV and leprosy prevention and control strategic plan, 2007-2010

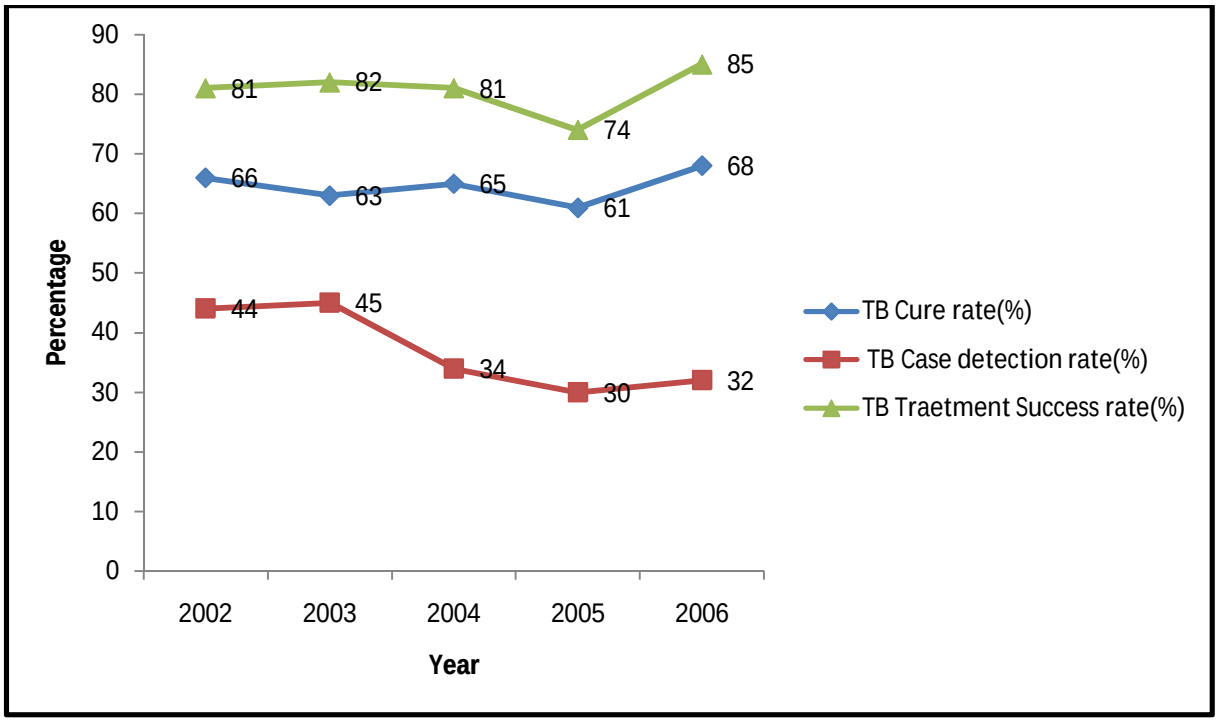
According to 2005/06 health institutions report, 120,163 (97.7%) TB patients were new cases; out of which, 36,674 (31%) were smear-positive cases. The seven-year trend of TB case notification record indicated that proportional increment of extra-PTB (EPTB) and smear-negative TB, while there is a downward trend for smear-positive TB (see Table 3). This trend is assumed to be due to the ongoing HIV/AIDS epidemic and causes for a growing caseload. HIV accounted for about 32% of the estimated 141,000 total TB cases in 2005, and the prevalence of HIV among TB patients was estimated 41% in 2007. This double burden of TB and HIV is attributing to increasing demand for care and worsen situation of the already overstretched health care delivery system in the country. They deplete resources, worsen stress and aggravate attrition of health workers at service delivery points (4).

Table 3 Seven years (1999-2005) overview of TB case notification in Ethiopia

Year	Total new cases	Smear positive TB		Smear negative TB		EPTB		Case notification rate per 100,000 population	
		N	%	N	%	N	%	smear positive	all form
1999	83334	26459	32	30333	36	26542	31	42	131
2000	90729	32423	36	28994	32	29312	32	50	139
2001	105250	35915	34	32197	31	37138	35	53	157
2002	108488	37014	34	32656	30	38818	36	54	157
2003	121026	41430	34	37119	31	42477	35	59	173
2004	123090	38800	31	40269	33	44021	36	53	169
2005	120163	36674	31	40234	33	43255	36	49	160

Source - Tuberculosis, TB/HIV and leprosy prevention and control strategic plan, 2007-2010

TB treatment success and cure rate is progressing in the country, while a case detection rate that determine by the number of smear-positive cases, has the downward trend as stated before (see figure 1) (4;6).



Source- Health and Health Related Indicators, FMOH, 2007

Figure 1 Trend in TB cure rate, case detection rate and treatment success rate from 2002-2006 in Ethiopia

We have found only two published community based studies that estimated the prevalence of smear-positive TB in Ethiopia; a study carried out in Addis Ababa (2001) reported 189/100,000 population (95%CI 112-267), and a study in southern rural district (2003) reported 78/100,000 population (95%CI 36-120) (27;28). A first nation based WHO collaborative drug resistance survey indicated that 1.9% of all TB cases were MDR-TB; 1.6 % among previously untreated patients and 11.8% among previously treated cases. However, second line drugs for patients affected by MDR-TB are not available in the country. The national TB control program (NTCP) is planning to start MDR-TB treatment in a national referral centre (4;15).

1.3.3.2 Tuberculosis control in Ethiopia

In Ethiopia, TB has been identified as one of the major public health problem, since about five decades. The effort to control TB began in the early 1960s with establishment of a national central office, and TB centers and sanatoriums in three major urban towns. However, these centers and national central office were not able to reduce the disease burden. As a result, a standardized and well-organized TB programme, incorporating DOTS, is implemented since 1992. Currently, DOTS covers over 90% of the *woredas* in the country. The program is combined and implemented with the leprosy program; named National Tuberculosis and Leprosy Control Program since 1994. The program is guided by the national strategic plan that was developed for the period from 2007 to 2010. The plan elaborates prevention and control strategies of TB, TB/HIV and leprosy. Its implementation is intended to reduce morbidity, mortality and disability due to TB, TB/HIV and leprosy (4).

The NTCP is organized in a hierarchical fashion with varying responsibilities under FMOH. Within an integrated health system, the program relies on supervisory staff at the national, regional, zonal and *woreda* levels, which has basic knowledge and skill on TB, TB/HIV and leprosy. At the national level, the TB and leprosy control team is responsible for developing guidelines, soliciting and coordinating external resources, providing technical assistance to the RHBs, and monitoring the programme performance in accordance with the national guidelines. At the regional level, a regional team is responsible for the planning, guidance and supervision of TB, TB/HIV and leprosy control activities in the region. At the zonal level, a zonal expert is responsible for the planning, guidance and supervision of TB, TB/HIV and leprosy prevention and control activities in the zone. At the *woreda* level, a *woreda* expert keeps the TB, TB/HIV and leprosy registers and provides guidance and supervision to the general health staff that are responsible for implementation of the TB, TB/HIV and leprosy control activities (4).

The NTCP has numerous challenges in combating the epidemic, such as high HIV prevalence, low case detection rate, extended delay for diagnosis and treatment, inefficient and sub-standard laboratory service. The program is also suffering from lack of operational research that could improve the service delivery (4).

1.4 Tuberculosis in prison

TB is known to be the disease of under-privileged social conditions such as poverty, malnutrition, and overcrowding. Prison is also a setting that constitutes all these conditions under one roof. It concentrates individuals with background of poverty usually in overcrowded and unhygienic environment, and with limited access to health service. Prison is therefore becoming the place for concentrating, disseminating, making worse and even exporting TB, including MDR-TB in the prison and general population at large. Everywhere, prisoners usually come from a poor and socially marginalized segment of the society. So they come to prison with poor health and high vulnerability to infection. Although prison could be the strategic place where untreated conditions are discovered and dealt with, so that prisoners leave healthier than they were when they came in. This only happens rarely; they are rather at greater risks of acquiring and transmitting infectious diseases like TB (29-31).

In Africa, where poverty, HIV/AIDS, and chronic malnutrition are unacceptably prevalent, the prison population probably has a high burden of TB. However, published information about TB in African prisons is very limited. Thus, we made a literature review on TB in prison, in order to identify gaps of knowledge and describe the epidemiology of TB in prisons, particularly for the African setting. We used Pub Med/Medline and Google Scholar database, and searched using key words, such as “Tuberculosis and prison”, “Tuberculosis, Africa, and Prison” and “Prison and Health”. We present the review as follows: prevalence of TB in prison, factors associated with TB in prison (socio-demographic, prison and morbidity factors), drug resistant and molecular epidemiology of TB in prison.

1.4.1 Prevalence of tuberculosis in prisons

Globally, the prevalence of TB in prison is very high that may account for up to 25% of a given country TB burden. WHO estimated a prevalence of TB in prisons is 10-100 fold higher than a prevalence in the general population (32). According to our review among published studies, it ranged from 3 to 200-fold higher than in the general population, both in high and low income countries (23;31;33-46).

In Africa, we found only seven published prison studies that reported the prevalence of TB in prison. These studies estimated 4 up to 35 times higher than the prevalence in the general population (33;35;38;40;41;44;47). For instance, the prevalence of TB in prison of Antananarivo was 16 times higher than in the general population of Madagascar (44). In Zambia, about 10-fold higher than in the general population (33).

In other continents, most notably in the Eastern Europe countries, we found a number of published studies (23;30;31;36;37;42;43;48-51). A Georgian study was one of the first nation based study that reported a high burden of TB in prisons. The prevalence of smear- or culture-positive TB was 5995/100,000-almost 200 times more than the prevalence in the general population (39) (see Table 4).

The studies indicate that the disparity of TB burden in the prison population is very disproportionate; to be infected with *Mycobacterium* is becoming a part of prisoners' sentence.

Table 4 Prevalence studies of TB in prisons of selected countries

Country , Year and Reference number	Eligible and screened prisoners=N	Screening criteria	Diagnosis method‡			Prevalence (%)	Comparison to the prevalence of general population
			SMR	CXR	CUL		
Botswana,2002(38)	1027 and 667	ACFQ**	x	x		3.8	10-fold higher
Cameroon,2004(35)	2474 and 503	≥ 2 wks cough	x		x	3.5	35-fold higher
Malawi, 1996(40)	914 and 267	≥ 1 wks cough	x	x		5.1	10-fold higher
Madagscar,1995(44)	2849 and NA	NA	x		x	5.9	16-fold higher
Zambia,2001(33)	6118 and 1080	ACFQ	x		x	4	10-fold higher
Thailand,2005(34)	71,594 and 20397	WHOQ¥	x			0.35	6-fold higher
Georgia,1998(39)	7630 and 2574	WHOQ	x		x	5.9	200-fold higher
Brazil, 2002(37)	1171 and 1081	WHOQ	x		x	4.6	about 10-fold higher
Taiwan,1998(80)	51,494	all prisoners		x		0.26	about 4-fold higher
Europe,2002*(46)	NA	entry screening		x	x	0.39	about 17-fold higher
Pakistan,2002(45)	4870	TB symptoms	x		x	0.66	3.75-fold higher

* Report from 20 Europe countries, NA-not available

** ACFQ: active case finding questionnaire

¥ WHOQ: WHO TB screening questionnaire

‡ Diagnosis method: SMR-smear microscopy, CXR-chest X-ray and CUL-culture

1.4.2 Factors associated with tuberculosis in prisons

1.4.2.1 Socio- demographic factors

Most prisoners predominantly come from the poorly educated and socio-economic deprived segment of the general population, so they are at greater risk of acquiring and developing TB even before admission to prison. Studies have identified the following risk factors for TB among prisoners: low educated (37); homelessness, belonging to racial and ethnic minority groups and excess alcohol use (36); and low income and narcotic drug use (52). Accordingly, they may have poor access to health care that could increase the risk and prolonged period of infectiousness. Indeed, these factors have also an adverse effect on immunologic function that increases susceptibility to infection and development of the active disease (53).

A large number of prison studies reported that the mean and median age of TB cases ranged from 27 to 37 years. In other words, TB in prisons whether from high or low incidence countries, is consistently reported among young adults (15-49). They are also a largest proportion of the prison population (33-36;40;47).

Prison studies indicated a significant difference between male and female prisoners regarding identifying TB suspect and diagnosis (33;34;36;40). In Zambia prisons, new cases of TB only detected among male prisoners (33). Similarly, a prison study from Malawi showed that all PTB cases were male (40). Thus, the epidemiological difference could be due to poorer access to diagnostic facilities, higher exposure to infection and increased susceptibility rather than biological difference (53).

1.4.2.2 Prison related factors

Overcrowding is one of the typical characteristic of prisons that attributes to a high burden of TB. A case-control study in St. Petersburg prisons (Russia) reported that an overcrowded cell (more than 2 people per bed) and spending less time outdoors were independent risk factors for developing TB in the prison (52). The Georgian study also indicated that being accommodated in a prison with large number of prisoners (>600) had a significant association with an increased risk of active TB; there was three times greater risk for prisoners accommodated in large prisons (>600 prisoners) compared to small prisons (< 300 prisoners). Large prisons are notorious for having poor hygienic standards and lack of adequate ventilation (39).

The length of imprisonment is one of the commonly identified risk factor for TB. But, the risk related to duration of staying, either short or long period staying, has given contradictory results in different studies. For instance, having PTB was positively associated with a short staying (1-2 years) in Ivory Coast (41), Cameroon (35) and Tanzania (47) prisons. These studies suggested that prisoners could have TB before they were sentenced, or a high transmission rate of TB and poor living conditions may led to a rapid progression to the disease in those susceptible. Conversely, the Georgian study showed that the risk of getting TB for those who stayed 2 years or more was two times greater than for those who were imprisoned for less than one year (39). As a result of poor living conditions, physical and emotional stress, the longer prison stay may attribute to lengthy exposure to infection as well as deterioration of immunologic function. On the other hand, the length of staying was not a significant risk factor for TB in a Zambia prisons study (33).

Re-imprisonment (35;43), and a history of previously being in a prison (54;55) were found to increase the risk of TB. A study in Maricopa County (USA) reported that 24% of TB patients in the civilian society had a history of imprisonment in the county jail prior to their TB diagnosis. The majority of them (83%), who later developed TB, had not received any TB screening while in jail (55). Similarly, a study in Memphis (USA) found that 43% of community residents with TB had been incarcerated in the same jail at some time before their diagnosis. This jail was a source of TB outbreak for prisoners and community members that lasted several years (56).

Overall, the studies explicitly stated that the prison related factors are attributing to a high TB burden both inside as well as outside of prisons and thus need to be addressed in TB control strategies.

1.4.2.3 Morbidity related factors

Historically, prisons and diseases have been strongly linked ever since prisons became the main repository of socially marginalized and poor individuals. In 1666 an English Act of Parliament noted that prisoners were infecting others in a court when they came for their trials. John Howard, the great prison reformer, also died in 1790 from typhus after he visited a sick prisoner in Ukraine (31). This historical event illustrates that prison health is not only about those inside bars, it is also the health of the general population. In other words, prison health is an integral part of community health, because prison staff, guards, visitors, judiciary staff, and health personnel have close contact with prisoners that may easily acquire and transmit TB or any other infectious diseases to other healthy prisoners and the general population (29).

A large number of studies documented high burden of infectious diseases, such as HIV, sexual transmitted infections, hepatitis and skin infections, mental health problems and substance abuse (31;47;57-59). For example, a study in Ghana prisons reported higher prevalence of HIV, hepatitis and STI among prisoners and prison officers as compared to the general public. Significant associated factors included prisoners aged 17-46, low socio-economic status (being illiterate, unmarried and female prisoners), longer imprisonment, intravenous drug use, and homosexuality. Intra-prison transmission between prisoners and prison officers was also suggested as a possible transmission route (60).

The rapid rise of TB epidemic is also well linked with the fastest growing risk of HIV infection in the prison population. For instance, HIV infection in Russian prisons was 75 times higher than the community at large (31). In Zambia's prisons, more than one in four prisoners among the 13-15,000 prisoners was infected with HIV. It was higher than the estimated prevalence of HIV among adult in the general population (58).

Malnutrition is also commonly identified in different studies (33;35;39;41;47). For instance, a study in Zambia found that nutritional status and food intake was universally poor in all surveyed prisons (33). Cameroon (35) and Georgia (39) studies reported a low body mass index (BMI) as a significant predictor of TB.

In general, the prison population is a vulnerable group for suffering from higher burden of communicable and non-communicable diseases.

1.4.3 Drug resistant tuberculosis in prisons

High levels of MDR-TB are reported from some prisons with up to 24% of all TB patients (32). Since the early 1990s, many Eastern Europe countries reported outbreaks of TB in prisons, where the TB strains transmitted in prisons were more likely to be drug-resistant or associated with HIV co-infection (30). A number of studies, mainly from Russia showed the emergence of MDR-TB from prison populations to be a major health risk to the population, with economic implications for the TB control (23;25;61-64). History of imprisonment was identified as a strong predictor for acquiring drug resistant TB, including MDR-TB. Active transmission of drug resistant strains; especially Beijing family genotype, inadequate TB control program, lack of TB drugs, and spread of HIV infection were mentioned as contributing factors for the catastrophic emergence of MDR-TB in the prison (23;36;61;65).

In Africa, only Zambia (33) and Botswana (38) studies reported on drug resistant TB in prisons. The Zambian study found resistance to at least one anti-TB drug among 40 (23.8%) of isolates; where 16 (9.5%) of them were MDR-TB. This rate was found to be on the upper limit of resistance rates reported among African countries (33).

On the whole, prisons are found to be an ideal site for concentrating and exporting drug resistant TB.

1.4.4 Molecular epidemiology of tuberculosis in prison

Introduction of molecular epidemiology studies contributed much to our understanding of transmission dynamics and causative strains of TB in prison. It gives an apparent reason why we should be aggressive in control and prevention of TB in prison. A number of studies revealed that prison is a place where *Mycobacterium* strains easily concentrated and disseminated. Studies have further identified prisons as possible sources of outbreaks in the general population (61;66-69). For example, a nine year retrospective epidemiological analysis of TB cases from Arkansas correctional facilities (USA) demonstrated a high proportion of clustered TB cases[2], a dominance of a single strain for more than 50% of cases, and patients from the community were infected by a strain that caused the largest cluster in the prison system (66). A study in Tennessee (USA) indicated a Mycobacteria strain that was responsible for an outbreak in the jail two years before was accountable for an outbreak in the surrounding community (67). Similarly, a study in a large Spanish city also reported the existence of common *Mycobacterium* strains that spread between imprisoned and urban population. HIV-positive injecting drug users (IDUs), with a record of previous or current imprisonment were responsible for dissemination of these common strains to the urban civilian population (68). Lengthy imprisonment and diagnostic delay for PTB were reported to cause active transmission of TB in the prison (69).

In Africa, there was only one published report from Madagascar. It also indicated a higher proportion of clustered cases among the prisoners than in the general population. It suggested a higher transmission rate of TB in the prison than in a non-prison population. It showed active circulation of strains between the prison and the outside (44).

All the above studies suggest that the absence of comprehensive and integrated TB control strategies in prisons could lead to an outbreak, both in the prison and surrounding community. Therefore, controlling TB in prisons should be a public health priority.

[2] A cluster is defined as ≥ 2 *M. tuberculosis* isolates exhibiting 100% identical IS*6110* restriction fragment length polymorphism (RFLP) or Spoligotyping patterns

1.5 Rationale of the study

European and North American countries are giving a considerable recognition and implementing control and prevention measures for TB in prisons (29;46). WHO/EURO prison health project, started in 1995, is one of the initiatives addressing and integrating health needs of prisoners. In addition, a number of scientific articles and reports are available that give guidelines for planning, implementing and monitoring prison TB programs at national and international level.

In Africa, only Malawi has published implementation of specific interventions for TB in prisons (70). The lack of specific and integrated interventions in prisons can make the settings to be amplification sites of TB, including MDR-TB, since a late case detection, inadequate treatment of infectious cases, release and recidivism without screening protocol, overcrowding, and poor ventilation are likely apparent characteristics of African prisons. However, information about epidemiology TB in prisons is very limited.

In Ethiopia, this is the first study on TB in prison. As to the TB control program in prison, there was a plan for establishing laboratory service, conducting screening survey and developing specific guidelines in 2008 (4), but none of them have been implemented yet.

Thus, this epidemiological study was conducted, in order to determine prevalence and associated risk factors for PTB in Eastern Ethiopian prisons. We expect that the results will facilitate decision making about how to screen TB, prevent further spread and provide appropriate prevention and control measures. It will have a substantial contribution for developing and implementing TB control program in prisons. This will give an opportunity to detect and manage those undiagnosed TB cases, and reduce potential sources of transmission for the prison and general population. Furthermore, it will persuade policy makers, program managers, and scientific communities to take necessary steps and measures for the well being of prison and general population at large.

1.6 Research questions

- What is the prevalence of PTB among the prison population in Eastern Ethiopia?
- What factors are associated with PTB infection in the prison population of Eastern Ethiopia?

1.7 Objectives

1.7.1 General objective

- To determine prevalence and associated risk factors of PTB in the Eastern Ethiopian prisons for the purpose of improving TB control and prevention programmes.

1.7.2 Specific objectives

- To determine a point prevalence of smear- or culture-positive PTB in three Eastern Ethiopian prisons.
- To describe socio-demography, prison and morbidity factors that may be associated risk factors for PTB in three Eastern Ethiopian prisons.
- To assess the level of biomedical knowledge of TB and associated factors in three Eastern Ethiopian prisons.
- To provide health and prison authorities with baseline information that could be used for appropriate actions.

2 CHAPTER II. METHDOLOGIES

2.1 Study area and population

The study area is located at about 500-600 km far from the capital city, Addis Ababa and in the eastern part of Ethiopia. Eastern Ethiopia is constituted of two national regional states (Harari and Somali Regional States), one city administration (Dire Dawa) and one zonal administration (Eastern Hararge Zone, Oromia National Regional State). The regional states share boundaries with the Oromia Regional State in the west, Afar Regional State in the northeast, with Kenya in the south, with Somalia in the east and south east, and with Djibouti in the northwest (see figure 2). Demography and health profile of these regions are summarized in Table 5 (2;6).

Table 5 Demography and health profile of the Eastern Ethiopian region in 2006/07

Indicator*	Dire Dawa city administration	Hararie Region	Somali Region	Eastern Hararghe zone**
Total population	383,529	189,550	4,218,297	1,736,122
Urban population	283,811	95,684	1,265,489	98691
Rural population	99,718	93,866	2,952,808	1,736,122
Potential Health Coverage (%)	95	145	42	46
IMR per 1000	71	66	57	76
U5MR per 1000	136	103	93	122
Male LE	54.1	56	58.7	53
Female LE	55.8	55	55.4	55.5
TB Case detection rate (%)	6.5	53	14	31.7
TB treatment success rate (%)	49	76	59	89
HIV Prevalence (%)	4.2	3.2	0.8	1.5

Source: Health and Health related indicator of 2006/07, and HISDP III

*Key: IMR-infant mortality rate, LE-life expectancy and U5MR-under five mortality rate

** Health Indicators represent Oromia regional state

In the Eastern Ethiopia, there are two regional, one federal and several small zonal and *woreda* level prisons (police stations). The two regional and one federal prison are found in the capital cities of the regional states. These are large prisons that could hold about 600-1200 prisoners. They receive mainly sentenced and some pre-trial prisoners from several surrounding woredas. So, we assumed that selecting the

regional and federal prisons might be representative for the prison population in the region. They are also located on the main road which facilitated transporting samples from the study area to Addis Ababa. The principal investigator had already established links with the regional health offices, which facilitated the implementation of the research project according to plan, and enabled us to get the required logistic support. Therefore, these reasons were considered to select the study area and prisons, i.e. Harar and Jijiga, and Dire Dawa prisons (see figure 2). Prisoners who were willing and eligible in these prisons during the study period (July-November, 2008) were considered as the study population.

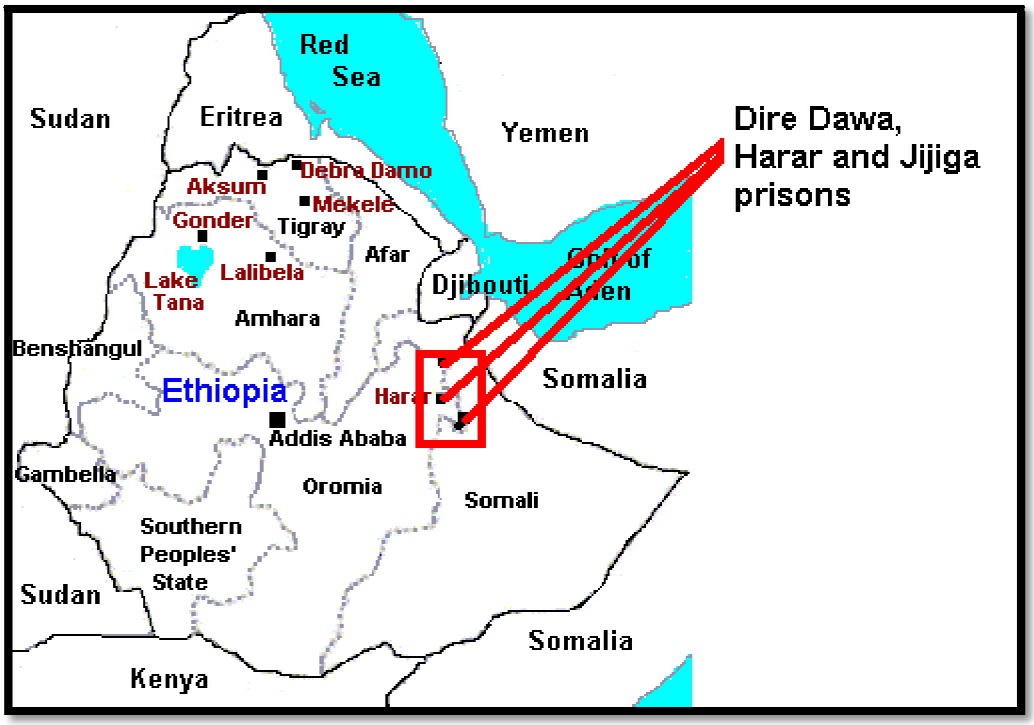


Figure 2 Map of Ethiopia, historical sites, administrative regions and study prisons[3]

[3] Source- http://www.ethiopiantreasures.toucansurf.com/pages/geography.htm

2.2 Study design

The study was cross-sectional with a quantitative approach. Information about exposure and disease was collected at one point in time. The information was used to estimate a point prevalence of PTB, identify factors associated with PTB infection and transmission, and possible associations were drawn to identify risk factors (predictors). However, the associations must be interpreted with caution, because of selection in or out of the study population, recall about the exposures and under or over reporting (71;72).

2.3 Sampling method

2.3.1 Sample size estimation

Due to the absence of published studies in the Ethiopian prisons, we assumed 4% prevalence of TB (p) from an African study (33), 95% CI (z=1.96), 0.85% margin of error (e) and 10% for compensating to incompleteness and unwillingness to participate. Total sample size was estimated 2245; it was the total eligible study population. We used the following formula for calculating the sample size (n) = $\{ [z^2 * p (1-p)]/e^2 \}$ (73).

2.3.2 Inclusion and exclusion criteria

2.3.2.1 Inclusion criteria

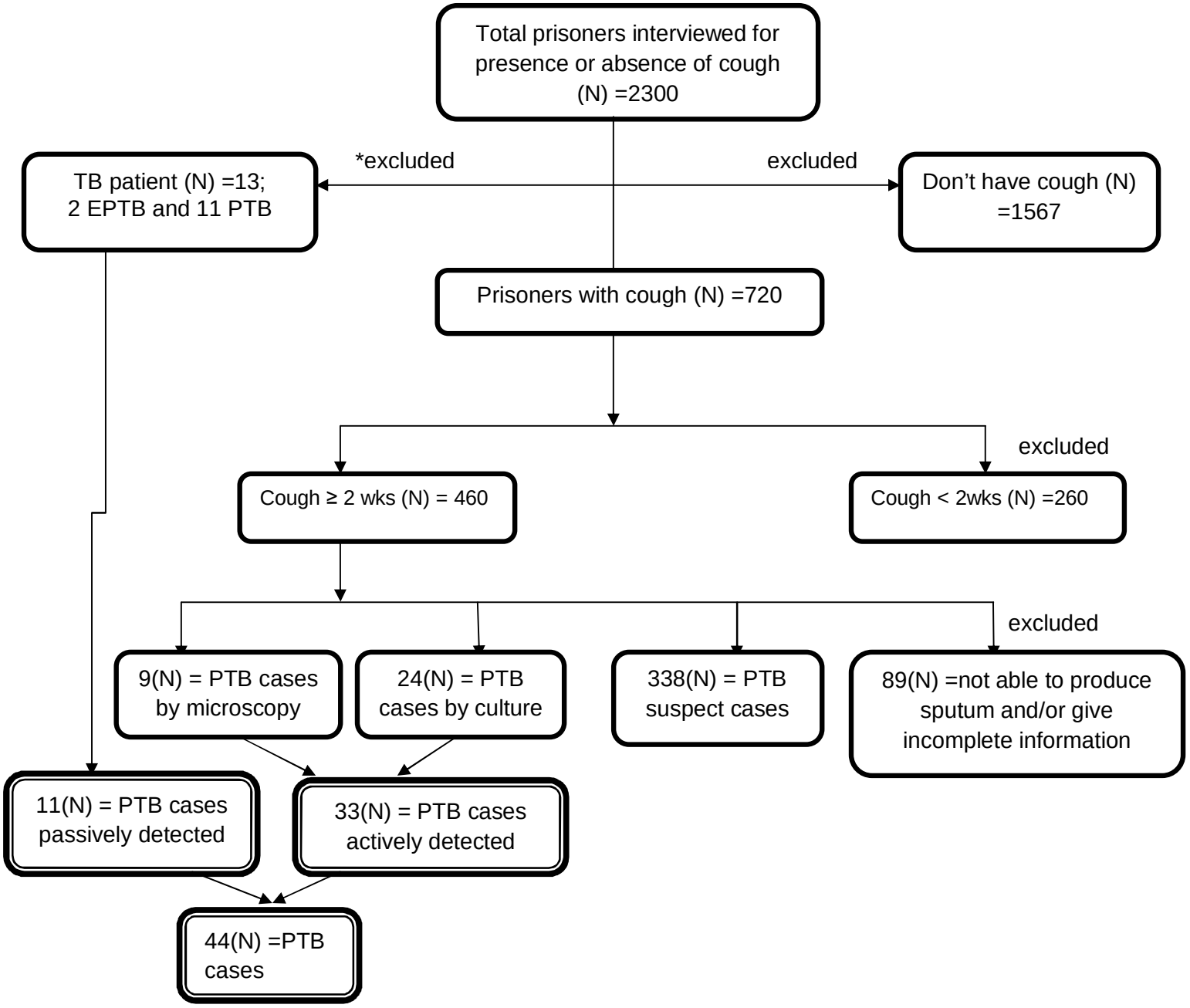
Prisoners who were mentally fit, willing to participate, above or equal to 15 years old and had ≥ 2 weeks duration of cough were included in the study. In addition, PTB patients, who were taking anti-TB treatment during the study, were included in the study.

2.3.2.2 Exclusion criteria

Prisoners, who had ≤ 2 weeks duration of cough, were unwilling to participate or EPTB patients were excluded. In addition, those prisoners who had ≥ 2 weeks duration of cough, but were unable to produce sputum and/or provided incomplete information were also excluded from the study.

2.3.3 Sampling procedure

During the study period, about 2300 persons were held in the three prisons. It was almost equivalent with the estimated sample size. So, we used a mass screening strategy to identify PTB suspects. This strategy provided an equal chance of selecting eligible individuals, and reduced a chance of losing PTB suspects. First, we made a complete registration of all prisoners who had just a cough. The registration was done by prisoners, who were health committee members. It was conducted through visiting cell to cell at day and night time. Secondly, all those who coughed were interviewed whether or not they fulfilled the inclusion criteria. Of the eligible 2300 prisoners, 720(31.3%) had a cough and 460(20%) fulfilled the inclusion criteria. Later, 89(3.9%) prisoners were excluded due to inability of producing sputum and/or were providing incomplete information. Finally, 382(16.6%) prisoners regarded as the study population; out of which, 44(11.5%) met the case definition of a PTB case, and 338(88.5%) of them remained as PTB suspects (see figure 3).



*TB patient who were taking anti-TB treatment during the study, were excluded from the screening, but PTB patients were included in the study population

Figure 3 Sampling and screening framework of PTB among prisoners in three Eastern Ethiopian prisons

2.4 Data collection

We used a structured questionnaire for collecting data from the study population (annex 7.3). The questionnaire had four parts; socio-demographic and behavioral information, prison history and condition, medical history and biomedical knowledge of TB. It had mainly closed type of questions that are commonly used in cross-sectional studies (71;72). The questionnaire was prepared in English and *Amharic* languages, and was translated to local languages; *Afan Oromo* and *Somali*. So, the participants were interviewed with their mother languages, accordingly. As a result, the knowledge of the local languages was considered for selecting data collectors. We provided them two day training on basic technique of interview. As a part of practical exercise, the questionnaire was also pre-tested among 30 prisoners (10 per prison). Then, we reviewed and added some questions after pre-testing the questionnaire.

2.5 Definition of variables

2.5.1 Dependent (out come) variables

- Two outcome variables were identified and these include, being a confirmed TB patient (PTB) or a suspected patient and high/low score in biomedical knowledge of a person about TB.
- A person is defined as TB patient (PTB) if the case is confirmed bacteriologically (Two positive sputum smears for AFB or culture-positive by smear) or a PTB patient on anti-TB treatment.
- PTB suspect a person with apparent sign of coughing (≥ 2 weeks of cough duration), but negative bacteriological tests (i.e. negative for sputum smears and culture).
- Low biomedical knowledge of TB refers to a person who scored below a mean value for biomedical knowledge of TB questions.
- While a person with high biomedical knowledge of TB had score equal or above a mean value for biomedical knowledge of TB questions.

2.5.2 Independent variables

The following variables were considered as independent variables and were used as explanatory variables to define the outcome variables.

Table 6 Definition and coding system of independent variables

Variable	Type	Level	Coding system and definition*	Remarks
Age	Continuous	2	1=15-44 , 2=45^{+}	Converted into categorical
Gender	Categorical	2	1= female, 2=male	
Marital status	Categorical	2	1=married, 2=non-married	
Education	Categorical	3	1=primary and above, 2= no read and write, 3=read and write	
Occupation	Categorical	2	1=employed, 2=unemployed	
Residence place	Categorical	2	1=rural, 2=urban	
Life style	Categorical	2	1=pastoralist, 2=non-pastoralist	
Smoking cigarette	Categorical	2	1=no, 2=yes	
Khat chewing	Categorical	2	1=no, 2=yes	
Prison facility	Categorical	3	1=C, 2=B, 3=A	Names of prison
Length of staying	Continuous	2	1= ≤ 2 year, 2=>2 year	Converted into categorical
Frequency of imprisonment	Continuous	2	1=once, 2= twice or more	Converted into categorical
Prior imprisonment in other prison	Categorical	2	1=no, 2=yes	
Sharing cell with TB patient	Categorical	2	1=no, 2=yes	
Sharing cell with coughing person‡	Categorical	2	1=no, 2=yes	
Prisoners per cell	Continuous	3	1=<50, 2= 51-100, 3=>100	Converted into categorical
Housing and ventilation status of cell**	Categorical	2	1=bad, 2=good	Based on scored mean value of six variables

Variable	Type	Level	Coding system and definition*	Remarks
Sharing food and drink materials	Categorical	2	1=no, 2=yes	
Food support from family	Categorical	2	1=no, 2=yes	
TB symptoms***	Categorical	2	1=no, 2=yes	
Cough duration	Continuous	2	1=2- 4 weeks, 2= >4 weeks	Converted into categorical
Visited and received treatment	Categorical	2	1=yes, 2=no	For TB symptoms
Where treatment received	Categorical	3	1=prison clinic, 2=prison and civilian clinics, 3=non-visitors	For TB symptoms
Frequency of visit	Continuous	3	1= 1-3 times, 2= above 3 and 3=non-visitors	Converted into categorical and for TB symptoms
TB symptoms before admission to prison	Categorical	2	1=no, 2=yes	
Identified co-morbidity	Categorical	3	1=no, 2=yes, 3=I don't know	
Hospital admission	Categorical	2	1=no, 2=yes	For any causes
Prior history of TB	Categorical	2	1=no, 2=yes	
Contact history with TB patient at home	Categorical	3	1=yes, 2=no, 3=I don't know	
Body mass index: kg/m^2	Continuous	2	1= <18.5, 2= ≥ 18.5	Converted into categorical

* re-grouping could be applied according to number of expected observation per cell (e.g. age as quartile factor)

** presence of window, window opening practice, frequency of spending outside of cell, floor type of cell, availability of sleeping material and place, and attitude towards cell and personal hygiene

***cough ≥ 2 weeks, chest pain, difficulty of breathing, fever, night sweat, loss of appetite and weight loss

‡ A chronic cough has duration of 2- 3 weeks or above.

2.6 Collection and handling of sputum specimen

A collection of specimen for identifying *Mycobacterium* was conducted during the study period. Sputum was the specimen of choice in the investigation of TB, because 85% of TB disease in high prevalence countries is pulmonary (12;13). It is possible to get positive or negative result of sputum analysis, due to TB lesion in the lung may drain intermittently. Therefore, three early morning sputum specimens were collected on three consecutive days using coded and clean plastic containers by laboratory personnel according to WHO (1998) guidelines on sputum collection procedure. The collected specimen was used for direct smear microscopy immediately and stored at 4 ^{0}C in refrigerator. Then, the three samples of each person was pooled in one container and transported using ice box on every third day of the sample collection to the culture laboratory, i.e. 500-600km far from the sample collection sites. Practically, the sputum was stored for 4-7 days in refrigerator at 4 ^{0}C prior to the culture (12;13).

2.7 Bacteriological analysis of specimen

2.7.1 Direct smear microscopy of the sputum

We used the common staining technique, carbon fuchsin (Ziehl-Neelsen) procedure for direct smear microscopy according to NTCP protocol (74). A positive result indicated the presence of AFB in the specimen. It was recorded in terms of the number of AFB per 100 fields. A negative result in this method indicated that no acid-fast bacilli had been seen in 100 fields. It did not exclude the diagnosis of TB as some patients harbor fewer tubercle bacilli that can not be detected by direct microscopy. A poor quality specimen may also produce negative results (13;74). In this study, all sputum specimens were stained and examined in the microscope (100 fields) by trained laboratory technicians. It was conducted at a regional TB laboratory with close collaboration with the prison health service and the regional TB control program.

2.7.2 Specimen culturing

The pooled sputum samples were subjected to digestion and decontamination procedure that liquefies the organic debris and eliminates the unwanted normal flora. We used sodium hydroxide (modified Petroff) method; as it is used widely in developing countries because of its relative simplicity and the fact that the reagents are easy to obtain. The definitive diagnosis of TB was made using culture on Löwenstein-Jensen (LJ) medium. Each sputum specimen was inoculated both on LJ glycerol and pyruvate based media. The culture media was incubated at 37^0 C up to 8 weeks and assessed weekly for growth of *Mycobacterium*. For confirming the growth of *M.tuberculosis*, morphology examination and culture smear were applied (12). The work was carried out in collaboration with TB laboratory, Aklilu Lemma Institute of Pathobiology (ALIPB), Ethiopia.

2.8 Data management and analysis

2.8.1 Data management

All collected data from questionnaire and laboratory analysis was checked before entry to a database. Then, the data was entered in to a computer using EpiData version 3.1 software (Lauritsen JM & Bruus M, The EpiData Association, Odense Denmark, 2003-2004). The database was created based on data type and size, categories, validating permitted values and ranges, and codes to missing value. After entry on this database, we conducted visual checks of data lists that could able us to observe errors and illogical values. The data was verified using distribution and frequency checks to look into the range of values, identify missing data or possibly miscoded data and any skewness in each observation. Prisons names were coded using alphabet A, B and C for ethical issue. Finally, the data was exported for analysis.

2.8.2 Data analysis

The data was exported to STATA version 10 statistical software for analysis (StataCorp LP, 2007, College Station, Texas 77845 USA). Continuous variables were categorized, rearranged and recoded, in order to get adequate number of observation for analysis. Response to person's biomedical knowledge about TB was graded as 1 for correct response and 0 for incorrect. Then, we dichotomized into above and below a mean value, after checking for normal distribution. Likewise, housing and ventilation status of a cell was labeled as 'good', and 'bad'.

Descriptive statistics such as proportion, mean ± standard deviation (SD), median and inter-quartiles range (IQR) were used to describe the variables. Distribution of categories of outcome variables within categories of independent explanatory variables was assessed using Pearson chi square(X^2) test. Fisher exact test was used if any of a cell in 2x2 table had expected cell count < 5. T-test, Mann-Whitney U and Non-parametric (NP) X^2 tests were used for comparing proportion and mean of groups, accordingly. In all the tests differences were considered as significant if P-value (P) ≤ 0.05.

Univariate association (unconditional) between individual exposure variables and response variable was assessed using simple binary logistic regression, where the strength of association was evaluated using odds ratio (OR), with the corresponding 95% confidence interval (CI) as parameter estimate. If OR is ≥ 2 with the corresponding P-value (≤ 0.05), then the variable was regarded as having association with outcome variable.

We used multivariate logistic regression model strategy to identify risk factors (significant predictors) of PTB and biomedical knowledge of TB. Each candidate variable was analyzed using simple logistic regression model and likelihood ratio test (LR). Age (i.e. quartile variable) was used as the main effect variable for the PTB risk factors model, as each variable was adjusted in the simple logistic regression model. Then, selection of variables for inclusion in the final multivariate regression model was based on our knowledge of their biological relevance to the response variable as well as

on results of statistical tests. Combination of the following criteria was used to select the candidate variables:

- Minimum about 10 observation in each cell
- P-value ≤ 0.25 from LR test or ≥ 4% difference of log likelihood compared to the null model
- Collinearity coefficient of variables less than 0.60 was considered as an acceptable value
- Their biologic relevance to PTB

The candidate variables with P-value ≤ 0.05 were directly selected for inclusion in the model. Further consideration of potential variables with P-value 0.25≤P>0.05 were based upon results of deviance test that compares the likelihood ratios of full model (model containing all the variables) with restricted model (with variable tested was held back). Similarly, a P-value ≤ 0.05 was a cut-of-point for considering variables for inclusion in the model. A final multivariate logistic regression model was built using forward selection procedure. Fit of the model to the observed data was assessed using three-step procedure. First, overall fit of the model was assessed by comparing the variation in intercepts of full model (model containing all the variables) vs. null model (a model with out variable). A model with high value of overall LR X^2 test along with significant P-value shows the usefulness of the variables as a group in describing the outcome variable. Second: fit of the model to individual explanatory variables was assessed using Hosmer-Lemeshow goodness-of-fit-test (by default approach of grouping the observations into 10 categories).Third: the ability of the model to correctly predict outcome variable was assessed by computing test property statistics (sensitivity, specificity, negative predictive value (NPV) and positive predictive value(PPV) and graphically by receiver operating characteristics curve (ROC) (75;76).

2.9 Quality assurance methods

2.9.1 Data quality assurance

Data quality was maintained using following strategies:

- Using translated questionnaire from English to *Amharic*, *Afan Oromo* and *Somali* languages and then back translated to English
- Pre-testing of the questionnaire
- Providing training for research assistants
- Regular checking filled questionnaire for completeness and appropriateness
- Extensive supervision during data collection
- Using a well designed database for data entry

2.9.2 Direct microscopy (AFS) quality assurance

We followed a national guideline for direct smear microscopy procedure (74), and used following methods:

- Using recommended sputum collection, handling and processing procedure
- Using newly prepared and pre-tested reagents
- Checking performance of microscopy using control slide
- All positive and negative smear slides were read blindly by at least two trained laboratory technicians

2.9.3 Culture quality assurance

We followed WHO recommendation (12), and following methods were used for quality control:

- Sputum was properly stored (at 4^0C) and transported using an ice box
- Media was freshly prepared and checked before use
- Guidelines for decontamination, digestion and culture were strictly followed
- Incubator temperature (37^0C) regularly checked
- Weekly monitoring for growth

2.10 Ethical clearance and Project management

The first task of the study was getting ethical clearance, most notably the study subjects are among vulnerable groups that demands an approval of all regulatory and collaborating institutions. As a result, we applied for and got the approval from the Regional Committee for Medical Research Ethics in Southern Norway, ALIPB, Armauer Hansen Research Institute, and National Ethical Committee for Health Research, Ethiopia (annex 7.4-7.5). In the mean time (before we got the final ethical clearance letter), the principal investigator travelled to the study area for establishing collaboration with prison authorities and health offices. They provided us with a letter of support that stated their willingness to provide the necessary support for the implementation of the research project. Then, we established a research team that had six members; the principal investigator, a local supervisor from ALIPB who is the project manager of a NUFU project[4], a TB expert from the regional health office, two persons from the prison administration and health service, and a senior laboratory technician from the regional TB laboratory center. The team was mainly involved on recruiting data collectors and laboratory technicians, managing logistics and administrative issues. We had regular discussion about the progress on subject recruitment, data collection and any other issues related to the project. The collaborative approach made a paramount contribution to implement the study according to the plan.

The second important task was establishing trust and responsibility with data collectors that could assure the quality of data. We provided two days training about the study protocol, and conducted practical exercise on pre-testing the questionnaire. We also assessed the flow of samples and logistics for the laboratory investigation. In addition, we gave the questionnaire to prison health staffs and managers for comments. The pre-testing phase made an important contribution, in order to revise the questionnaire and identify a convenient way for sputum collection.

[4] Studies of molecular epidemiology, clinical epidemiology and immunology of tuberculosis in pastoral communities and their livestock in Ethiopia(2007-2011)

The principal investigator was responsible for supervising and monitoring the day to day activity at the field sites. The local co-supervisor was responsible for handling and supervising sputum culture at the TB laboratory, ALIPB.

Each study participant was selected after we provided information about the study and obtained written consent (annex 7.1 and 7.2). Collected data and code of the participant was closely kept by the principal investigator. Newly diagnosed and available PTB cases were provided with anti-TB treatment by the prison health service and regional TB control program.

2.11 Communication of results

The Master thesis (manuscript) will be presented and defended at the Section for International Health, University of Oslo, Norway. The result will be published in international peer reviewed journals. Besides, it will be presented and submitted to FMOH, RHBs and prison authority in Ethiopia, and scientific meetings and conferences so as to lobby for reformulation of national TB control policy with the necessary attention given to prison settings.

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3 CHAPTER III. RESULTS

Major findings of the study are presented step by step as follows: baseline characteristics of the study participants, PTB associated factors (i.e. socio-demographic and behavioral factors, prison, and morbidity related factors), risk factors for PTB, prevalence of PTB, biomedical knowledge of TB, and retrospective record analysis.

3.1. Socio-demographic and behavioral factors

3.1.1 Baseline characteristics

Of the 382 study participants, 363(95%) and 299(78.3%) were male, and between 15-44 years of old, respectively. As shown in Figure 3, age distribution of the study population showed skewness to the right indicating the dominance of young and productive age group (15-49 years). The median value of age was 29 years (IQR = 21-40 years).

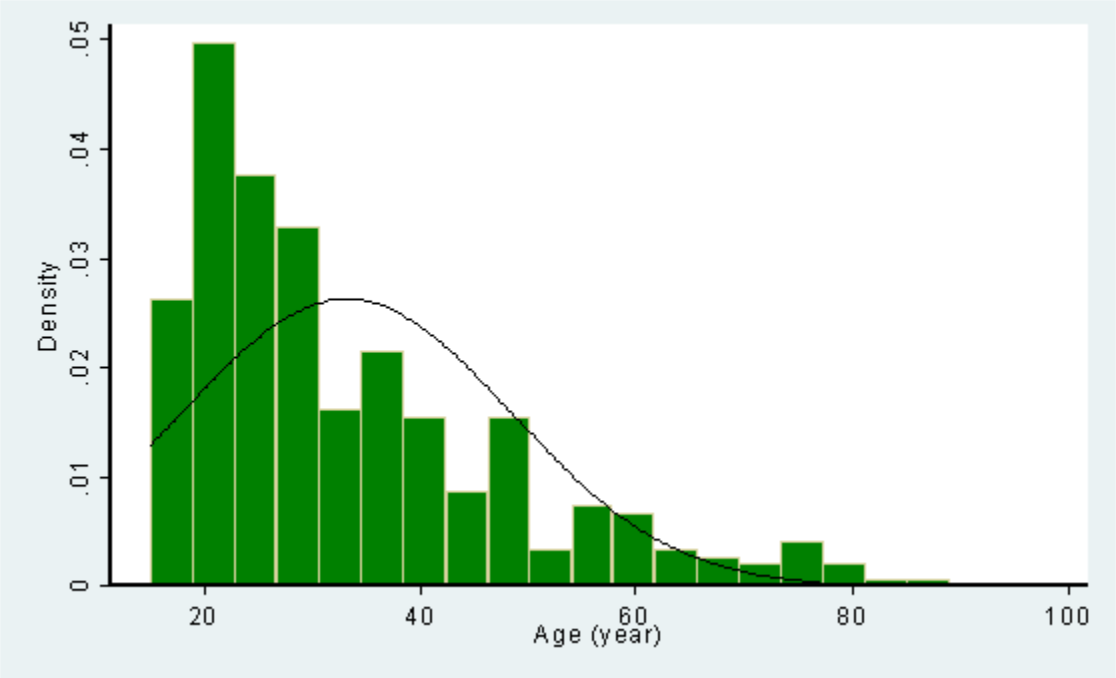


Figure 4 Age distribution of the study population

As to the marital status before imprisonment, 221(57.8%) and 147(38.5%) prisoners were married and single, respectively. The level of education indicated that 164(42.9%) of them were not able to read and write or illiterate, but 173(45.3%) of them have completed the primary or secondary school. Being a farmer was the leading occupation, i.e. 165(43.2%) of prisoners. Secondly, 123(32.2%) of them were employed privately; most of them were daily laborers that earn about 1 US$ per day. Fifty one (13.3%) prisoners were unemployed. Urban and rural residents were almost proportional, 56.8% urban vs. 43.2% rural. Majority of them, 325(85.1%), were non-pastoralist (i.e. settled and agro-pastoralist) and the rest, 57(14.9%) of them were pastoralist (see Table 7).

During the study, 180(47.1%) prisoners were smoking cigarette. The median duration of smoking was 6 years, respectively; half of them were smoking for the last six years. More than three fourth, 297(77.7%), were chewing *Khat* (*Catha edulis*, family *Celastraceae**[5]). The median duration of chewing was 9 years; half of them were chewing for the last nine years (see Table 7).

[5]Source - wikiepideia

Table 7 Socio-demographic and behavioral characteristics of the study population

Variables	Label	Frequency	Percent
Gender	male	363	95
	female	19	5
Age	15-24	141	36.9
	25-34	101	26.4
	35-44	57	15
	45+	83	21.7
Marital status before imprisonment	single	147	38.5
	married	221	57.8
	divorced, separated and widowed	14	3.7
Level of education	no read and write	164	42.9
	read and write	45	11.8
	primary	130	34
	secondary and above	43	11.3
Occupation before imprisonment	government	43	11.3
	farmer	165	43.2
	private(daily labourer)	123	32.2
	unemployed	51	13.3
Residence place	rural	165	43.2
	urban	217	56.8
Life style before imprisonment	Pastoralist	57	14.9
	Non-pastoralist	325	85.1
Current cigarette smoking	yes	180	47.1
	no	202	52.9
Current chewing *khat*	yes	297	77.7
	no	85	22.3

3.1.2 Socio-demographic and behavioral factors

The proportion of PTB cases among 15-44 year of age group was higher than 45 and above year of age group; 13.4% vs. 4.8%, this was significantly associated with PTB [P=0.031 and OR=3]. The mean age of PTB cases (28.7 ± 8.2) was lower than those suspects (33.7 ± 15.8), but this mean difference was not statistically significant [Mann-Whitney U test, P=0.332]. Two third of PTB cases were jailed from urban areas that was significantly associated with PTB [P=0.010 and OR=2.5] (see Table 8).

Table 8 Univariate analysis of the association between PTB and socio-demographic and behavioral factors among the prison population in the Eastern Ethiopia

Variables	Label	PTB Suspect N (%)	PTB Cases N (%)	OR(95%CI)	P-value
Gender	female	15[79]	4[21]	1.0	0.255*
	male	323[89]	40[11]	0.5[0.1, 1.5]	
Age category	45+	79[95.2]	4[4.8]	1.0	0.031**
	15-44	259[86.6]	40[13.4]	3 [1.1 ,8.8]	
Marital status before imprisonment	married	196[88.7]	25[11.3]	1.0	0.882
	non-married	142[88.2]	19[11.8]	1[0.5, 1.9]	
Level of Education	primary and above	155[89.6]	18[10.4]	1.0	0.165
	no read and write	147[89.6]	17[10.4]	1[0.5, 2]	
	read and write	36[80]	9[20]	2[0.9, 5.2]	
Occupation before imprisonment	employed	292[89.2]	39[11.8]	1.0	0.680
	unemployed	46[90.2]	5[9.8]	0.8[0.3, 2.2]	
Residence place	rural	154[93.3]	11[6.7]	1.0	0.010**
	urban	184[84.8]	33[15.2]	2.5[1.2, 5.1]	
Life style before imprisonment	pastoralist	52[91.2]	5[8.8]	1.0	0.481
	non-pastoralist	286[88]	39(34)	1.4[0.5, 3.7]	
Current cigarette smoking	no	180[89]	22[11]	1.0	0.684
	yes	158[87.8]	22[12.2]	1[0.6, 2.1]	
Current chewing *khat*	no	71[83.5]	14[16.5]	1.0	0.105
	yes	267[90]	30[10]	1[0.3, 1]	

*Fisher exact test, ** P≤ 0.05(significant level)

3.2 Prison related factors

3.2.1 Baseline characteristics

The average number of prisoners in the three prisons was about 2300 during the study period; 1100 in A, 600 in B and 700 in C prisons. Of the 382 study participants, 165 were from prison A that constituted 15% of the total prisoners, 103 from B that constituted 17.2% of the total prisoners, and 114 from C that constituted 16.3% of the total prisoners. The proportion of the screened prisoners per total number of prisoners per prison did not have a significant difference [NP X^2 =1.5, df = 2 and P=0.47]. Moreover, Figure 5 illustrated a proportion of the study population at each prison.

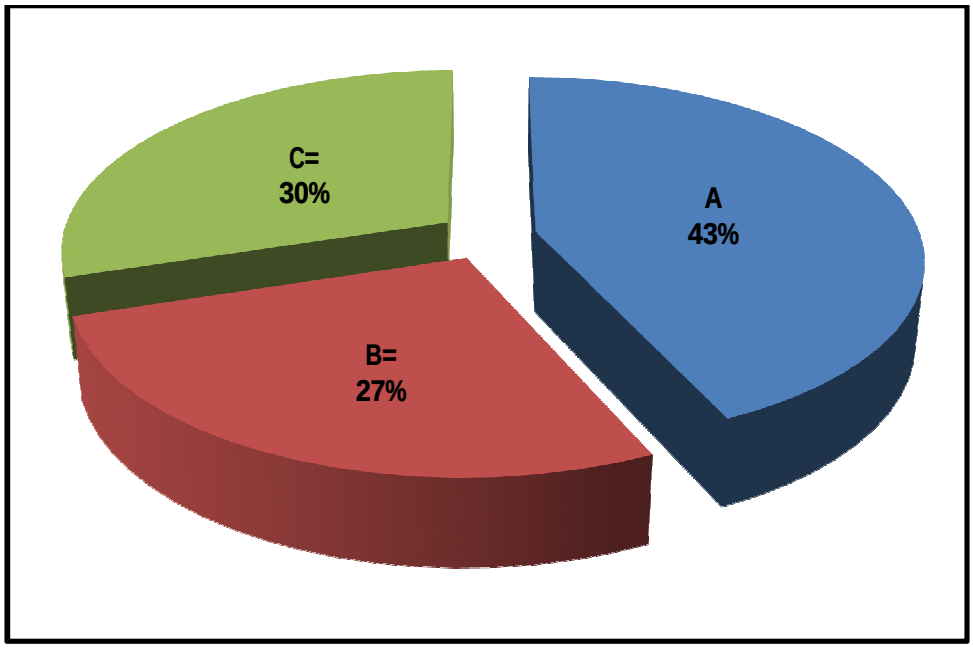


Figure 5 Proportion of the study population in each prison

As to the duration of staying in custody, 326(85.3%) prisoners stayed for ≤ 2 year in the current prisons. The median duration of staying was 7.5 months (IQR= 3 - 24 months). The majority of them, 328(85.9%), were imprisoned for the first time, while 54 (14.1%) prisoners had been incarcerated two or more times. In addition, 65(17%) of them had a history of imprisonment in another prison. Nevertheless, most of the prisoners were

jailed for one up to three months in police stations during a pre-trial period. They were usually transferred when they got sentence and some of them even during the pre-trial.

One hundred nineteen (31.2%) prisoners reported of sharing a cell with a TB patient. The median duration of sharing was 3 months (IQR = 2 - 8 months). Also, 136(35.6%) of them were sharing a cell with a chronically coughing person. The median duration of sharing was 3 months (IQR = 2 - 6.5 months). Besides, 163(42.7%) of them were sharing eating and drinking materials, such as cups, plastic bottles, and plates. Sixty (15.7%) prisoners were only getting food from their respective families, at least once per week (see Table 9).

Table 9 Prison related characteristics of the study population

Variables	**Label**	**Frequency**	**Percent**
Length of staying in year	≤ 2	326	85.3
	> 2	56	14.7
Frequency of imprisonment	once	328	85.9
	twice or more	54	14.1
Previous imprisonment in other prison	yes	65	17
	no	317	83
Sharing cell with TB patient	yes	119	31.2
	no	263	68.8
Sharing cell with chronically coughing person	yes	136	35.6
	no	246	64.4
Sharing food and drink materials	yes	163	42.7
	no	219	57.3
Food support from family	yes	60	15.7
	no	322	84.3
Number of prisoners per cell	≤ 50	158	41.4
	51-100	99	25.9
	>100	125	32.7

Figure 6 illustrated density of prisoners per cell, which demonstrates a wide range of distribution, i.e. IQR = 27-107 prisoners per cell. The median number of prisoners per cell was 65. The space used for sleeping was ranging from 0.7 to 1 meter square (m^2). One hundred twenty five (32.7%) of them were in a cell that had ≥ 100 prisoners, and 158(41.4%) of them were in a cell that had ≤ 50 prisoners (see Table 9).

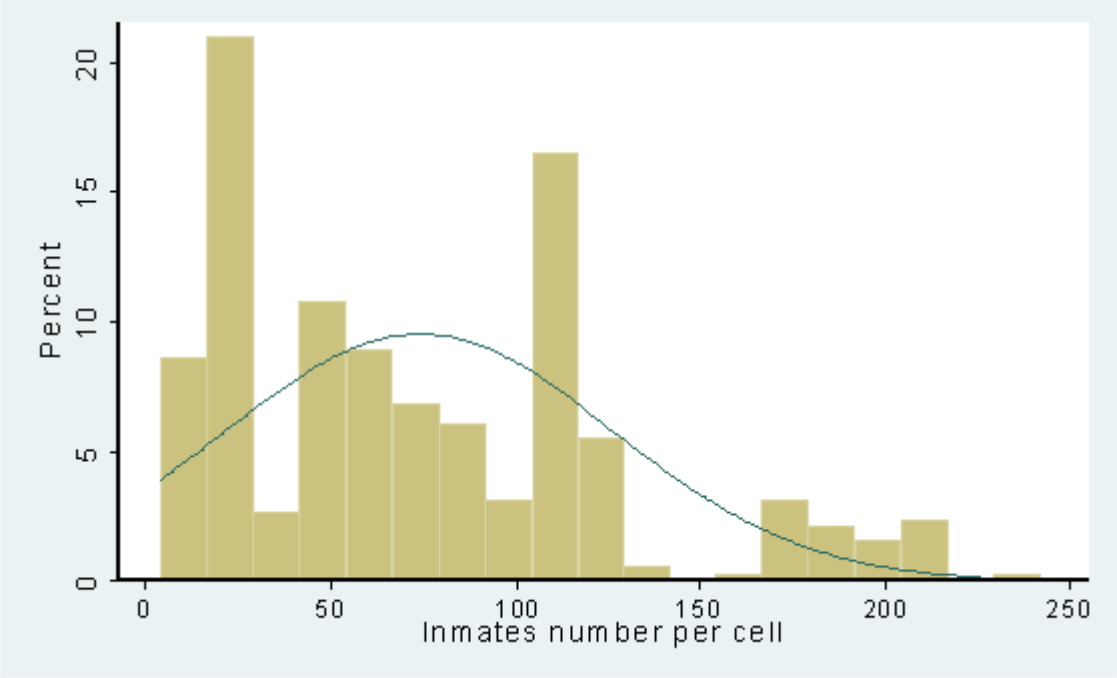


Figure 6 Distribution of prisoners per cell in the Eastern Ethiopian prisons

Most of the study population, 348(91.1%), were in a cell that had window. But, 34(8.9%) of them were in a cell without any window. Most of them were always opening the window during day time. There was a permission to be outside of a cell starting from 7:30am till 17:00pm every day, although 173(45.3%) of them were spending less time outside of their cells, and 189(49.5%) of them usually stayed outside of their cells. Mattress were supplied for the most of prisoners in B and C, but cloth, bed sheet and blanket were not provided; 260(68.1%) of them had only mattress. Sixty nine (18.1%) of them did not have their own sleeping place and materials. The administration in prison A provided bed, mattress, and blanket for the female prisoners (see Table 10).

Two hundred seventy eight (72.8%) prisoners were in a cell with unpaved floor (i.e. soil or stone covered). As to their attitude about personal and cell hygiene status, 288(75.4%) and 53(13.9%) of them felt good and bad, respectively (see table 10). All cells in prison A and C did not have toilet. So, prisoners were using bucket and other containers at night, and common toilets and showers during the day.

Table 10 Housing and ventilation conditions of cells in three Eastern Ethiopian prisons

Variables	**Label**	**Frequency**	**Percent**
Presence of window in cell	yes	348	91.1
	no	34	8.9
Window opening practice	never	35	9.2
	sometimes	19	5
	always	328	85.8
Spending out side of a cell per day	Very less time	20	5.2
	Less time	173	45.3
	Usually	189	49.5
Own sleeping place and cloth	yes	313	81.9
	no	69	18.1
Sleeping place	carpet on floor	117	30.6
	mattress on floor	260	68.1
	bed	5	1.3
Type of floor	unpaved floor	278	72.8
	paved floor	104	27.2
attitude towards personal and cell hygiene	bad	53	13.9
	good	288	75.4
	very good	41	10.7

3.2.2 Prison associated factors

The prevalence of PTB among the study population was 12.7%, 8.7% and 12.3% in prison A, B and C, respectively. This difference was not statistically significant [P=0.582] (see Table 11).

Frequency of imprisonment was significantly associated with PTB [P=0.008 and OR=2.6], with higher prevalence recorded among those who had two or more times imprisonment than those who were in prison once (22.2% vs. 9.8%). Sharing a cell with a TB patient [P=0.029 and OR=2] or a chronically coughing person [P=0.034 and OR=2] had a significant association with PTB. At the same time, the mean duration of sharing with a TB patient among PTB cases [10.4 ± 8 months] was higher as compared to suspects [5.1 ± 4.9 months]. This difference was statistically significant [Mann-Whitney U test, P=0.005] (see Table 11).

Factors that determine housing and ventilation condition of cells, such as presence of window [fisher exact test, P=0.782]; window opening practice [fisher exact test, P=0.076]; frequency of spending outside of a cell [fisher exact test, P=0.332]; own sleeping materials and place [P=0.204] and type of floor in a cell [P=0.724] were not significantly associated with PTB.

Table 11 Univariate analysis of the association between PTB and prison factors among the study population in the Eastern Ethiopian prisons

Variables	Label	PTB Suspect N (%)	PTB Cases N (%)	OR(95% CI)	P-value
Prison setting	C	100[87.7]	14[12.3]	1.0	0.582
	B	94[91.3]	9[8.7]	0.7[0.3, 1.6]	
	A	144[87.3]	21[12.7]	1[0.5, 2]	
Length of staying	≤ 2 year	286[87.7]	40[12.3]	1.0	0.267
	> 2 year	52[92.9]	4[7.1]	0.5[0.2, 1.6]	
Frequency of imprisonment	once	296[90.2]	32[9.8]	1.0	0.008**
	twice or more	42[77.8]	12[22.2]	2.6[1.3, 5.5]	
Previous imprisonment in other prison	no	282[89]	35[11]	1.0	0.519
	yes	56[86.2]	9[13.8]	1.3[0.6, 2.8]	
Sharing cell with TB patient	no	239[91]	24[9]	1.0	0.029**
	yes	99[83.2]	20[16.8]	2[1.1, 3.8]	
Sharing cell with chronically coughing person	no	224[91]	22[9]	1.0	0.034**
	yes	114[83.8]	22[16.2]	2[1, 3.7]	
Number of prisoners per cell	≤ 50	139[88]	19[12]	1.0	0.666
	51-100	90[91]	9[9]	1.4[0.5, 3.9]	
	>100	109[87.2]	16[12.8]	2.1[0.9. 4.9]	
Housing and ventilation status of cell	bad	190[86.8]	29[13.2]	1.0	0.221
	good	148[90.8]	15[9.2]	0.7[0.3, 1.3]	
Sharing food and drink materials	no	188[85.8]	31[14.2]	1.0	0.061
	yes	150[92]	13[8]	0.5[0.3, 1]	
Food support from family	yes	57[95]	3[5]	1.0	0.085
	no	281[87.3]	41[12.7]	2.8[0.8,9.2]	

** P≤ 0.05(significant level)

To find epidemiological link between present and prior TB infections (diagnosed prior to the study), we traced the present PTB patients in their cells. Fifteen (34.6%) newly diagnosed PTB cases were sharing a cell with a prisoner who had a history of TB (i.e. on anti-TB treatment, defaulter and treatment completed); out of which, 11(73.3%) were sharing with those on anti-TB treatment and defaulters (see Table 12).

Table 12 Epidemiological link between present and prior TB infections among the prison population in the Eastern Ethiopian prisons

Prison	Cell Code	Number of prisoners/cell	PTB cases†=N		PTB on treatment ‡=N		PTB suspect with history of PTB*=N	
			Past history of TB		Past history of TB			
			yes	No	yes	No	TC	D
C	a	105		2		3	2	
	b	108		1	1(R)		1	
	c	21		1			2	1
B	a	70	1(D)				3	2
	b	65	1(D)	3			5	
	c	70		1			1	
A	a	94		2			2	
	b**	5	1(TC)		1(D)	3		
	c	88		1			1	
	d	118	2(TC)	1		1		
	e	125		1			1	1
	f	110		1			1	1
	f	105	1(D)	1			1	1
Total=N			6	15	2	7	20	6

D-default, TC-treatment completed and R-relapse after treatment

† PTB cases diagnosed in this study completed

‡ PTB cases on anti-TB treatment and indentified passively by prison health service

* PTB suspects that had past history of TB (treatment completed or defaulter) but they were negative in this study

** A separation cell for smear-positive TB patient

3.3 Morbidity related factors

3.3.1 Baseline characteristics

As shown in Figure 7, chest pain was the leading TB symptom among PTB suspects as well as PTB cases (68% vs. 84%). Then, night sweat (49% vs. 57%) and shortness of breath (45% vs. 34%) were also commonly identified in that order.

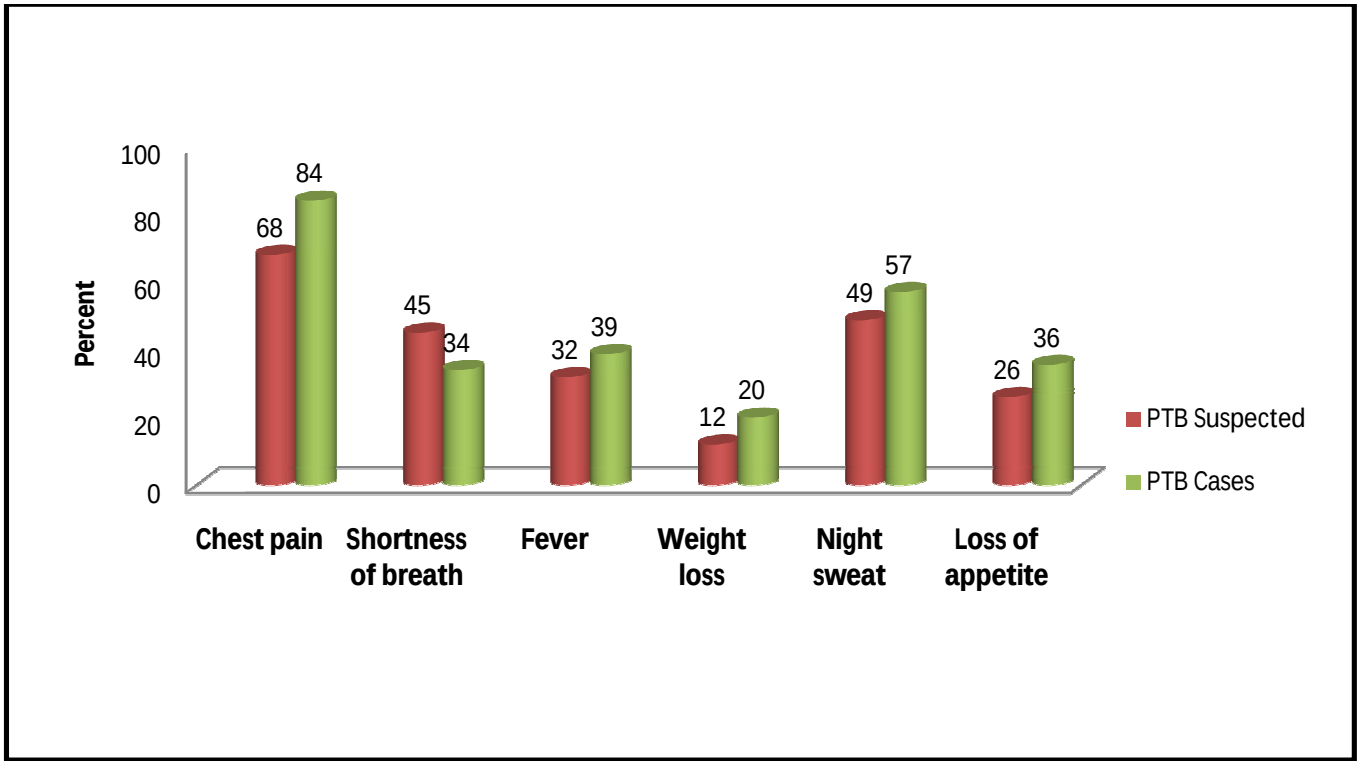


Figure 7 Proportion of TB symptoms among the study population

In this study, 294(77%) and 88(23%) study participants had 2 - 4 weeks and > 4 weeks of cough, respectively. The mean duration of cough was 34 ± 27 days prior to visiting and receiving a treatment. The median and IQR was 30 and 21-30 days, respectively. Two hundred eighty six (74.9%) prisoners visited health institutions and received treatment for TB symptoms. Fifty six (14.7%) of them visited and got a treatment from both prison and civilian clinics, and 230(60.2%) only visited prison clinics. Moreover, 184(48.2%) and 102(26.7%) of them had 1-3 times and > 3 times visit to clinics because of TB symptoms, respectively. The mean number of visit was 3.5 ± 2.4. On the other hand, 96(25.1%) prisoners did not visit and receive a treatment, even if they had TB symptoms. Their main reasons were being negligent and not able to get

the service. One hundred seven (28%) prisoners were admitted to the prison with TB symptoms; out of which, 39(36.8%) of them did not visit and receive a treatment during a pre-and post-imprisonment period. Twenty six (6.8%) prisoners reported for having identified co-morbidities; hypertension (N=9), HIV/AIDS (N=6) and asthma (N=5) were mainly recognized. Seventy (18.3%) of them had a history of admission to hospitals for any causes. As to their history of contact with a TB patient before imprisonment, 113(29.6%) of them replied for having contact, and 188(49.2%) did not have contact. Eighty one (21.2%) of them did not know whether they had or not. As to the BMI level, 186(48.7%) of them were below 18.5 kg/m^2, and 196(51.3%) of them were above or equal to 18.5 kg/m^2 (see Table 13).

Table 13 Morbidity related characteristics of the study population in the Eastern Ethiopian prisons

Variables	**Label**	**Frequency**	**Percent**
Duration of cough in week	2-4	294	77
	>4	88	23
Visited and received treatment for TB symptoms	yes	288	75.4
	no	94	24.6
Where treatment received	prison clinic	230	60.2
	prison and civilian clinic	56	14.7
	non-visitors	96	25.1
Frequency of visit	1-3	184	48.2
	> 3	102	26.7
	non-visitors	96	25.1
Having TB symptoms during admission	yes	107	28
	no	275	72
Having recognizable co-morbidity	yes	26	6.8
	no	296	77.5
	I don't know	60	15.7
History of admission to hospital for any causes	yes	70	18.3
	no	312	81.7
Contact with TB patient before imprisonment	yes	113	29.6
	no	188	49.2
	I don't know	81	21.2
BMI(kg/m^2)	< 18.5	186	48.7
	≥ 18.5	196	51.3

3.3.2 Morbidity associated factors

In the present study, chest pain was the only TB symptom that showed a significant association with PTB [P=0.027, and OR=2.5]. Cough duration was significantly associated with PTB [P=0.026 and OR=2.1], with higher prevalence documented among those who had more than four week's duration of cough than those who had 2-4 weeks (18.2% vs. 9.5%). As to the place of visit and treatment for TB symptoms, the proportion of PTB among those who visited both (prison and civilian clinic) was higher than those who did not visit; 28.6% vs. 6.2%. It was significantly associated with PTB [P<0.001 and OR=6]. Similarly, the frequency of visit to clinics for TB symptoms showed a significant association with PTB [P=0.040], with higher prevalence recorded among those who visited more than three times as compared to non-visitors; 17.6% vs. 6.2% [OR=3.2] (see Table 14).

Table 14 Univariate analysis of the association between PTB and morbidity factors among the study population in the Eastern Ethiopia

Variables	Label	PTB Suspect N (%)	PTB Cases N (%)	OR(95% CI)	P-value
Chest pain	no	109[94]	7[6]	1.0	0.027**
	yes	229[86.1]	37[13.9]	2.5[1.1, 5.8]	
Shortness of breath	no	185[86.4]	29[13.6]	1.0	0.160
	yes	153[91]	15[9]	0.6[0.3, 1.2]	
Fever	no	231[89.5]	27[10.5]	1.0	0.352
	yes	107[86.3]	17[13.7]	1.4[0.7, 2.6]	
Weight loss	no	297[89.5]	35[10.5]	1.0	0.124
	yes	41[82]	9[18]	1.8[0.8, 4.1]	
Night sweat	no	174[90.2]	19[9.8]	1.0	0.300
	yes	164[86.8]	25[13.2]	1.4[0.7, 2.6]	
Loss of appetite	no	250[89.9]	28[10.1]	1.0	0.148
	yes	88[84.6]	16[15.4]	1.6[0.8, 3.1]	
Duration of cough in week	2 - 4	266[90.5]	28[9.5]	1.0	0.026**
	> 4	72[81.8]	16[18.2]	2.1[1.1, 4.1]	
Visited and received treatment for TB symptoms	yes	248[86.7]	38[13.3]	1.0	0.062
	no	90[93.8]	6[6.2]	0.4[0.2, 1.1]	
Where treatment received	non-visitors	90[93.8]	6[6.2]	1.0	<0.001**
	prison clinic	208[90.4]	22[9.6]	1.6[0.6, 4.1]	
	prison and civilian clinic	40[71.4]	16[28.6]	6[2.1, 16.5]	
Frequency of visit	non-visitors	90[93.8]	6[6.2]	1.0	0.040**
	1- 3	164[89.1]	20[10.9]	1.8[0.7,4.7]	
	> 3	84[82.4]	18[17.6]	3.2[1.2, 8.5]	
Having TB symptoms during admission	no	247[89.8]	28[10.2]	1.0	0.190
	yes	91[85]	16[15]	1.5[0.8, 2.9]	
Having recognizable co-morbidity	yes	23[88.5]	3[11.5]	1.0	0.766*
	no	260[87.8]	36[12.2]	1.1[0.3, 3.7]	
	I don't know	55[91.7]	5[8.3]	0.7[0.1, 3.2]	
History of admission to hospital for any causes	no	276[88.5]	36[11.5]	1.0	0.979
	yes	62[88.6]	8[11.4]	1[0.4, 2.2]	
Contact with TB patient before imprisonment	yes	102[90.3]	11[9.7]	1.0	0.778
	no	165[87.8]	23[12.2]	1.3[0.6, 2.7]	
	I don't know	71[87.6]	10[12.4]	1.3[0.5, 3.2]	
Body mass index(kg/m^2)	< 18.5	163[87.6]	23[12.4]	1.0	0.613
	≥ 18.5	175[89.3]	21[10.7]	0.8[0.4, 1.6]	

*Fisher exact test ** P≤ 0.05(significant level)

3.4 Risk factors for pulmonary tuberculosis

3.4.1 Simple logistic regression analysis of candidate variables

Further assessment of fit of individual predictor variables to the model was carried out using Wald and LR tests and the results presented in Table 15. By taking 0.25 as a probability cut-of-point from LR-test, candidate variables were selected for multivariate analysis as follows: residence place, frequency of imprisonment, sharing a cell with a TB patient or a chronically coughing prisoner, sharing eating and drinking materials, food support, chest pain, cough duration, visiting and receiving a treatment for TB symptoms, place for receiving a treatment for TB symptoms, and frequency of visits to clinics. However, visiting and receiving a treatment [correlation coefficient=0.8] and place for receiving a treatment for TB symptoms [correlation coefficient=0.74] had both collinearity with frequency of visit for TB symptoms. Therefore, we dropped these two variables from the list of candidates.

Table 15 Fit of individual exposure variables to the model as evaluated by Wald and LR tests

		Likelihood ratio test		
Candidate Predictors	**Wald test(P-value)**	**LogL**	**-2logL**	**P value**
Null model		-136.46		
age **	0.602	-136.32	0.27	0.601
age + gender	0.225	-135.66	1.58	0.453
age + marriage	0.916	-136.31	0.28	0.868
age + education	0.163	-135.36	2.18	0.335
age+ occupation	0.544	-136.13	0.66	0.719
age + residence place	0.013	-132.88	7.16	0.028*
age + life style	0.478	-136.05	0.81	0.666
age+ smoking cigarette	0.692	-136.24	0.43	0.807
age + *khat* chewing	0.117	-135.16	2.60	0.273
age+ prison settings	0.827	-136.30	0.32	0.851
age+ length of staying	0.492	-136.08	0.75	0.688
age + frequency imprisonment	0.009	-133.21	6.50	0.039*
age+ previous imprisonment	0.506	-136.11	0.70	0.706
age+ sharing cell with TB patient	0.029	-134.01	4.89	0.087*
age +sharing cell with coughing person	0.034	-134.11	4.70	0.096*
age+ prisoners number/cell	0.989	-135.29	2.33	0.872
age+ housing and ventilation status	0.229	-135.58	1.76	0.414
age+ sharing materials	0.069	-134.56	3.79	0.150*
age+ food support	0.098	-134.55	3.82	0.148*
age+ chest pain	0.032	-133.61	5.70	0.058*
age + shortness of breath	0.155	-135.28	2.36	0.307
age+ fever	0.323	-135.84	1.23	0.541
age+ weight fever	0.121	-135.22	2.47	0.291
age+ night sweat	0.312	-135.80	1.30	0.521
age+ loss of appetite	0.162	-135.38	2.16	0.340
age+ cough duration	0.022	-133.86	5.19	0.075*
age+ treatment received	0.076	-134.48	3.96	0.138*
age+ place of treatment received	<0.001	-129.62	13.67	0.001*
age+ frequency of visit to clinics	0.011	-132.95	7.02	0.030*
age+ symptom during admission	0.167	-135.40	2.12	0.347
age+ identified co-morbidity	0.487	-136.08	0.76	0.684
age+ admission history	0.990	-136.32	0.27	0.872
age+ contact with TB patient	0.577	-136.17	0.58	0.747
age+ BMI	0.727	-136.2592	0.40	0.821

* Variables with p-value less 0.25, ** age as a quartile variable

3.4.2 Multivariate logistic regression analysis of pulmonary tuberculosis predictors

First, we developed a model with factors that had P-value ≤ 0.05, such as resident place, chest pain, frequency of imprisonment, and frequency of visits for TB symptoms. Age did not fulfill the criteria to be the candidate variable, but we added to the model because of its biologic importance [Log likelihood = -120.6, LR X^2 (8) =31.63 and P<0.001]. Secondly, other selected candidate variables were added one by one according to their order of P-value, as follows:

- Duration of cough: Log likelihood = -118.6, LR X^2 (1) =4.07 and P=0.044.
- Sharing a cell with a TB patient: Log likelihood=-116.81, LR X^2(1) =3.60 and P=0.056.
- Sharing a cell with a chronically coughing prisoner: Log likelihood = -111.18, LR X^2 (1) = 11.27 and P=0.001.

We dropped the following candidate variables, because of their non-significant contribution in the model:

- Sharing eating and drinking equipment: Log likelihood = -109.62, LR X^2 (1) =3.12 and P=0.078.
- Food support from family: Log likelihood = -109.95, LR X^2 (1) =2.46 and P=0.12.

Finally, we presented results of the final multivariate logistic regression model in Table 16.

Table 16 Final multivariate logistic regression model showing risk factors associated with PTB among the prison population in Eastern Ethiopia

Factors	AOR	P-value	95% CI	
Agequan2*	1.44	0.461	0.55	3.76
Agequan3	1.64	0.287	0.65	4.14
Agequan4	0.32	0.087	0.08	1.17
Urban resident	2.79	0.011**	1.26	6.17
Having chest pain	2.07	0.108	0.85	5.05
Twice or more imprisonment	2.09	0.088	0.89	4.87
1-3 times visit to clinic	2.05	0.165	0.74	5.67
More than 3 times visit to clinic	3.33	0.026**	1.15	9.60
More than 4 weeks duration of cough	2.69	0.015**	1.20	5.98
Sharing cell with TB patient	2.82	0.007**	1.33	6.00
Sharing cell with chronic coughing prisoner	3.61	0.001**	1.68	7.76

*age as a quartile variable, ** P≤ 0.05(significance level)

As can be seen from the above results, keeping all the other variables in the model constant, the risk of getting active tuberculosis was about three time more likely among those prisons coming from urban areas compared to those from rural settings (AOR=2.79, 95%CI=1.26-6.17). Likewise, the odds of being TB patients is higher among those who had repeated visits to the clinics for TB symptoms (AOR=3.33, 95%CI=1.15-9.60). The higher the duration of cough (> 4 weeks), the higher would be the risk of being TB patients (AOR=2.69, 95%CI=1.20-5.98). Sharing a cell with a known TB patient (AOR=2.82, 95%CI=1.33-6) or a person with chronic cough (AOR=3.61, 95%CI=1.68-7.76) was highly associated with acquisition of new TB cases.

3.4.3 Evaluation of multivariate logistic regression model

In this study, we assessed whether the logistic regression model fit in predicting PTB among the study population. It was done using summary measure of goodness-of-fits tests and predictive ability of the model.

The summaries of goodness-of-fit tests provide an overall assessment of how well factors in the model fit the observed data in predicting PTB among the study population. LR X^2 was strongly significant (X^2 = 50.56, df=11 and P< 0.001); suggesting that, the recorded factors as a group were important in explaining occurrence of PTB among the prison population in Eastern Ethiopia. Likewise, Hosmer-Lemeshow X^2 test (X^2 = 8, df=11.78 and P=0.161) ascertained fit of the model to the observed data. Insignificant P-value suggested that there was not as such a significant difference in observed and predicted PTB status in individual observation.

In Figure 9(a), the area under the ROC curve was about 0.80. It indicated that the model was reliable enough to reasonably predict PTB outcome in prison population in Eastern Ethiopia. Figure 9(b) illustrated the predictive ability of the model at possible probability cut-of-points. For instance, 0.1 appeared to provide a better estimation, as the sensitivity and specificity of the model were 75% and 73.08%, respectively. The PPV and NPV were 26.6% and 95.7%, respectively.

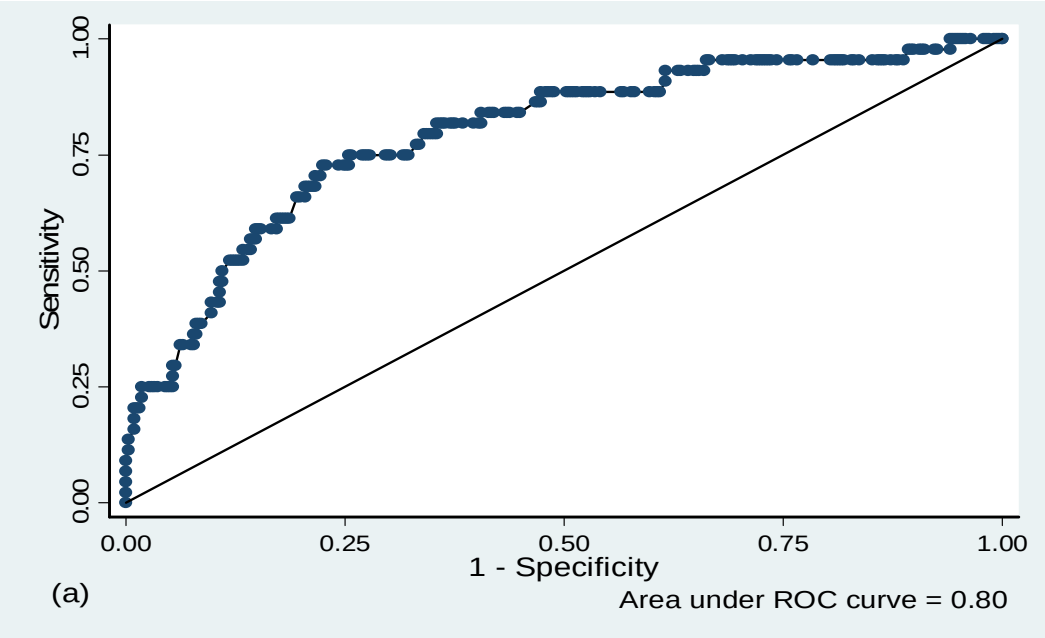


Figure 9(a). A ROC curve for logistic regression model of PTB predictors among the study population in the Eastern Ethiopian prisons

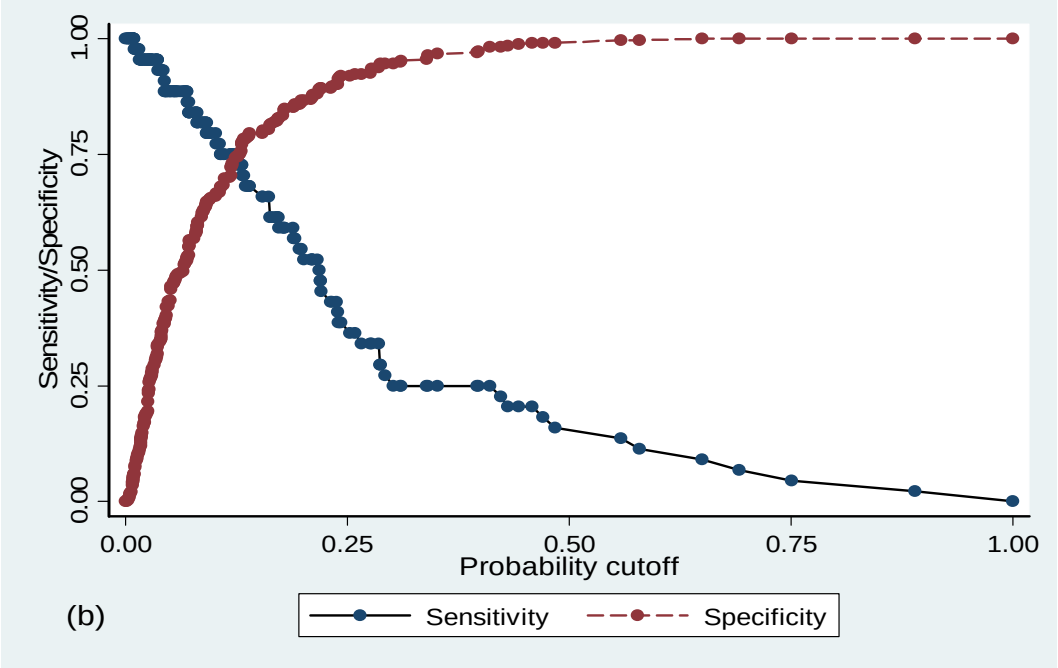


Figure 9(b). A two way-graph for logistic regression model of PTB predictors among the study population in the Eastern Ethiopian prison

3.5 Prevalence of pulmonary tuberculosis

In the present study, 62(16.2%) prisoners had a prior history of TB; out of which, 16(26%) were diagnosed after imprisonment in the current prisons, 39(63%) of them had already completed the treatment, and 13(21%) were receiving anti-TB treatments i.e. 2 Extra-pulmonary TB, 5 smear-positive and 6 smear-negative PTB patients that were detected passively through referral to civilian health institutions. Furthermore, 10(16%) of them were defaulters. The main reasons for defaulting were imprisonment (N=5), unaffordable transport cost, long distance from home (N=3) and lost treatment card (N=2). Of the 44 PTB cases, 8(18.2%) had prior history of TB, i.e. 4 defaulters, 3 completed treatment and 1 relapse after treatment completed (see Table 12).

Of the 371 actively screened prisoners, 33(8.9%) were smear- or culture-positive PTB cases (see figure 3). The prevalence of PTB, using the active case finding method, was 1.4% [95%CI=1.01-2.03]. However, using the passive case detection approach, the prevalence of TB was 0.56% [95%CI= 0.31-0.99]. We compared the prevalence of the two case detection approach, active vs. passive, the difference showed statistical variation [t-test, P=0.005]. The overall point prevalence of PTB was 1.9% [95%CI=1.41-2.58] or 1913/100,000 prison population [95%CI=1410-2580] (see Table 17).

Table 17 Summary of TB cases that identified in the Eastern Ethiopian prisons

Methods of case detection	Type of TB	Frequency[N]	Prevalence (%) [95% CI]
Passive case detection	EPTB	2	
	Smear negative PTB	6	
	Smear positive PTB	5	
	Total TB cases	13	0.56 [0.31, 0.99]
Active case detection	Smear positive PTB	9	
	Culture positive PTB	24	
	Total PTB cases	33	1.435 [1.01, 2.03]
	Total PTB cases	44	1.913 [1.41, 2.58]
	Total TB cases	46	2 [1.48, 2.68]
	Total prisoners	2300	

In this study, we used two laboratory methods for screening and diagnosing PTB i.e. direct smear microscopy and culture (LJ medium). Accordingly, the direct microscopy was only able to detect 9 PTB cases, and additional 24 cases were detected by culture (see figure 3). As a result, the sensitivity and specificity of direct smear microscopy were 27% and 99.2% respectively, and the PPV and NPV were 75% and 93.8%, respectively.

3.6 Biomedical knowledge of tuberculosis

3.6.1 Baseline characteristics

Analysis of baseline survey showed only 6(1.6%) prisoners knew and described causes of TB as being bacteria. "*Nefas*" or "*Bird*", local term for a cold and windy air mentioned as the cause in several occasion. Two hundred eighty three (74.9%) of them correctly described the mode of TB transmission as being breath from a coughing person. Two hundred thirty five (62.2%) prisoners responded that visiting health institutions was a priority decision for getting a treatment for TB, and the rest, mentioned traditional healers and some of them did not reply at all. Most of them, 348(92.1%), recognized TB as curable disease. One hundred eighty six (49.2%) of them did not know that anti-TB drugs are provided freely. Also, 319(84.4%) prisoners mentioned death and infecting others as a consequence of not getting treatment. Similarly, 292(77.2%) of them correctly explained the consequence of defaulting from the treatment as death, relapse of infection and inability to cure from the infection for long time. It was only 8(2%) prisoners who mentioned about drug resistance as a risk for defaulting from treatment. Almost half of them did not know about the risk of TB in the prison, but 192(50.8%) of them mentioned inadequate access to food and health service, overcrowding and acquiring TB infection. One hundred sixteen (30.7%) prisoners did not know any measures of TB prevention and control, compared to large proportion of them (262; 69.3%) who identified eating a balanced diet, getting better health care, and keep personal and environment hygiene as TB prevention measures (see Table 18).

Table 18 Biomedical knowledge of TB among the study population in the Eastern Ethiopian prisons

Questions	Correct =N (%)	Not correct = N (%)
Cause of TB	6(1.6)	372(98.4)
Mode of transmission of TB	283(74.9)	95(25.1)
Means of treatment for TB	235(62.2)	143(37.8)
Provision of free anti-TB drugs	192(50.8)	186(49.2)
Is TB curable	348(92.1)	30(7.9)
Consequence for not treated	319(84.4)	59(15.6)
Risk of TB inside prison	192(50.8)	186(49.2)
Consequence for defaulting treatment	292(77.2)	86(22.8)
How to prevent TB	262(69.3)	116(30.7)

3.6.2 Biomedical knowledge of tuberculosis associated factors

Using the mean value (i.e. 5.6 ± 2.2 points) as the cut-of-point, 155(40.6%) and 227(59.4%) study participants were categorized into low and high level of biomedical knowledge of TB, respectively. Based on this binary category, we conducted univariate analysis with socio-demographic, prison and morbidity related factors.

We found higher proportion of low knowledge among those who were not able to read and write or illiterate as compared to those who had formal education. This was significantly associated with the level of knowledge [P=0.002]. Pastoralists had higher proportion of low knowledge as compared to non-pastoralists, i.e. 66.7% vs. 36%; It had a significant association with the level of knowledge [P<0.001 and OR=3.6]. As to the prison facility, prisoners in B (34%) and C (73.8%) had higher proportion of low knowledge as compared to prison A (21.8%). This difference was significantly associated with the level of knowledge [P<0.001]. Prisoners who did not have past history of TB [P=0.001 and OR=2.9] and visit for TB symptoms [P<0.001 and OR=2.5] had a significant association with low level of knowledge (see Table 19).

Table 19 Univariate analysis of factors of importance for biomedical knowledge of TB among the study population in the Eastern Ethiopian prisons

Variables	Label	High =N (%)	Low =N(%)	OR(95% CI)	P-value
Gender	female	8[42.1]	11[57.9]	1.0	0.115
	male	219[60.3]	144[39.7]	0.5[0.2, 1.2]	
Age	45+	48[58.5]	34[41.5]	1.0	0.853
	15-44	179[59.7]	121[40.3]	0.9[0.6, 1.6]	
Occupation before imprisonment	government	28[65.1]	15[34.9]	1.0	0.576
	farmer	102[61.8]	63[38.2]	1.2[0.6, 2.3]	
	private(daily laborer)	68[55.3]	55[44.7]	1.5[0.7, 3.1]	
	unemployed	29[56.9]	22[43.1]	1.4[0.6, 3.3]	
Level of education	secondary and above	26[60.5]	17[39.5]	1.0	0.002*
	no read and write	80[48.8]	84[51.2]	1.6[0.8, 3.2]	
	read and write	32[71.1]	13[28.9]	0.6[0.3, 1.5]	
	primary(1-8)	89[68.5]	41[31.5]	0.7[0.3, 1.4]	
Residence place	urban	131[60.4]	86[39.6]	1.0	0.666
	rural	96[58.2]	69[41.8]	1.1[0.7, 1.6]	
Life style	non-pastoralist	208[64]	117[36]	1.0	<0.001*
	pastoralist	19[33.3]	38[66.7]	3.6[1.9, 6.4]	
Prison facility	A	129[78.2]	36[21.8]	1.0	<0.001*
	B	68[66]	35[34]	1.8[1.1, 3.2]	
	C	30[26.3]	84[73.8]	10[5.7, 17.5]	
Length of stay in prison	≤ 2 years	195[59.8]	131[40.2]	1.0	0.707
	> 2 years	32[57.1]	24[42.9]	1.1[0.6, 1.9]	
Sharing eating and drinking materials	yes	123[56.2]	96[43.8]	1.0	0.133
	no	104[63.8]	59[36.2]	0.7[0.5, 1.1]	
History of TB	yes	48[78.7]	13[21.3]	1.0	0.001*
	no	179[55.8]	142[44.2]	2.9[1.5, 5.6]	
Sharing cell with a` TB patient	yes	67[56.3]	52[43.7]	1.0	0.403
	no	160[60.8]	103[39.2]	0.8[0.5, 1.3]	
Duration of cough in weeks	2 - 4	180[61.2]	114[38.8]	1.0	0.190
	> 4	47[53.4]	41[46.6]	1.2[0.9, 1.5]	
Contact with TB patient before imprisonment	yes	60[53.1]	53[46.9]	1.0	0.159
	no	113[60.1]	75[39.9]	0.7[0.5, 1.2]	
	I don't know	54[66.7]	27[33.3]	0.6[0.3, 1.0]	
Visited and received treatment for TB symptoms	yes	186[65]	100[35]	1.0	<0.001*
	no	41[42.7]	55[57.3]	2.5[1.6, 3.9]	

* P ≤ 0.05(significant level)

3.6.3 Predictors for biomedical knowledge of tuberculosis

3.6.3.1 Simple logistic regression analysis of candidate variables

We used a similar selection method and strategy for a biomedical knowledge of TB model, as we did for PTB predictors, except the adjustment for age.

As shown in Table 20, candidate variables with P ≤ 0.25 were selected. These included type of occupation, life style, prison facility, TB history, sharing eating and drinking materials, contact with TB patient, cough duration, and visiting and receiving treatment for TB symptoms.

Table 20 Wald and LR tests of candidate variables for biomedical knowledge of TB model among the study population in the Eastern Ethiopian prisons

		Likelihood ratio test		
Candidate Predictors	**Wald test(P-value)**	**LogL**	**-2logL**	**P value**
null model		-257.96		
Age	0.853	-257.94	0.03	0.854
Occupation	0.220	-257.2	1.51	0.219*
Education	0.286	-257.39	1.14	0.286
Residence place	0.666	-257.86	0.19	0.667
Life style	<0.001	-248.64	18.63	<0.001*
Prison facility	<0.001	-220.63	74.64	<0.001*
TB history	0.001	-251.96	11.98	0.001*
Length of stay in prison	0.707	-257.89	0.14	0.707
Sharing eating and drink materials	0.133	-256.82	2.27	0.132*
Sharing cell with TB patient	0.404	-257.61	0.70	0.404
Contact with TB patient	0.056	-256.11	3.69	0.055*
Cough duration	0.191	-257.10	1.70	0.192*
Visited and treatment received for TB symptoms	<0.001	-250.63	14.66	<0.001*

* Variables with p-value less 0.25

3.6.3.2 Multivariate logistic regression analysis of predictors of TB knowledge

Factors with P ≤ 0.05 were added into the model and these included life style before imprisonment, prison facility, prior history of TB, duration of cough, contact history with TB patients, visiting and receiving treatment for TB symptoms. Though person's level of education was not candidate variable (P > 0.25), we decided to add into the model in view of its known effect on level of awareness. Consequently, it appeared as significant predictor after having been included in the model [Log likelihood=-198.44, LR X^2 (2) =7.91 and P= 0.019]. On the other hand, type of occupation [Log likelihood=-196.64, LR X^2 (3) =3.61 and P= 0.307], and sharing eating and drinking utensils [Log likelihood=-198.3, LR X^2 (1) =0.29 and P= 0.589] were dropped, due to their non-significant contribution in the model.

A multivariate logistic regression analysis showing association of recorded variables with biomedical knowledge of TB status is presented in Table 21. Significant independent predictors were as follows: illiterates (not able to read and write) (P=0.004, AOR=2.22 and 95%CI 1.29-3.82) were two times more likely to have low knowledge about TB as compared to those who had the formal education. Prisoners in C (P<0.001, AOR=15.62 and 95%CI 7.47-33.54) had almost fifteen-fold greater odds of having low knowledge as compared to those in prison A. Similarly, three times higher risk for those in prison B (P=0.004, AOR=2.67 and 95%CI 1.38-5.16). Those who did not visit and receive a treatment for TB symptoms (P=0.002, AOR=2.52 and 95% CI 1.41-4.49) had almost twice higher likelihood to have low knowledge as compared to those who visited and received a treatment. Prisoners with a cough > 4 weeks(P=0.050, AOR=1.77 and 95%CI 0.99-3.12) had about two-fold higher risk of having low level of knowledge as compared to those with 2-4 weeks of duration. Prisoners who did not have past history of TB (P=0.001, AOR=4.09 and 95%CI 1.83-8.95) had four times higher likelihood to have low knowledge as compared to those who had past history of TB. As to their history of TB contact before imprisonment, those who reported for not having contact (P=0.024, AOR=2.09 and 95%CI 1.10-3.92) had four times higher likelihood of the low knowledge as compared to those who had contact (see Table 21).

Table 21 Multivariate logistic regression model of biomedical knowledge of TB among the study population in the Eastern Ethiopian prisons

Factors	AOR	P-value	95% CI	
Illiterate	2.22	0.004*	1.29	3.82
Able to read and write	1.22	0.637	0.52	2.87
Pastoralist	1.29	0.506	0.6	2.77
Prisoners in B	2.67	0.004*	1.38	5.16
Prisoners in C	15.62	<0.001*	7.47	32.54
Not having past history of TB	4.09	0.001*	1.83	8.95
No contact with TB patient	2.09	0.024*	1.1	3.92
Don't know for having any contact with TB patient	2.11	0.066	0.95	4.67
Not visited and received treatment for TB symptoms	2.52	0.002*	1.41	4.49
Cough greater than 4 weeks	1.77	0.050*	0.99	3.12

* Significant p-value(less than 0.05)

3.6.3.3 Evaluation of logistic regression model of TB knowledge

Table 22 illustrates that goodness-of-fit tests guaranteed that the observed value of risk factor in the model is well fit to predict the likelihood of biomedical knowledge of TB.

Table 22 Goodness-of-fits tests of logistic regression model of biomedical knowledge of TB among the study population in the Eastern Ethiopian prisons

Test	X^2	df	P
LR X^2	122.86	10	<0.001
Hosmer-Lemeshow X^2	6.27	8	0.617

A predictive ability of the logistic regression model is presented in Figure 10. The area under the ROC was 0.81 (figure 10(a)), so using the model for predicting the biomedical knowledge of TB has a moderate predictive ability among the study population. Figure 10(b) illustrated the predictive ability of the model at possible probability cut-of-points. For instance, 0.3 appeared to provide a better estimation, as the sensitivity and specificity of the model were 83% and 61%, respectively. The PPV and NPV were 59% and 84%, respectively.

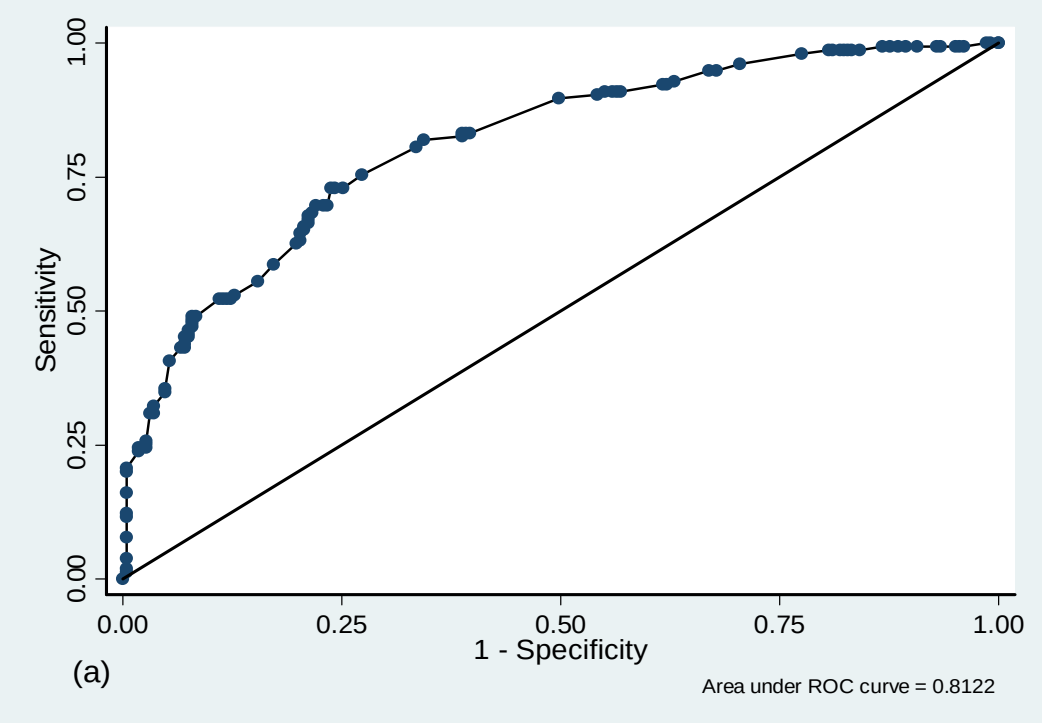


Figure 10(a). ROC for logistic regression model of biomedical knowledge of TB predictors among the study population in the Eastern Ethiopian prisons

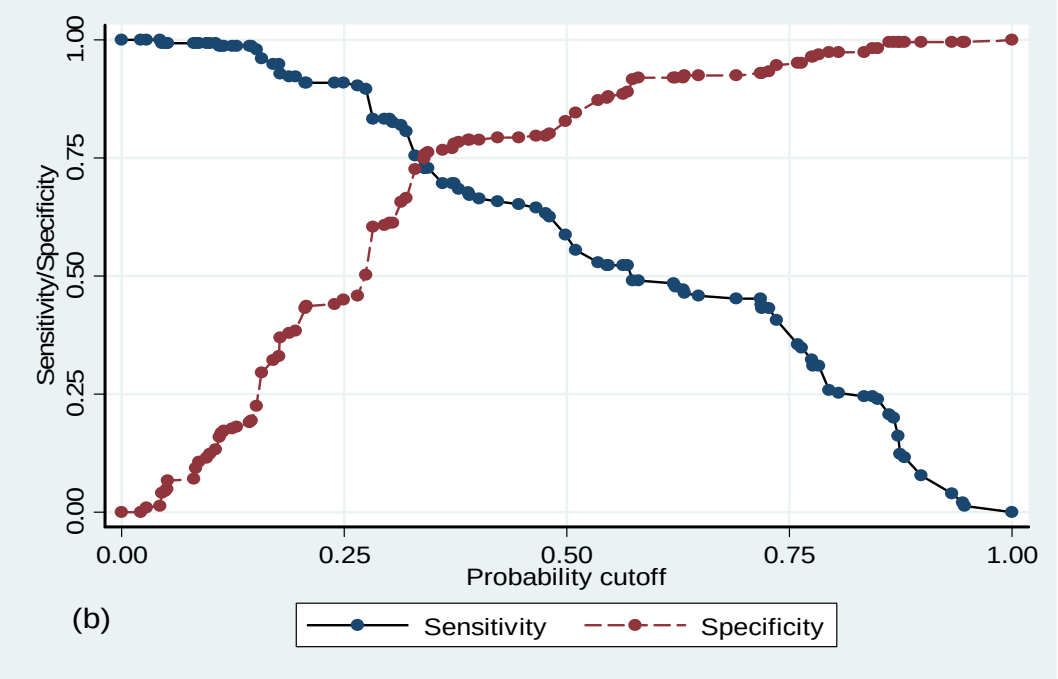


Figure 10(b). Two way-ROC for logistic regression model of biomedical knowledge of TB predictors among the study population in the Eastern Ethiopian prisons

3.7 Analysis of retrospective tuberculosis record

We reviewed a ten year TB records of Harar prison that was recorded at a civilian (Harar) TB center; where prisoners were referred for a diagnosis and treatment for the disease. The center was functioning as a middle level hospital and had a complete TB registration for prison population. Nonetheless, Jijiga and Dire Dawa prisons did not have an accessible and complete registration, as result we have not been able to get a complete records from these prisons (see Table 23).

In Harar prison, we identified 304 TB patients in the ten-year period, i.e. 1997-2006/07. The mean prevalence of TB was 2300/100,000 [95%CI=1590, 3300]. Most, 260(90%), of them were diagnosed in the first five years (1997-2001). Then, we observed a sharp decrease in the number of patients in the next five years. As shown in Figure 11, the prevalence of TB was 4.94% in 1997, and dropped to 0.5% in 2006/07. This downward trend of TB prevalence was statistically significant [chi X^2 test for trend=146.14 and P<0.001].

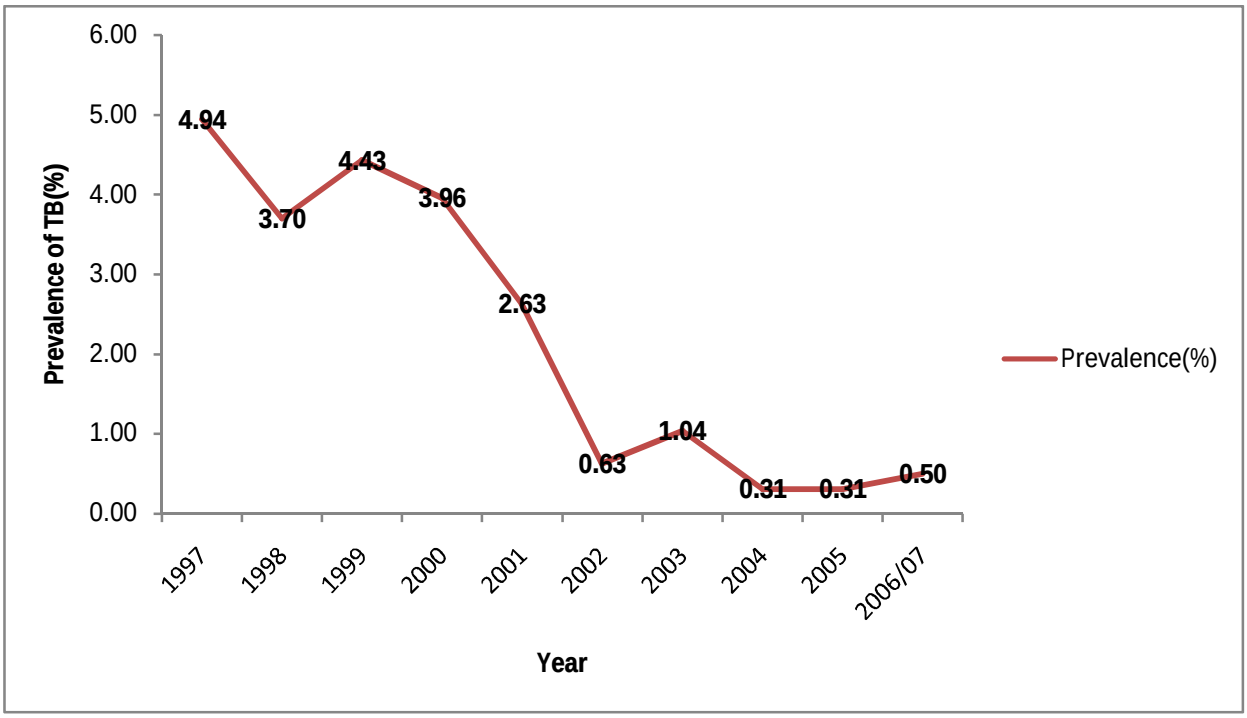


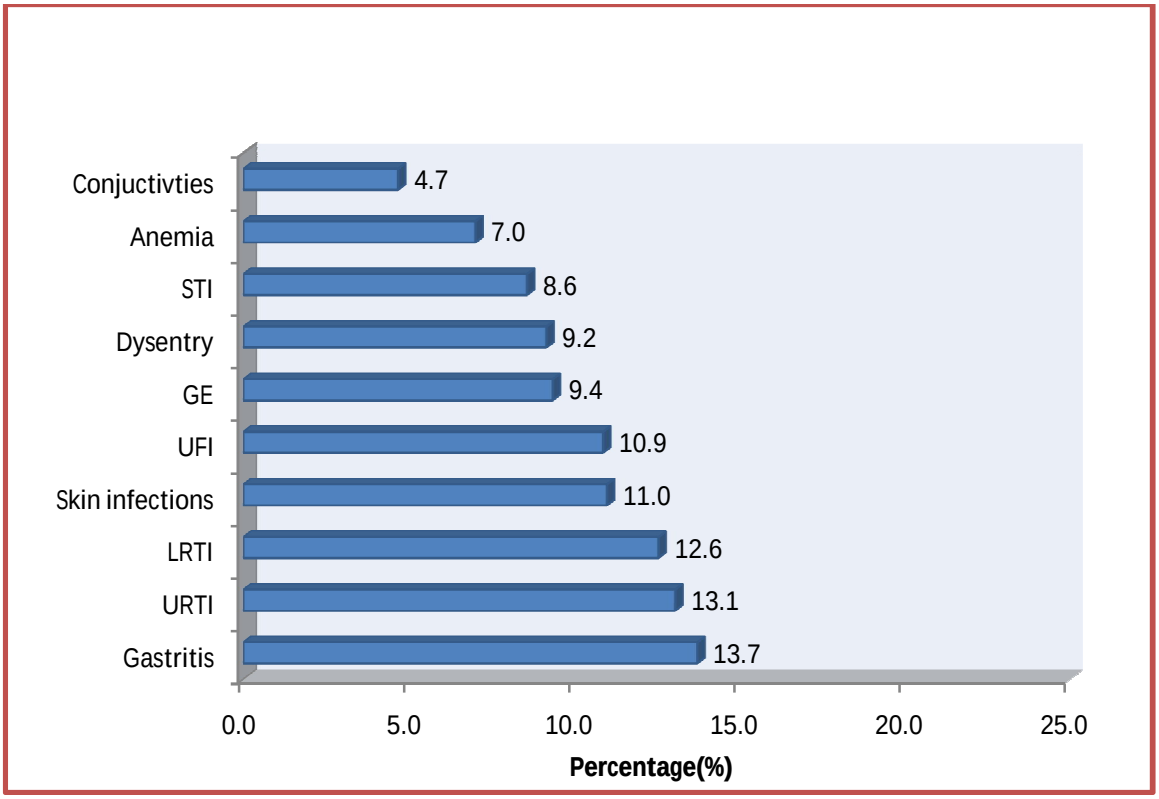
Figure 11 Ten years (1997-2006/07) trend of TB prevalence in Harar prison in the Eastern Ethiopia

The proportion of male and female was largely disproportional in the record; 97.7% vs. 2.3%. Most of PTB cases (89.1%) were under the age of 45 years, and almost half of them between 25-34 years of age. This proportional difference was statistically significant [NP chi X^2 test =173.9, df=3 and P<0.001]. As to the TB type, half of them were smear-negative PTB. The proportion of smear-positive PTB and EPTB was 12.8% and 36.8%, respectively. The proportional difference of TB type showed statistical significance [NP chi X^2 test =65.8, df=2 and P<0.001]. One hundred ninety one (63.7%) patients had a favorable outcome, i.e. treatment completed and cured. But, 55(18.3%) of them were defaulters. The treatment outcome was not available for only four prisoners in the record (see Table 23).

Table 23 Ten years (1997-2006/07) TB patients record in Harar prison in the Eastern Ethiopia

Variables	Label	Average Prison Population[N]/year	Frequency =N	Percent
Year	1997	1315	65	21.4
	1998	1350	50	16.4
	1999	1400	62	20.4
	2000	1415	56	18.4
	2001	1370	36	11.8
	2002	1270	8	2.6
	2003	1250	13	4.3
	2004	1300	4	1.3
	2005	1310	4	1.3
	2006	1200	6	2.0
Gender	female	–	7	2.3
	male	–	297	97.7
Age in years	15-24	–	49	16
	25-34	–	175	57.6
	35-44	–	47	15.5
	45+	–	33	10.9
TB type	extra-pulmonary	–	112	36.8
	pulmonary negative	–	153	50.3
	pulmonary positive	–	39	12.8
Treatment outcome	treatment completed	–	169	56.4
	cured	–	22	7.3
	died	–	16	5.3
	default	–	55	18.3
	transferred out	–	38	12.7

Three years (2005-2008) out-patient morbidity records of Harar and Jijiga prisons clinics were reviewed and results presented as follows (Figure 12). As can be seen gastritis, upper and lower respiratory infections were among the top three cause of morbidity.



Key: UFI-unknown febrile illness, STI-sexual transmitted disease, LRTI and URTI-lower and upper respiratory infections, GE-gastro enteritis (helmentic or parasitic infections)

Figure 12 Three years (2005-2008) top ten out-patient morbidity records of Harar and Jijiga prisons clinics in the Eastern Ethiopia

4 CHAPTER IV. DISCUSSION

4.1 Background of the study population

In the present study, most of the study participants were male, which exactly represent demographic characteristics of the prison population in Eastern Ethiopia (sex ratio: female to male, 1 to 22). In this study, female to male ratio was 1:19. In addition, more than three-fourth of them were aged between 15-44 years that comprise the young and economically productive group; almost half of them were illiterate; majority of them had a low income; half of them were smoking cigarette and chewing *khat* for the last six to nine years. In particular, *khat* chewers were likely to be cigarette smoker; physically inactive; spend less time out-doors, and share cigarette and drinking equipments. These backgrounds indicate that most of the prisoners were typically drawn from a poorly educated and socio-economically deprived segment of the general population. So, they may have a number of undiagnosed health problems and could be at a greater risk of acquiring health and related problems. In other words, they entered the prison with a high risk of already being unhealthy. At the same time, poor prison conditions like overcrowding, unhygienic environment, and limited access to health care may exaggerate the already established risks and bring them to be more susceptible to a disease. As a result, TB which is driven by these under-privileged conditions may be an ever present danger in this high risk population. Hence, developing and implementing TB control strategies will give an opportunity to screen, treat and prevent TB.

The finding is more or less similar to that of Russia (24), France (77;78) and Ghana (60) prisons studies. Generally, both in high and low income countries, prison population represent a poorly educated, socially marginalized and a low income category of the general population. These studies also reported higher burden of communicable and non-communicable morbidities among the prisoners than in the general public.

4.2 Prevalence of pulmonary tuberculosis

This is the first study of its kind documenting TB status in Ethiopian prisons. The result shows that the prevalence of PTB was 1913/100,000 prison population [95%CI = 1410-2580]. It is about seven times higher than the prevalence of PTB in the general population (14). This high TB burden may attribute to an aggressive transmission of TB in the prison, and a source of outbreak to the surrounding community, as similar scenario was reported in Madagascar (44) and US (67). This could also enhance transmission of drug resistant strains, since delayed diagnosis, inadequate treatment and receiving defaulters could make the prison an ideal place for the emergence of MDR-TB (65;79). Prisons are therefore playing a significant role in sustaining the TB epidemic.

A large number of studies reported higher prevalence of PTB in prisons than in the general population (33-40). For example, the prevalence of PTB in Zambia (33) and Malawi (40) prisons was ten times higher than that of the general population. Similarly, prisons in developed countries (US and Europe) had experienced higher prevalence of TB than in the general public (36;46). The magnitude of PTB prevalence in our study was lower than that of the Zambian study (i.e. 4005/100,000) (33); but, higher than findings of prison studies in Thailand (354.8/100,000) (34), Taiwan (258.7/100,000) (80), and US (29.4/100,000) (36). Despite the difference in study design and methodology, background of individuals and country, most studies carried out so far show high burden of TB among the prison populations in general. The reported disproportional magnitude of TB in the prison population in different countries is mainly attributed to poor house ventilation (39;52), absence of segregation of TB patients, inadequate or non-existent TB control program, high HIV prevalence (58;60), and inadequate access to health service. Therefore, in any national or regional TB control programmes, prisoners should be accorded a special attention, if the socio-economic impacts of the disease need to be sustainably put under control.

Analysis of retrospective data revealed downward trend of TB prevalence in Harar prison. The high TB prevalence that was observed from 1997 to 2001, gradually decreased during the next five years (figure 11). Possible reasons for the changing trend of TB prevalence were: (1) high influx of prisoners occurred in the first four years; (2) as a result, there was a continuous support and supervision from International Committee for Red Cross (ICRC) that helped to increase detected cases in the first four years, and (3) there was also a progressive improvement in terms of health care, housing, hygiene, water and food supply in the prison. At this stage of the study, it might be difficult to attribute the decrease in the prevalence to an improvement in the prison conditions. Because, our active case finding indicated a high burden of undetected PTB cases; three previously undetected PTB cases were found for every 1 case that was identified passively. Thus, a reduction in the number of detected cases may be possible to explain the downward trend.

4.3 Risk factors for pulmonary tuberculosis

4.3.1 Socio-demographic factors

An interesting finding of this study is that prisoners whose origin was linked to urban areas had higher risk of acquiring TB than those from rural areas (Table 16). One possible explanation could be the relatively high rate of associated HIV infection, a leading modulator of TB infection. According to the latest MOH annual report, HIV prevalence was about six times high in urban than rural areas of the country (10.5% vs. 1.9%) (7). It has been an established fact that HIV often leads to a greater rate of TB either through reactivation or increased susceptibility to new infection (10;21). It is the main risk factor for fuelling TB epidemic most notably in the SSA (18). To our knowledge, there has not been any documentation about urban origin prisoners to be a major risk factor for the high TB prevalence in prison populations. However some related studies among civilian populations in the southern Ethiopia (81) and Malawi (82) reported higher HIV prevalence among TB patients in urban than rural settings.

We identified PTB more frequently among the male than female prisoners (Table 8). Likewise, the retrospective record also showed a significant proportion of male prisoners in the overall number of TB cases in the ten-year period (Table 23). This might be due to small sample size of the female prisoners which may preclude the actual effect of sex, thus making risk comparison inaccurate. However, our general expectation is that the male prisoners may be at greater risk of acquiring the infection and become source of transmission, as there is a high overcrowding and poor housing condition compared to their female counterparts. This argument is corroborated by studies carried out among Zambian (33), Malawian (40) and US (36) prisons that documented higher TB prevalence among males than females. Congruent to this observation was also studies that report male as being a risk factor for TB among Thai (34) and Spanish (43) prisons.

Young adults, who were in the age range between 15-44 years, were found to have a significantly higher PTB (Table 8). Although it did not show any level of association in multivariate analysis, a high rate of HIV infection could be one of the possible explanations to the high TB prevalence in this age group. This association was consistently reported among the prison and general population in Africa (18;19;83). Likewise, prison studies from high and low TB burden countries documented a high TB prevalence among young adults (33;34;36;40).

4.3.2 Prison factors

Sharing a cell with a TB patient or a chronically coughing prisoner was identified to be risk factors for acquiring PTB infection (Table 16). This is further augmented by the epidemiological link between newly diagnosed PTB cases, and those who were receiving anti-TB treatment and defaulters; most notably horizontal pattern (person-to-person) of transmission was documented in this study (Table 12). This is partly explained by lack of segregating TB patients, absence of pre-detention TB screening, and overcrowding that prolong period of infectiousness thus favoring transmission of *M. tuberculosis*.

Studies carried out in Russia (65), Spain (69) and Madagascar (44), which involved the use of DNA fingerprinting tools, reported that an active transmission was responsible for TB outbreak within prisons. More importantly, such phenomena often account for episodes of TB outbreaks in surrounding communities (56;67). Congruent to this opinion, our study, like the study carried out in Malawi (40), also suggested that the active transmission may be responsible for the high burden of PTB among the study population. Unlike several previous studies carried out among the prison populations, our study reported horizontal (person-to-person) transmission as being an independent risk factor.

In prison A, smear-positive patients were only segregated for the full initial phase of DOTS treatment, whereas prison B and C did not have a separation ward for TB patients. Segregation of smear-positive patients could be a priority in a prison TB control program, as these patients are the most contagious and constitute the major source of infection. However, we can not rule out the possibility of transmission from smear-negative patients, as well. For instance, a study carried out among civilian population in USA reported that smear-negative culture-positive patients were responsible for 17% transmission of TB (84). Same report indicted these group of people were at least 22% as likely as smear-positive patients to transmit TB. In addition, due to a limited diagnostic performance of direct smear microscopy; main diagnostic tool of TB in low income countries (85), there will be higher likelihood to miss infectious cases and categorize a smear-positive patient as negative. Hence, this should be taken into consideration of planning TB control strategies in the prison.

In this study, the length of stay in the prison was not significantly associated with PTB, despite the majority of study participants stayed for the short duration (Table 9 and 11). It was similar to that of a Zambian prison study (33), whereas, Ivory Coast (41) and Cameroon (35) studies indicated a short staying as the risk factor for TB. On the contrary, Spain (43) and Georgian (39) studies reported a longer staying as the risk factor. This point has already been presented in the literature review. Instead, re-imprisonment was found to be significantly associated with PTB (with univariate analysis, Table 11). Although it did not show any level of association in multivariate

analysis (Table 16), frequent imprisonment could put an individual to repeated exposure of TB infection. This has also been documented usually among individuals who commit crime repeatedly, such as homeless and street gangs that are likely to be deprived of living conditions and health care, thus have greater risk of acquiring TB (36). Similarly, studies carried out in Spain (43) and Cameroon (35) identified re-imprisonment as the risk factor for TB.

Factors relating to living and crowding conditions did not show any level of significance and hence were not considered as explanatory variables for PTB prevalence in this study, though they are known to favor dissemination of TB. The fact that living and overcrowding conditions are similar for all the prisoners in all the three sites, might have precluded their effects on outcomes of TB infection. This finding was similar with that of a Zambian study (33); where there is no differences related to living conditions such as overcrowding, poor dietary conditions and large number of prisoners per cell between culture-positive and -negative TB groups. In contrary, a case-control study in Russia (52) mentioned prison factors like high ratio of prisoners per available bed, not having own bed clothes, and little time out-doors as independent risk factors. Cross-sectional nature of the study could be one of the possible reasons for not observing the significance level of these factors.

4.3.3 Morbidity factors

The longer duration of cough (>4 weeks) and repeated visits (> 3 times) for TB symptoms were identified to be risk factors of PTB in the study (Table 16). Prisoners with such factors might have escaped early detection of the infection and, subsequently exposed to increased disease severity. This may also point to the presence of TB diagnostic and management delay that reflects lack of effective diagnostic tools in high TB endemic settings, as Strola et.al reviewed (86). In particular, this could be more challenging in the prisons, where there is no laboratory facility, high burden of respiratory diseases, under-funded and overstretched prison health care system, and limited access to a referral service.

The median duration of cough in our study is similar to that of a Malawi prison study, i.e. 4 weeks (40). By contrast, Thailand (34), and Georgian (39) prison studies identified ≥ 2 weeks of cough as being risk factor for PTB. Unlike our study, these studies compared the risk between those who had ≥ 2 weeks vs. no cough or ≤ 2 weeks. The repeated visit for TB symptoms is an interesting finding of the present study which could be one of the possible reasons for documenting the longer duration of cough as the risk factor for acquiring PTB, because those who have repeated visit may likely to have the longer duration of cough.

Among TB symptoms, chest pain was the only symptoms significantly associated with PTB in this study (Table 14), whereas a Brazilian prison study reported a range of symptoms that had significant association with TB (37). Similarly, a Georgian study mentioned loss of appetite as an independent risk factor (39). In Thailand prisons study, weight loss made significant independent contribution to a diagnosis of smear-positive TB (34).

In this study, nutritional status (BMI) was not significantly associated with PTB, despite the fact that malnutrition adversely affects the immune status (53;87). One of the possible reasons is that most of them had a common source of food, where every prisoner was provided three meals per day. So this may reduce individual variation and certainly its effect on outcomes of TB infection. In particular, considering their pre-imprisonment socio-economic status, the food ration (i.e. about 0.55 USD/person/day) was relatively adequate for the majority of prisoners. In contrast, prison studies in Cameron (35), Brazil (37), and Georgia (39) mentioned low BMI (i.e. ≤ 18.5 or ≤ 20 kg/m^2) as the risk factor for TB.

4.4 Cough as a screening criterion of pulmonary tuberculosis

In the present study, we used the threshold of ≥ 2 weeks of cough to define a TB suspect, as stated in the NTCP manual (14). Tuberculosis Coalition for Technical Assistence also recommended this threshold, in order to reduce a clinic and laboratory workload; while recognizing the risk of missing cases among those with short duration (1-2 weeks) (88). On the other hand, a four year (1999-2002) admission screening report in Malawi prisons demonstrated that 39% of PTB patients had a cough for 1-3 weeks (70). Likewise, a study carried out in Zambian prisons revealed that the prevalence of TB was not significantly different among those with a cough of > 3 weeks vs. 1-3 weeks (33). In contrast, our finding showed a significant difference (P=0,026) on the prevalence of PTB between 2-4 weeks vs. > 4 weeks of cough.

The finding from the Malawi (70) and Zambia (33) prison studies suggested that limiting screening based on the duration of cough may lead to missing of TB cases. In addition, a reporting error on the actual duration, mainly where there is a high rate of illiteracy; could attribute to excluding suspected individuals. For instance, we excluded 260 prisoners because of the short duration of cough. If we screened these prisoners, it would have given the opportunity to establish an acceptable threshold of screening. It may also reveal a benefit of screening the short duration of cough. Therefore, it is difficult to recommend an acceptable threshold for the duration of cough from the present study. However, we feel that ≥ 2 weeks of cough can be used as an active screening criterion for PTB in prison. Because, it will yield early diagnosis (reduce delay in diagnosis), improve out comes and reduce spread of disease in high TB endemic areas (89;90).

4.5 Biomedical knowledge of tuberculosis

4.5.1 Baseline description of biomedical knowledge of tuberculosis

In this study, we found that a high proportion of prisoners had low level of biomedical knowledge of TB. Almost all the participants did not know the cause of TB. They commonly mentioned a wind, local *Amharic* name "*Nefas*" and a blowing cold wind, local Amharic name "B*ird*" as the cause of TB. This perception is popular in Ethiopia; most notably for someone who travels by a bus or taxi, as most of passengers complain and be against to somebody who tries to open a window. Similarly, a qualitative study conducted in Addis Ababa (Ethiopia) explained briefly about this phenomenon (91). In addition, half of them did not know that anti-TB drugs are provided freely and risks for TB in the prison. They mentioned overcrowding as a factor responsible for a high TB burden in the prison, but none of them mentioned that reducing a number of prisoners per cell and segregating TB patients as means for TB control. The low level of biomedical knowledge of TB may have an influence on health seeking behavior and practice, as similarly reported among civilian TB patients in the Eastern (92) and northern Ethiopia (93), and India (94). The knowledge about the disease is also as an important factor for the adherence to the treatment or improves adherence to the treatment (95;96). In Ethiopia, ICRC implemented TB control program in six large prisons in 1995. This program had to be discontinued, due to unacceptably a high number of defaulters, for instance up to 62% in the Addis Ababa prison (97). In this historical disaster, there was a structural problem on the program, but we also expect that limited awareness of individuals may attribute to the high defaulter rate. Improving the knowledge of TB should therefore be given the priority in the prison health care service.

To our knowledge, we found only one prison study from USA (1997) that similarly reported about the TB knowledge gaps; misconception about transmission, prevention and treatment of TB were commonly identified (98). The findings are not exclusive to the prison population, because community based studies in Ethiopia (99;100) and Vietnam (101;102) reported that limited knowledge of TB was also common among the general public.

4.5.2 Predictors for biomedical knowledge of tuberculosis

The level of education is a well known indicator of the awareness status of a person. It is not a surprise to found prisoners, who were illiterate and had low knowledge of TB (Table 21). The finding was similar to that of civilian studies in Vietnam (101;102), and Northern Ethiopia (100).

Prisoners, who did not visit and receive a treatment for TB symptoms and had longer duration of cough (> 30 days), were more likely to have low knowledge of TB (Table 21). It illustrates the contribution of low knowledge on diagnostic and management delay of TB (86).

An interesting finding of the study is about the difference across the three prisons. Prisoners in C had 15 times higher risk of having low knowledge of TB as compared to those in prison A. Also, prisoners in B had three times greater risk (Table 21). One of the possible reasons for the difference could be status of prison health service and efforts they made for disseminating health information. Because, Prison A had three permanent and full time nurses, segregation room for smear-positive patients and well equipped media centre with one full time staff. So health education was continuously provided using the mass media. Prison B had similar number of staffs and media center, but their center was not equipped, and disseminates health information rarely. In contrary, Prison C had only one nurse, no media center and almost no provision of health information. Therefore, we suggest that the difference on the level of biomedical knowledge across the three prisons may be the cumulative effect of the status of health service.

4.6 Prison health care delivery system

The prison health service was governed by the prison authority and staffed with nurses. It had collaboration with civilian health institutions and offices. The service was only provided at an out-patient level after elected health committee members, who were prisoners, made pre-screening and registration in each cell. These prisoners were not trained and gave less attention for TB symptoms unless a person complained repeatedly or had sever signs and symptoms, such as haemoptysis, sever chest pain and difficulty of breathing. Some of them gave also a priority for close friends and influential prisoners. Furthermore, there was no laboratory facility; shortage of essential drugs and other supplies; limited referral service (i.e. about 6 persons per day) and budget constraints. Individuals were jailed without an admission screening for any of diseases. There was no segregation of TB patients except in the prison A. Hence, the prison health care was under intense pressure to manage both pre-and post-imprisonment related morbidities. It may also contribute to late case finding and delayed treatment of TB.

The referral service was one of the challenging tasks in the prison health service, since there was no transport service and inability of getting enough number of guards. Moreover, the health personnel had another challenge, which is identifying a patient that really deserves the referral, because prisoners complained frequently to get referral and to be outside of the prison. For example, one of a nurse said “Getting referral is like a business for the prisoners, because all the walk way from the prison to hospital is an opportunity to meet friends and family, so most of them get some money as well”. Despite this, getting referral for TB diagnosis has another up-hill, as the health personnel used strict criteria such as repeated complaints of cough and other TB symptoms that was treated two or more times with broad-spectrum antibiotics or accompanied with sever signs and symptoms. That is why the morbidity record also indicated respiratory illnesses as the major causes of out-patient visit. It can be another possible reason of identifying repeated visit for TB symptoms and longer duration of cough as the risk factors for PTB in the present study.

On the whole, the prison health care was poorly organized and less equipped in managing a high burden of respiratory illnesses, and may attribute to diagnostic and management delay of TB. This challenge of prison health care was more or less similarly reported in a qualitative study carried out in South Africa (103). Unlike our study, the South African study addressed much broader view about prevailing issues that were hindering effective health care services in the correctional facilities in South Africa. It also stated that prison is a strategic point to increase access to health service for those who is likely to make health care seeking a very low priority while outside of prison. In the same way, Coninx et al. (104) reported that the prison set up is more conducive for screening and managing undiagnosed health problems, providing education and making them economically productive. But, this is done rarely, as the view attached to prison which regard as a punishment center, completely under-funded and sub-standard health service could be some of the obstacles for establishing effective prison health care system.

4.7 Strength and limitations of the study

4.7.1 Strength

- The study was conducted in a high risk environment, among the most neglected and vulnerable group of the population; where there are a number of un-met needs and high burden of diseases.
- It provides important information previously unavailable in Ethiopia. So, it can serve as a baseline for planning TB control program in the prison, and a platform on which other studies can build.
- The study employed a better sampling estimation and procedure that provided an equal chance of participation.
- Mycobacteria culture is one of the robust, time intensive and resource-demanding methods of TB diagnosis. Despite this, we cultured all sputum specimens.
- We used recommended data management and analysis methods.

4.7.2 Limitations

- We were unable to perform screening among those who had the short duration of cough (i.e. 260 individuals) and, the prevalence of PTB may therefore have been underestimated, because reporting error (under-reporting) and cross-sectional nature of the study may influence to categorize these prisoners into the short duration of cough group.
- Prisoners with ≥ 2 week of cough and not able to produce sputum, or had dry cough were excluded in this study. Also, we had a difficulty of getting productive sputum and adequate amount for the culture (i.e. 3-5 ml) so that the use of poor quality of sputum may reduce the performance of laboratory investigation. While the use of an alternative diagnostic tool like chest X-ray could have been the solution in the study. In addition, this may have been underestimated the actual prevalence of PTB.
- We did not screen for HIV infection, even if it is the main driving factor of TB epidemiology in Ethiopia.
- Prison staffs were not included in the study, despite their frequent contact with prisoners.
- Over- and under-reporting about the risks of PTB is highly anticipated in our study. This may have influence on the value of parameter estimators, such as odds ratio, P-value and confidence interval; it may have underestimated or overestimated the prediction of risk factors for PTB. In addition, the small sample size of PTB patients could have similar influence on the analysis.
- Shortage of reagents and disinfectants, irregularity of electric power supply and sub-standard culture laboratory facility were some of determinants that may reduce the performance of diagnostic method, i.e. culture.

These above limitations indicate possibility of confounder, selection and information related bias. Hence, the result of study should be interpreted with caution.

5 CHAPTER V. CONCLUSION and RECOMMENDATION

5.1 Conclusion

In this study, we documented a high prevalence of PTB among the prison population; about seven times greater than the prevalence in the general population. It also demonstrates a high burden of undetected and infectious PTB cases in the prison. Risk factors found to associated with PTB included being an urban resident, having repeated visits for TB symptoms (> 3 times), longer duration of cough (> 4 weeks), sharing a cell with a TB patient or a chronically coughing person. In addition, a high proportion of prisoners had low level of knowledge about TB.

In brief, the high prevalence and associated risk factors for PTB may favor an active transmission of PTB, and put the prison population at increased risk of developing PTB. This could be also a great health threat to the surrounding community. Thus, developing and implementing TB control strategies in the prisons is urgently needed. The study findings should be taken into account to target high risk individuals and prioritize TB prevention and control activities. It should be also regarded as a baseline for planning and implementing the prison TB control program, and further studies.

5.2 Recommendations

- Conducting an active surveillance of TB is highly rewarding, because it enables to identify early infectious cases, prevent further delay in diagnosis and reduce prolonged transmission of TB in the prison.
- Segregation of smear positive patients for the full initial phase of DOTS treatment should be given a priority in prison TB control strategies.
- We found prisoners that had TB symptoms, and were defaulters before admission to the prison. As a result, conducting admission screening among new prisoners with a cough of ≥ 2 weeks, and asking about history of TB will give an opportunity to identify early infectious cases, trace defaulters, and further reduces the transmission of TB and emergence of MDR-TB.
- The captive audience of prison may facilitate implementation of DOTS, and provision of health education. The prison health service should therefore develop an information, education and communication (IEC) strategy that improves health seeking behavior and practice, and adherence to the treatment.
- The prison health service was poorly staffed and equipped so that a capacity building program should be required.
- Currently, the NTCP does not have a specific guideline for the prison, so it is urgently needed to develop and implement well-planned and integrated risk reduction strategies of TB control and prevention in the prisons.

5.3 Further research implications

- Conducting a prospective longitudinal study will give a better estimation of prevalence (incidence) and associated risk factors of TB. It will also give an opportunity to address the dilemma of acceptable screening strategy and criteria for the prison TB control program.
- Culture is not cost effective and efficient screening tool of TB. The smear microscopy has also a low sensitivity, which impairs screening performance. Thus, using a simple, cost effective and rapid diagnostic test that can serve as a “point-of-care” diagnosis is highly needed, most notably for conducting an active screening of TB in the prison.
- Conducting a comparative study on molecular epidemiology and drug resistant of TB between the prison population and surrounding communities. It may provide a better understanding about the transmission dynamics and nature of epidemiology of TB. This will be the basic knowledge for planning, implementing and monitoring TB control measures at the prison and community level.
- We found young adults and urban residents at increased risk of acquiring PTB, so further study should address with TB/HIV co-infection in the prison. Also, the prison staffs should be included.
- Conducting a qualitative study on health seeking behavior and practice, and access to TB care. This will have a substantial importance to identify barriers and ways forward for planning and implementation of TB control strategies in the prison.

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7 Appendices

7.1 English version of information sheet

University of Oslo

Faculty of Medicine

Department of General Practice and Community Medicine

Section for International Community Health

Enquiry about participation in PTB research project in Eastern Ethiopian prisons

Good morning/good afternoon. My name is _____. I am working for an investigator doing his thesis for the partial fulfillment of master's degree in international community health. I would like to thank you for accepting our invitation for this information session about the research project. The purpose of this research is to determine the magnitude and factors associated with pulmonary tuberculosis (TB) among inmates in this prison. The study finding will give baseline information about the burden of the disease and helps for planning and implementing TB control and prevention intervention. I will ask you information about factors associated with pulmonary TB and to submit three samples of sputum that will be analyzed for the diagnosis of TB. You are selected to participate in this study due to symptom you have i.e. cough ≥ 2 weeks. So, participation will give you an opportunity for diagnosis and getting recommended treatment of TB according to national guidelines.

I would like to assure you that all of your responses to our questions will be kept confidential throughout the study process using coding system that only managed by the researcher. Any of the information you provide will be used only by the research team and will, by no means, be revealed to a third party. After finalizing analysis and reporting, your personal identifiers will be removed. I would like to assure you that your participation in this research will not affect your imprisonment or working condition. In addition, this study has an ethical clearance (legal permission).

You have full right to refuse, withdraw or completely reject part or all of your participation in the study. But we encourage your full participation as the answers you

give on this form are very important to this study and helps for planning TB control and prevention measures in prison.

Do you understand the information correctly? If you have questions, you can ask at any time and also we will provide you the answers.

We would be thankful if you spend sometime with us answering questions related to the issues described above. The interview will take 30 minutes.

7.2 Declaration of consent for the study

Consent Form

I have read or understand the information sheet above and clearly understood the purpose and anticipated benefit of the research. I hereby need to assure with my signature below that I, without any coercion or forceful act by the research team, have decided to voluntarily participate in the study in-front of the witness.

Study subject's

Code number_____

Signature _____

Date_____

Witness's

Name _____

Signature _____

Date_____

Data collector's

Name_____

Signature_____

Date_____

7.3 English version interviewed type of questionnaire

Code Number---------- **Prison Code**---------- **Cell No**----------

No	Questions	Coding category/response	Skip to
Part I. Socio-demography characteristics			
101	Age in years	-------years	
102	Sex	0. female 1. male	
103	Marital status	0. single 1. married 2. divorced 3. widowed 4. separated	
104	Education	0. not able to read and write 1. able to read and write without formal school year 2. primary(1-8) 3. secondary(9-10 or 12) 4. College (10+ or 12+)	
105	Occupation before imprisonment	0. civil servant(gov't) 1. farmers 2. self employed 3. student 4. house wife 5. unemployed 6. Others……	
106	Residence place(according to local administration)	0. rural 1. urban	
107	Life style before imprisonment	0. pastoralist 1. non-pastoralist 2. mixed	
108	Do you smoke?	0. no 1. yes	
109	If yes, for how long?	----years	
110	Do you Chew 'chat'?	0. no 1. yes	
111	If yes, for how long?	-----years	
Part II. Prison History and condition			

201	Do you have support from family in terms of visit and bringing food?	0. I don't have 1. visit only 2. food only 3. visit and food	
202	If you have family visit, how many times per week do they bring food?	----------per week	
203	How long did you imprisoned in the current prison?	------months	
204	How many times did you get imprisonment in the current prison?	-------- times	
205	Have you been imprisoned in another prison?	0. no ⟶ 1. yes	Skip to Q.208
206	If yes to Q.205, how many times?	-------times	
207	If yes to Q.205, how long?	--------months	
208	Have you been imprisoned with known TB patient in same cell?	0. no 1. yes 2. I don't know	
209	If Yes to Q.208, for how long?	--------months/years	
210	Have you imprisoned with chronically coughing person in same cell?	0.no ⟶ 1. yes	Skip to Q.212
211	If yes, for how long?	----------	
212	How many inmates are imprisoned in your cell?	----------per cell	
213	Do you have window in your cell?	0. no ⟶ 1. yes	Skip to Q.215
214	If yes to Q.213, How often do you open the window?	0. usually 1. less time 2. very less time	
215	How frequently are you spending your time outside of your cell?	0. everyday 1. sometimes 2. none	
216	Do you have your own bed clothes?	0. yes 1. no	

217	How is your sleeping place in prison?	0. Mattress on floor 1. Carpet on floor 2. Bed 3. Others….	
218	Status of the pavement of your cell's floor	0. soil 1. Cement 2. stone 3. others	
219	attitude to personal and cell hygiene of in you cell	0. very good 1. good 2. bad	
220	Do you share drinking and eating materials with other persons?	0. yes 1. no	
	Part III. Morbidity History and Status		
301	Currently, what kind of symptoms(complaints) do you have? **N.B. Don't mention choices for interviewee. Multiple choices possible.**	0. cough 1. chest pain 2. difficulty of breathing 3. fever 4. weight loss 5. night sweating 6. loss of appetite 7. malaise 8. fatigue 9. others(specify)	
302	For how long have you been coughing?	----------weeks	
303	Did you visit and receive any treatment for your current complaint?	0. no → 1. yes	Skip to Q.305
304	If yes to Q.303, where?	0. health institution outside of the prison 1. prison's clinic 2. both 3. others----------	
305	How many times did you visit for these symptoms (those mentioned in Q.301)?	----times	
306	If no to Q.303, why?	…….	

307	Did you have these symptoms (those mentioned in Q.301) before your imprisonment in this prison?	0. no → 1. yes	Skip to Q.309
308	If yes to Q. 307, Did you visit prison clinic at that time?	0. yes 1. no 2. I don't remember	
309	Have you been diagnosed for TB?	0. no 1. yes	
310	If yes to Q.309, When have you been diagnosed for TB?	0. Before imprisoment 1. During impriosment 2. I don't know	
311	If yes to Q.309, did you take treatment?	0. yes 1. no	
312	If yes to Q.309, did you complete the full course of treatment?	0. yes 1. no	
313	If no to Q.312, why?	----------	
314	Do you have identified or diagnosed health problem like Diabetic mellitus, Hypertension…etc?	0. no → 1. yes 2. I don't know	Skip to Q.318
315	If yes to Q.314, what is/are the problem?	----------	
316	If yes to Q.314, are you taking any treatment?	0. yes 1. no →	Skip to Q.318
317	If no to Q.316, why?	----------	
318	Have you ever been hospitalized?	0. no → 1. yes	Skip to Q.321
319	If yes to Q.318, how long?	---------months	
320	If yes to Q.318, What was the reason for hospitalization?	----------	
321	Did you have contact with known TB patient at home?	0. no 1. yes 2. I don't know	
322	Weight(to be measured by data	.-----kg	

	collector)		
323	Height(to be measured by data collector)	------meter	
324	Collected sputum (to be filled by data collector): make mark if taken. **N.B.** the respondent should know why and when should give the sputum.	0. morning1 1. morning2 2. morning3 3. no sputum(write reason why there is no sputum)	

Part IV. Medical Knowledge of TB

401**.** What do you think are causes of TB?

----

402. What do you think the mode of transmission of TB from person to person?

----

403. How do you think TB can be treated?

---

404. Did you know that the TB treatment is available free of charge?

0. No 1. Yes 2. I don't know

405. If TB patient is treated, can it be cured?

0. No 1. Yes 2. I don't know

406. Do you know any danger if a TB patient is not treated?

0. No 1. Yes

407. If yes to Q.406, what is it?

For the patient, _____

For the people around, _____

408. Do you know that TB in prison has different pattern from TB in community?

0. No 1. Yes

409. If yes to Q.408, what is it?

410. Do you know that interrupting TB treatment could bring problem?

0. Yes, 1. No

411. If yes to Q.410, what are the problems? _____

412. What are the means of preventing TB? _____

Part V. Direct Microscopy (AFB) result

sputum	**AFB result**		**Grading**			
	Negative	**positive**	**scanty**	**+1**	**+2**	**+3**
First day						
Second day						
Third day						

Part VI. Culture Result

LJ medium	**Direct Smear Microscopy**		**Remark**
	Positive	**Negative**	
LJ glycerol			
LJ pyruvate			

We would like to express our respect and gratitude to you for your interest and motive to participate in this study.

Thank you!!!!!

7.4 Ethical approval letter from the Regional Committee for Medical Research Ethics in Southern Norway

UNIVERSITY OF OSLO
FACULTY OF MEDICINE

Professor Gunnar Bjune
International Community Health
Universitetet i Oslo
Pb1130 Blindern

Regional Committee for Medical Research Ethics
Southern Norway, Section A
P.B 1130 Blindern
NO-0318 Oslo

Phone: 228 44 666
Fax: 228 44 661
E-mail: rek-2@medisin.uio.no
Homepage: www.etikkom.no

Date: 6 June 2008
Your ref.:
Our ref.: S- 08315a

S-08315a **Pulmonary tuberculosis in prison settings of eastern Ethiopia**
Project Manager: Phd, Professor and Head of Section Gunnar Bjune, Universitetet i Oslo
M. Phil. Student Dawit Shabel Abebe

We refer to your letter dated 27 May 2008 with a revised information letter enclosed.

The committee has no objections to the revised information letter with declaration of consent.

The committee gives its approval to the implementation of the project.

Best wishes for the project!

Yours Sincerely

Kristian Hagestad
Chief County Medical Officer, Spec. of Public Health
Chairperson

Jørgen Hardang
Secretary

7.5 Ethical approval letter from National Ethical committee for Health Research, Ethiopia

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The Federal Democratic Republic of Ethiopia
Ethiopian Science and Technology Agency

Aklilu Lemma Institute of Pathobiology
Addis Ababa University
Addis Ababa

ቁጥር Ref.No. ደ/ጤ/14-04/2000 ኢ
ቀን Date - 5 NOV 2008

Re: Puluminary Tuberculosis in prison setting of Harar, Eastern Ethiopia

Dear Sir/Mr/s/Dr.

The National Health Research Ethics Review Committee (NERC) has reviewed the aforementioned project proposal with special emphasis on the following points

1. Are all ethical principles considered?
   - 1.1 Respect for persons — Yes ☑ No ☐
   - 1.2 Beneficence — Yes ☑ No ☐
   - 1.3 Justice — Yes ☑ No ☐
2. Are the objectives of the study ethically achievable? Yes ☑ No ☐

   Are/Is methods ethically sound? Yes ☑ No ☐

Based on the above mentioned ethical assessment NERC has

a) **Approved** the proposal for implementation ☑
   Expiry date of the review
   4 (Date) Nov.. (Month) 2009 (Year)
b) Conditionally approved ☐
c) Not approved ☐

Finally we would like to take this opportunity to request your good office to maintain the highest ethical standards in the execution of the program and to monitor the ethical implementation of the project as stipulated in the project document.

With best regards,

Feleke Kibret
A/ Secretary of NERC

cc: Dawit Shawel
Aklilu Lemma Institute of Pathobiology
Addis Ababa

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You may contact

ፖ.ሳ.ቁ	አዲስ አበባ ኢትዮጵያ	ስልክ	ፋክስ
P.O.BOX 2490	Addis Ababa Ethiopia	Tel.251-011-5-511344	Fax 251-011-552 44 00/251-011-551 88 29
	e-mail estc@ethionet.et	Web Site:- http://www.estc.gov.et	