Bovine tuberculosis infection in animal and human populations in Ethiopia: a review

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ABSTRACT: Ethiopia is one among the nations that possesses the largest number of livestock population in the African continent estimated to be 33 million cattle, 24 million sheep and 18 million goats. In contrast to the huge livestock resource, the livestock productivity is however, found to be very low. The major biological and socio-economical factors attributing to the low productivity includes: the low genetic potential and performance, poor nutrition (in quality and quantity terms), the prevailing of different diseases, traditional way of husbandry systems and inadequate skilled manpower, among others. Ethiopia is one of the African countries where tuberculosis is wide spread in both humans and cattle and the endemic nature of tuberculosis in humans and cattle has long been documented. The disease is considered as one of the major livestock diseases that results in high morbidity and mortality, although the current status on the actual prevalence rate of bovine tuberculosis (BTB) at a national level is yet unknown. Detection of BTB in Ethiopia is carried out most commonly on the basis of tuberculin skin testing, abattoir meat inspection and very rarely on bacteriological techniques. Recently undertaken studies indicated the prevalence rate of BTB with a range of 3.4% (in small holder production system) to 50% (in intensive dairy productions) and a range of 3.5% to 5.2% in slaughterhouses in various places of the country. BTB in cattle remains to be a great concern due to the susceptibility of humans to the disease. The infections mainly take place by drinking raw milk and occur in the extra-pulmonary form, in the cervical lymphadenitis form in particular. The aim of this paper is to review the status of BTB in Ethiopia in relation with the existing animal husbandry systems and abattoir meat inspection surveillances. Control measures, economic impacts and the zoonotic aspect of the disease are also briefly addressed.

Keywords: *Mycobacterium bovis*; pastoral production; pasteurisation; zoonosis; food safety; test-and-slaughter

Contents

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1. Introduction

Bovine tuberculosis (BTB) is a chronic infectious disease of animals characterised by the formation of granulomas in tissues and organs, more significantly in the lungs, lymph nodes, intestine and kidney including others. BTB is caused by slowly growing non-photochromogenic bacilli members of the *Mycobacterium tuberculosis* complex: *M. bovis* and *M. caprae* species. However, *M. bovis* is the most universal pathogen among mycobacteria and affects many vertebrate animals of all age groups including humans although, cattle, goats and pigs are found to be most susceptible, while sheep and horses are showing a high natural resistance (Radostits et al., 2000; Thoen et al., 2006).

BTB has been significantly widely distributed throughout the world and it has been a cause for great economic loss in animal production. In developed countries, BTB in animals is a rarity with occasional severe occurrences in small groups of herds. In developing countries, however, such as in 46% of African, 44% of Asian and 35% of the South American and the Caribbean countries, sporadic occurrences and (particularly in Africa 11%) enzootic occurrences of BTB have been reported (Cosivi et al., 1998).

BTB, apart from being the most important disease of intensification with a serious effect on animal production, also has a significant public health importance (O'Reilly and Daborn, 1995). Although, the direct correlation between *M. bovis* infection in cattle and human populations is not well known (Collins and Grange, 1983; Cosivi et al., 1995), however, zoonotic BTB is present in most developing countries where surveillance and control activities are often inadequate or unavailable.

The actual impact of animal BTB on human health is generally considered low in developed and developing countries, which may be based on the rare identification of *M. bovis* isolates from human patients (Amanfu, 2006). In addition, the occurrence of BTB due to *M. bovis* in humans is difficult to determine accurately because of technical problems in isolating the micro-organism (Collins and Grange, 1983). Currently, the BTB in humans is becoming increasingly important in developing countries, as humans and animals are sharing the same micro-environment and dwelling premises, especially in rural areas. At present, due to the association of mycobacteria with the *HIV/AIDS* pandemic and in view of the high prevalence of *HIV/AIDS* in the developing world and susceptibility of *AIDS* patients to tuberculosis in general, the situation changing is most likely (Amanfu, 2006).

Prevalence data on BTB infection in Africa is scarce. There is, however, sufficient evidence to indicate that it is widely distributed in almost all African countries and even is found at high prevalence in some animal populations (WHO, 1994; Ayele et al., 2004; Zinsstag et al., 2006a). However, in the tropical countries including Ethiopia, BTB has been found to affect a higher proportion of exotic breeds than local zebus, which has been conferred through prevalence studies of BTB in different parts of Ethiopia (Ameni, 1996; Kiros, 1998; Ameni et al., 2001). The economic impact of BTB has also been reported (Gezahegne, 1991). Thus BTB is still a great concern in many developing countries and Ethiopia is one of those where BTB is considered as prevalent disease in cattle populations. Its zoonotic implication has also significantly indicated an increasing trend to be of public health hazards (Kiros, 1998; Regassa, 2005).

Currently after *HIV/AIDS,* human tuberculosis is responsible for the deaths of more people each year than any other single infectious disease, with more than 7 million new cases and 2 million deaths per year and it is responsible for one-third of all deaths of *HIV*-infected individuals in Africa (Zinsstag et al., 2006a). In Ethiopia, the endemic nature of the human tuberculosis has long been documented

(Octapodas, 1963) and has been recognised as a major problem of human health for accounting a high rate of morbidity and mortality (Ministry of Health, 1978–1980). However, it has been suggested that, due to historical and geographical reasons, human tuberculosis has recently been imported into Ethiopia (Alemu, 1992).

Although morbidity and mortality statistics have been lacking the curative services, they have brought an ever increasing incidence of tuberculosis to the attention of Ministry of Health, Ethiopia, indicating a more progressive spread of the disease than expected. For example, the total number of active tuberculosis patients was estimated to be 0.5 million in 1969 (Gorden, 1968), 0.8 million in 1978 and 1.5 million in 1980 (Ministry of Health, 1978–1980).

At present all types of tuberculous cases are found to be ranked 4th (4.3%) among the top 10 diseases leading causes of admission in 2003, also as the 2nd (11.5%) cause of death among the top 10 diseases in 2004 (Ministry of Health, 2004). However, the current level of the problem and its impact is not clearly estimated due to various constraints, most notably due to lack of health institutions and reliable data, in rural areas in particular. The aim of this paper is to review the status of BTB in Ethiopia in relation with the existing animal production systems. The zoonotic impact of *M. bovis* infection in humans and its economic importance is also briefly addressed.

2. Bovine tuberculosis: the status in Ethiopia

Ethiopia is one among the nations that possesses the largest livestock population in the African continent with an estimated 30–33 million cattle (Alemayehu, 2003; FAO-STAT, 2003), 24 million sheep, 18 million goats and 7 million equines (Alemayehu, 2003). The distribution and the quantity of each species is different according to the type of prevailing animal production systems and agro-ecological zones.

In contrast to the huge livestock resource, the livestock productivity is, however, found to be very low. The major biological and socio-economical factors attributing to the low productivity includes: the low genetic potential and performance, poor nutrition (in quality and quantity terms), the prevailing of different diseases, traditional way of husbandry systems and inadequate skilled manpower among others. Ethiopia is one of the African countries where BTB is considered as protruding disease in animals.

Detection of BTB in Ethiopia is carried out most commonly on the basis of tuberculin skin testing, abattoir meat inspection and rarely on bacteriological techniques. However, the current status on the actual prevalence rate of BTB at a national level is yet unknown. In Ethiopia, screening of cattle by the tuberculin skin test was sporadic until 1984. But, while the higher prevalence rate of the disease has been observed after the two year survey in government and some "parastatal" dairy farms, then it was decided to embark on a routine BTB survey, on these dairy farms, in particular using single and comparative intradermal skin tests (Alemu, 1992). Since then tuberculin skin test and abattoir meat inspection surveillances have been undertaken in different parts of the country at various times.

2.1. Undertaken studies in the animal populations

Most of the surveys carried out in Ethiopia have been based on tuberculin skin testing and abattoir inspection reports of animals in a particular locality. BTB is one of the endemic infectious diseases that have long been recorded in Ethiopia (FAO, 1967; Hailemariam, 1975) and the infection has been detected in cattle in Ethiopia and rarely in other species of domestic animals (FAO, 1972).

The disease is considered as one of the major livestock diseases that results in high morbidity and mortality (MoA, 1984). Furthermore, in recent years, Ethiopia has reported the occurrence of BTB in the years 1992–1996 and 2001 (FAO-OIE-WHO Animal health year books, 1992–1997; OIE 1998-2001, cited by Ayele et al., 2004; Zinsstag et al., 2006a). However, still there is lack of knowledge about the actual prevalence and distribution of the disease at a national level.

Despite this, the economic impacts and zoonotic importance of the BTB infection are either not well studied or documented. A study undertaken in previous years, 1984–1986, has shown the prevalence rate of 16.7% of BTB based on tuberculin skin tests on the government state farms and other "parastatal" dairy farms (Alemu, 1992). Among the recently undertaken studies, the prevalence rate of BTB ranges from 3.4% in a small holder production system to 50% in intensive dairy productions has been reported in various places of the country (Kiros, 1998; Ameni and Roger, 1998; Ameni et al., 2003a,b; Asseged et al., 2001; Regassa, 2001, 2005) (Tables 1, 2 and 3).

In Ethiopia, exotic breeds were found to be more susceptible than cross and local breeds to *M. bovis* with manifestation of high incidence and prevalence rates (Kiros, 1998; Regassa 2005; Ameni et al., 2006). In addition, a herd prevalence rate of 42.6% to 48.6% was found to be higher than the prevalence rate of individual animals (7.9% to 18.7%), that may indicate that the herd size can favour the transmission of BTB in intensive dairy farms in particular (Ameni et al., 2003b; Shitaye et al., 2006.)

2.2. Undertaken studies in the human populations

The role of BTB causing tuberculosis in humans has not been studied adequately. However, very few studies have indicated the isolation of the causal agent of BTB from humans in Ethiopia. With respect to this, Kiros (1998) demonstrated that out of 85 sputum samples taken from 28 dairy farm workers and 57 tuberculous patients where, 48 samples were positive for acid fast bacilli, of which 14 (29.2%) were niacin negative indicating *M. bovis* and 34 (70.2%) *M. tuberculosis* isolates. With a similar scenario, Regassa (2005) demonstrated that, out of 87 sputum and 21 fine needle aspiration (FNA) human samples, 42 mycobacteria species were identified by culture, of which, 7 (16.3%) and 31 (73.8%) were found as *M. bovis* and *M. tuberculosis,* respectively.

Furthermore, the author indicated that a higher prevalence of BTB in cattle owned by tuberculous patients was found than in cattle owned by non-tuberculous owners, which suggests the significant role of *M. bovis* in the incidences of tuberculosis in humans (Regassa, 2005). In addition, Kidane et al. (2002) indicated that *M. bovis* along with other *MTC* species were found to be a cause for tuberculous lymphadenitis in humans.

The occurrence of *M. bovis* in humans against the background of the soaring *HIV/AIDS* incidence in Eastern and Southern Africa implies that the risk of spillover of zoonotic BTB to rural communities is rapidly increasing (Zinsstag et al., 2006a). Thus, the correlation between the prevalence of *M. bovis* infection in humans and that of local cattle populations highlights the potential threat of this disease for humans (Daborn et al., 1996; Regassa, 2005), most notably in developing countries like Ethiopia, where drinking raw milk is a common practice in rural areas in particular.

3. The impact of animal production systems on bovine tuberculosis prevalence in cattle

The livestock production systems in the country basically falls into three categories according to the mode of animal husbandry and/or the production system, as well as the use of livestock products. These production systems include:

(i) Extensive production system:

– Integrated extensive production system; most notably crop production is the primary target, while animals are kept for draught power and for seasonal milk and meat production in the semi-arid and highland areas. This production system holds about 85% of the total livestock population of the country, though animal husbandry is a traditional practice with low hygienic standards.

– The pastoral production system; denotes an economy that derives the bulk of its food supply from animals (milk and meat) using a variety of herding practices based on constant or partial herd mobility ("oscillatory type of movement") in the low land areas of the country. It covers 12% of the total livestock population and 61% of the total area of land in the country (MoA, 2001; Anonymous, 2003).

(ii) Small holder production system; a small number of herds are reared for milk and milk product productions and mostly located near peri-urban areas.

(iii) Intensive production system; targeted for milk and milk products production, some intensive feed lots for meat production and mostly located near peri-urban and urban areas (MoA, 1984).

The small holders and intensive production systems in particular meet their target for milk and milk products production through the introduction of exotic breeds. However, in contrast, this introduction of exotic and cross-bred cattle, into the central highlands of Ethiopia in particular has created a conducive environment for the spread of BTB that puts the people, most notably those who drink raw milk, under the risk of BTB infection (Ameni et al., 2003b).

The prevalence of BTB is different in various production systems due to environmental and management factors (malnutrition, pregnancy and concurrent infection) that may suppress the immune responsiveness and these may be important in cattle herds (Collins, 1994; Tweddle and Livingstone, 1994; Kiros, 1998). The prevalence of BTB in Ethiopia studied on the aforementioned existing farming systems including on studies at slaughterhouses are stated herein.

3.1. Integrated extensive and/or pastoral production system

In Ethiopia, the extensive production system ("two categories"), that are mainly practiced as the integrated extensive husbandry system (more in the highland areas) and the pastoral production systems (in the lowland areas) of the country. Although the highland areas hold a large number of livestock populations, the cattle breeding however, is a welcome secondary activity to diversify the crop production. Thus, animals are reared and managed traditionally for draught power purpose. On the other side, the lowland areas where the pastoral production system is predominant, animals are the main source of beef, goats, camel meat and milk products to the nation including for export earnings. In both production systems drinking raw milk is a common practice, in rural areas in particular, which may expose the community to contagious diseases most notably BTB.

Regrettably, in this production system, despite the presence of a huge livestock population, the actual prevalence of BTB is not yet known. Difficulties in sampling techniques and animal handling, combined with inadequate veterinary infrastructures are factors that hamper the process of the study (Abdo, 1993). In pastoral areas in particular, the study process can be more complicated by the frequent movement of animals for water (watering points) and to livestock markets. To this effect, animals come together from different directions and due to the enclosure of animals overnight may expose to the increased transmission of BTB, leading to a high prevalence of the disease (WHO, 1993). This scenario can be more aggravated during a severe dry season, when drought takes place for a longer time in particular, so as animals will get enough time to be in contact with others, that favours the transmission of the infection.

From the very few undertaken studies, in an integrated extensive production system in the highlands, the prevalence rates of BTB ranging from 3.4% (Regassa, 2001) to 22.6% (Tadele, 1998) have been reported (Table 1). So far, to our knowledge, no study report has been made on the prevalence of BTB in the pastoral areas in the country.

3.2. Small holder production system

The small holder production system is dominantly practiced in highland areas near towns where dairy animals are reared for subsistence and/or commercial milk production purposes. Under this production system, prevalence studies on BTB have not been conducted adequately, although some cross-sectional studies have been undertaken. Among

Table 1. Prevalence of bovine tuberculosis detected by single tuberculin skin tests in a traditionally managed extensive production system in six farming areas in different districts

Area of study	No. of cattle			Reference
	tested	positive	%	
Assella*	281	25	8.9	Teshome, 1986
Debre-Birhan	76	11	14.5	Tadele, 1998
Kombolcha	53	12	22.6	Tadele, 1998
Dessie	34	4	11.8	Tadele, 1998
West Wellega	353	12	3.4	Regassa, 2001
North Shewa	1 041	169	16.2	Regassa, 2005
Total	1 838	233	12.9	

*a comparative intradermal tuberculin skin test was used; positive results are given for bovine tuberculin

Table 2. Prevalence of bovine tuberculosis in smallholder dairy farms based on tuberculin skin test in seven farming areas in different districts

Areas of study	No. of cattle			Reference
	tested	positive	%	
Holleta*	389	25	6.4	Teshome, 1986
Selale*	1 528	78	5.1	Teshome, 1986
Wolaita-Sodo*	416	59	14.2	Regassa, 1999
Fiche**	735	31	4.2	Gemta, 2000
Wuchale-Jida*	763	60	7.9	Ameni et al., 2003a
Assella*	514	18	3.5	Redi, 2003
Addis Ababa	473	61	12.9	Alemu, 1992
Total	4 818	332	6.9	

*comparative skin tests with bovine and avian tuberculin

**a single intradermal skin test with bovine tuberculin

these few conducted studies the prevalence rates of BTB of 5.1% (Teshome, 1986), 4.2% (Gemta, 2000) and 16.2% (Regassa, 2005) have been reported (Table 2).

3.3. Intensive production system

Although some few intensive feed lots exist, dairy production is the major practice of this system, which is targeted for the production of milk and milk products. The total number of the cattle population under this production system is insignificant compared to the national livestock population; however, it is the main source of milk for the city dwellers. Unlike other production systems, better prevalence studies have been undertaken and frequently incidences and higher prevalence rates of BTB have been observed. Based on the undertaken tuberculin skin tests, in different intensive dairy farms, a prevalence rate of 30.8% (Teshome,1986; Alemu, 1992), 24.3% to 65.8% (Ameni et al., 2003b) and 18.7% (Shitaye et al., 2006) have been reported (Table 3).

4. Meat inspection at slaughterhouses

In Ethiopia the routine abattoir inspection for any infection including BTB applies the method developed by the Meat Inspection and Quarantine Division of the Ministry of Agriculture (Hailemariam, 1975). It involves visual examination and palpation of intact organs like the liver and kidney as well as palpation and incision of the head, lung and pleural lymph nodes. Other lymph nodes are incised if lesions are detected in one of these tissues.

During observation of the miliary tuberculous lesions in various parts of the carcass (lung, intestine, liver and multiple lymph nodes), the whole carcass is condemned, while condemnation of organs is undertaken if localised tuberculous lesions are observed in parenchymatous organs and their associated lymph nodes. Currently, the detection of various zoonotic and economic important diseases in slaughterhouses is carried out in the municipality, commercial and/or export abattoirs, which are located in various places of the country.

4.1. Detection of tuberculous lesions at slaughterhouses

In Ethiopia, based on the detection of tuberculous lesions, condemnation of carcasses totally or partially is a standard practice for the control of zoonotic infections at abattoirs. Detection of tuberculous lesions in slaughterhouses takes place by observation of the visible tuberculous lesions in infected cattle; however, the level of the quality of such practices may vary from place to place and/or abattoir to abattoir in the country. Hence, the probability of carcasses to escape the abattoir inspection is likely to be high when a large number

Table 3. Prevalence of bovine tuberculosis detected by tuberculin skin tests in intensive dairy farms in 13 farming areas in different districts

Areas of study	No. of cattle			Reference
	tested	positive	%	
Addis Ababa	843	80	9.5	Teshome, 1986
Addis Ababa	2 098	392	18.7	Shitaye et al., 2006
Ambo	133	37	27.8	Ameni et al., 2003b
Asella	281	23	8.2	Alemu, 1992
Debre-Birhan*	51	3	5.9	Tadele, 1998
Debre-Zeit	739	308	41.7	Teshome, 1986
Debre-Zeit	788	234	29.7	Kiros, 1998
Debre-Zeit*	281	185	65.8	Ameni et al., 2003b
Dessie*	127	6	4.7	Tadele, 1998
Dessie	121	89	73.6	Ameni et al., 2003b
Holleta	70	17	24.3	Ameni et al., 2003b
Kombolcha*	197	96	48.7	Tadele, 1998
Mojo	493	338	68.6	Teshome, 1986
Mullo	525	162	30.9	Teshome, 1986
Repi	481	310	64.4	Anonymous, 1999
Sebeta	37	4	10.8	Ameni et al., 2003b
Sellale	44	3	6.8	Ameni et al., 2003b
State dairy farms**	6 940	1 217	17.5	Alemu, 1992
Ziway*	205	56	27.3	Ameni et al., 2003b
Total	14 454	3 560	24.6	

*test conducted only by a single intradermal skin test with bovine tuberculin

**tuberculin skin test conducted in the years 1987–1991 on state dairy farms around Addis Ababa

of animals are examined in large city abattoirs in particular.

The very few studies in Ethiopia have indicated that not all cattle infected with *M. bovis* have visible tuberculous lesions at slaughter (Asseged et al., 2004; Teklu et al., 2004). This may limit the sensitivity of this detection technique at abattoirs, although detection of tuberculous lesions through abattoir inspection is so far the common procedure in Ethiopia.

Among the undertaken abattoir studies, prevalence rates of 5.2% (Ameni and Wudie, 2003), 4.5% (Teklu et al., 2004) and 3.5% (Shitaye et al., 2006) have been reported in different abattoirs in the country (Table 4). The infection rate in cattle has been found to differ greatly from place to place, especially in slaughterhouses recorded as having a low prevalence of the infection. This difference is most probably linked to the type of the production system (most notably in extensive/pastoral), which is unlikely to favour the spread of the disease in contrast to intensive dairy farms (Ameni et al., 2006; Shitaye et al., 2006).

4.2. Bovine tuberculosis surveillance based on meat inspection data

Despite the irregularities of the abattoirs meat inspection in Ethiopia due to the limitation of other diagnostic methods, detection of BTB continues to depend on slaughter surveillance as the most

Table 4. Prevalence rates of bovine tuberculosis detected by abattoir meat inspection in cattle in different city abattoirs

City abattoirs	No. of cattle			Reference
	examined	positive	%	
Addis Ababa	81 944	123	0.15	Hailemariam, 1975
Addis Ababa	1 350	20	1.48	Asseged et al., 2004
Addis Ababa	984	34	3.46	Shitaye et al., 2006
Debre-Zeit	3 934	7	0.18	Hailemariam, 1975
Dire-Dawa	7 453	4	0.05	Hailemariam, 1975
Gonder	12 525	3	0.02	Hailemariam, 1975
Hossana	751	34	4.53	Teklu et al., 2004
Kombolcha	57 965	265	0.46	MoA, 1973
Makele	39 875	730	1.83	Hailemariam, 1975
Nazareth	1 125	58	5.16	Ameni and Wudie, 2003
Wolaita-Sodo	402	32	7.96	Regassa, 1999
Wondo-Genet	38 303	207	0.54	Hailemariam, 1975
Total	246 611	1 517	0.62	

economically efficient method for the detection of infected cattle with *M. bovis.* Thus, meat inspection at abattoirs is still considered as a pivotal and the utmost obligatory method for the detection of BTB or other mycobacterial infections. However, because of inadequate comprehensive abattoir surveillance throughout the country, BTB prevalence data from abattoir meat inspections are still scarce.

Data from 1971 for the condemnation rate of cattle with BTB originating from the Dire-Dawa (Eastern Ethiopia) slaughterhouse ranged between 1% and 1.5% that was 1.45% out of 6 940 animals slaughtered within 17 months (Teshome, 1995). Subsequently, summarised data from abattoirs on the number of cases with tuberculous lesions ranging from 0.02% to1.8% in different parts of the country has been reported (Hailemariam, 1975; Asseged et al., 2004). According to Gezahegne (1991), a report from eight export abattoirs showed a prevalence of 0.8% of 144 487 slaughtered animals, in which the whole carcass of 978 animals were condemned. Furthermore, recently based on meat inspection data Shitaye et al. (2006) indicated that BTB with a prevalence of 0.052% of 1 336 266 cattle, 0.001% of 534 436 sheep, 0.001% of 573 767 goats and 0.009% of 10 820 pigs slaughtered in Addis Ababa and Debre-Zeit abattoirs in the years 1996–2005.

5. Zoonotic importance of bovine tuberculosis in Ethiopia

BTB of cattle remains to be great concern due to the susceptibility of humans to the disease caused by *M. bovis* (Kleeberg, 1984) and there is increasing evidence that *M. bovis* infections may be much more significant than generally considered. In Sub-Saharan Africa, nearly 2 million tuberculosis cases in humans occur each year; yet it is unknown what role BTB plays in the rising epidemic of tuberculosis fostered by *HIV/AIDS* (Zinsstag et al., 2006a). A varying portion of pulmonary tuberculosis cases are considered to occur, however, almost all cases of the non-pulmonary type of tuberculosis in humans has been caused due to BTB (Schwabe, 1984).

It is noteworthy to quote Collins et al. (1985), "Every 15 seconds one person dies of tuberculosis in the world". Even though *M. tuberculosis* is mainly responsible for this mortality; some are caused by BTB (Teshome, 1995). BTB in the human population mainly takes place through drinking raw milk and occur in the extra-pulmonary form in the cervical lymphadenitis form in particular. Recently, Kidane et al. (2002) indicated that *M. bovis* was found to be a cause for tuberculous lymphadenitis in 17.1% of 29 human tuberculosis cases in Ethiopia.

The proportion of which BTB contributes to the total of tuberculosis cases in humans depends on the prevalence of the disease in cattle, socio-economic conditions, consumer habits, practiced food hygiene and medical prophylaxis measures. In countries where BTB in cattle is still highly prevalent, pasteurisation is not widely practiced and/or milk hygiene is insufficient, usually estimated to be about 10% to 15% of human tuberculosis is considered to be caused by BTB (Ashford et al., 2001).

In rural areas of Ethiopia most people drink raw milk and do have extremely close attachment with cattle (such as sharing shelter) that intensifies the transmission and spread of BTB. Detection of causal agents of BTB from raw milk (Kinfe and Eshetu, 1987; Teshome, 1993; Kiros, 1998) confirms the existing problem and the potential risk of the infection in humans. With respect to this, Kiros (1998) demonstrated that out of 7 138 human patients with tuberculosis, 38.4% were found with extra-pulmonary tuberculosis and the proportion of patients with extra-pulmonary tuberculosis was significant in patients who have close contact with cattle and in those who frequently used to drink raw milk in particular.

Recently, Regassa (2005) demonstrated the association of *M. tuberculosis* and *M. bovis* in causing tuberculosis between humans and cattle. The cattle owned by tuberculous patients had a higher prevalence (24.3%) than cattle owned by non-tuberculous owners with 8.6%. The author also noted that 73.8% and 16.7% of 42 human isolates were identified as *M. tuberculosis* and *M. bovis* and from cattle isolates 18.1% and 45.5% of 11 were found to be *M. tuberculosis* and *M. bovis* species, respectively. This showed that the role of *M. bovis* in causing human tuberculosis seemed to be significantly important. On the other hand, in Ethiopia, consuming raw meat is a welcome tradition, thus meat may also remain to be another area of concern or threat to be a source of BTB infection.

6. Risk factors conducive to the spreading of bovine tuberculosis infection in Ethiopia

6.1. Cultures and traditions

In developing countries, particularly in Africa, patients' beliefs and cultural traditions are major obstacles to implement the designed tuberculosis control strategies. Tuberculosis is stigmatised in many cultures/traditions and it remains as powerful as that of *HIV/AIDS,* which further complicates the process of investigation by patients hiding their tuberculosis status due to discriminatory views about tuberculosis patients. Social discrimination based on tuberculosis status is thus more a matter of stigma than of appropriate public health precautions. Therefore, risk factor assessment and identification of this pathogen, both in humans and animals, primarily should be targeted towards adapting dependable preventive, therapeutic and control measures.

6.2. Illiteracy

Like in most African countries, in Ethiopia, illiteracy is yet another unsolved problem in most rural communities in particular. Inability to read and write, and failure to utilise modern methods of communication (Ayele et al., 2004), and the limited

Table 5. Human tuberculosis case findings in Ethiopia*

Years	Pulmonary smear cases				Extra pulmonary cases		All new cases
	positive	%	negative	%	No.	%	
2000	28 104	33.1	30 333	35.7	26 542	31.2	84 979
2001	34 473	37.2	28 994	31.3	29 312	31.6	92 779
2002	38 291	35.6	32 197	29.9	37 138	34.5	107 626
2003	37 374	34.2	32 897	30.1	39 076	35.7	109 347
2004	41 430	34.2	37 119	30.7	42 477	35.1	121 026
Total	179 672	34.8	161 540	31.3	174 545	33.8	515 757

*source: Health and health related indictors, Planning and Programming Department, Ministry of Health, Addis Ababa, Ethiopia (1992–1996 Ethiopian calendar) knowledge of the community related to the epidemiology of BTB infection, makes prevention and control programmes difficult and often impossible to apply.

6.3. Demography, socio-economic status and feeding habits

From the total population of Ethiopia, about 85% of the people are engaged in agriculture. To this effect, very close contact with potentially infected animals may be high, which eventually leads to exposure of the BTB infection. For the urban residents, milk is considered as the main source of BTB infection, while abattoir workers and farmers are predominantly exposed to the aerosol infection as a result of close contact with infected animals (WHO, 1994).

The major factors among which contribute to the acquisition of the infection in both urban and rural populations are family ownership of cattle, previous livestock ownership, sharing of the house with animals, consumption of non-pasteurised milk (raw milk) or poorly cooked meat (WHO, 1994; Kazwala et al., 1998; Pavlik et al., 2003; Ayele et al., 2004). All these causalities and/or habits are the daily practices most notably of rural communities in Ethiopia. In particular, milk borne infection is the main cause of non-pulmonary tuberculosis in areas where BTB is common and uncontrolled (Daborn et al., 1996; Kiros 1998).

Professional occupation or workers such as, abattoir workers, veterinarians and laboratory technicians, animal care taker in zoos and those who are working in animals reservations and at national parks can also acquire the infection in due course of regular work (Grange and Yates, 1994; Liss et al., 1994; Pavlik et al., 2002).

Furthermore demographic factors, such as income, education, age, number of family, number of individuals dwelling per m^2 and sanitation etc are also contributing to the epidemiology of BTB (Ayele et al., 2004). Families with low income often face malnutrition which, when associated with the burden of *HIV/AIDS* infection, increases susceptibility to various infectious diseases such as tuberculosis by the impaired immune system, in particular the lymphocyte function which plays an important role in containing mycobacterial infections (Macallan, 1999). Moreover, reports indicated that infants are more vulnerable to food-borne *M. bovis* infection, where as older individuals averting BTB may occur as a result of endogenous reactivation (Grange and Yates, 1994; Grange 1995; Thoen and Steele, 1995; Pavlik et al., 2002).

6.4. Role of wild life reservoirs

In Africa a high prevalence of TBC was reported in monkeys (*Macaca mulatta*; Baywater et al., 1962), in buffaloes (Wiliamson and Payne, 1978) and deer (*Dama dama*; Tower 1968). Recent reports in South Africa indicated that there were four outbreaks of BTB in the buffaloes during the years 1996 to 2003. In addition to this, the disease has been prevalent in an Eastern province of South Africa in the 1930s and there are strong indications that greater kudu (*Tragelaphus strepsiceros*) act as maintenance hosts (Bengis and Cooper, 2004, unpublished data, cited by Kriek, 2006). Despite this, kudu have been the source of *M. bovis* infection in one wildlife reserve in Kwazulu-Natal in a group of BTB-free African buffaloes (Kriek, 2006). So far, to our knowledge, no BTB cases have been reported in Ethiopia in the wildlife population. However, the presence of the aforementioned animals in different wildlife reserves and even in free ranging forests may have an epidemiological role in the spread of the disease among other wild and domestic animal species. Moreover, Alemu (1992) suggested that the widely distributed Rock hyrax (*Procavia capensis*) might also be a possible reservoir of BTB in Ethiopia.

6.5. *HIV/AIDS* epidemic in Ethiopia

Available data suggest that the incidence of tuberculosis in humans has risen in recent years, partly as a result of the *HIV/AIDS* epidemic impact (WHO, 2005). In addition to this, the incidence of BTB in humans has also risen in recent years as a result of the impact of the *HIV/AIDS* epidemic (Cosivi et al., 1998; Ayele et al., 2004; Zinsstag et al., 2006a).

Tuberculosis and other mycobacterial infections are major opportunistic infections in *HIV/AIDS* infected individuals (Grange et al., 1994; Raviglione et al., 1995), while *HIV/AIDS* is a major predisposing factor for tuberculosis including reactivation of the disease. The current spreading pandemic of *HIV/AIDS* infection in developing countries, especially where BTB is prevalent in domestic and wild animals' poses an additional serious public health threat (Grange and Yates, 1994; Grange et al., 1994; Cosivi et al., 1995; Pavlik et al., 2002; Ayele et al., 2004). In Ethiopia, the first case of *HIV/AIDS* was reported in 1985 (Ministry of Health, 2002), while recent studies have shown a prevalence rate of 4.4% for *HIV/AIDS* in adults aged 15 to 49 years with the vast proportion having extra pulmonary tuberculosis (WHO, 2005).

7. Economic importance of bovine tuberculosis

The economic importance and public health significance of tuberculosis has been established in many countries (Konhya et al., 1980; Jaumally and Sibartie, 1983). Recently, Zinsstag et al. (2006b) reviewed the economic effects of BTB on cattle productivity, the burden of disease in different settings and at different stages of public health development and the transsectoral (Public health, Agricultural, Environment) economic analysis of BTB control. However, in Ethiopia, the economic impact of BTB on cattle productivity, BTB control programmes and other related economic effects of the disease are not yet well documented or studied. Few abattoir meat inspection surveillances have shown the condemnation rate of the total or partial carcass and organs. With this respect, Abel (1989) reported that out of 29 956 slaughtered cattle in Dire-Dawa city abattoir, a total of 31.2% and partial of 16.4% condemnation rates that may result in economic losses significantly.

Lately Gezahegne (1991) demonstrated that from 1.2 million slaughtered cattle in eight export abattoirs had an estimated cost of more than 600 000 ETB (300 000 USD) during a respective time, resulted due to condemned carcasses and organs. Asseged et al. (2004) demonstrated that, based on the ten years retrospective analysis of the detection of BTB lesions in the Addis Ababa abattoir, there was a cause of 0.024% for whole carcass condemnation. Recently, Shitaye et al. (2006) indicated that, in both Addis Ababa and Debre-Zeit abattoirs tuberculous lesions that, causes condemnation of carcasses and/or organs have also been found to be highly significant economically.

8. Control of tuberculosis in Ethiopia

The effective control and eradication of BTB from herds and/or farms of cattle depend on identifying and isolating potential sources of infection from the herds, through test-and-slaughter-strategy. However, there are also various modifications of eradication and control programmes adopted in different countries. In developed countries BTB has nearly been eradicated or drastically reduced in farm animals to low levels by control and eradication programmes (Cosivi et al., 1998; Pavlik et al., 2002; Ayele et al., 2004). In Ethiopia these measures, however, can not be adopted in practice due to various reasons such as: lack of knowledge on the actual prevalence of the disease, the prevailing technical and financial limitations, lack of veterinary infrastructures, cultural and/or traditional beliefs and geographical barriers, though certain control measures are in place.

8.1. Control in the cattle populations

Despite the presence of the above constraints, attempts have been undertaken in government state farms in particular. For example, based on tuberculin skin testing results in Mojo state dairy farm (Central Ethiopia) 50% of the positive reacted cattle were culled and slaughtered. In addition to this measure, the farm was closed and healthy cattle were transferred to other farms (Alemu, 1992). On government owned dairy farms, test and isolation of reactors combined with pasteurisation of milk are the current undergoing control practices. However, these measures, as compared to the cattle population of the country, are found to be insignificant.

Unlike state dairy farms, in other "parastatal" dairy farms (small holders in particular), these control measures are not well practiced. This scenario is worse by far in most of the extensive production systems. In general terms, control measures in the traditional extensive production systems are more difficult and complex. This is the virtue of the large numbers of livestock involved, the mobility of animals (pastoral production) and the social and economic factors involved. In Ethiopia so far, control of BTB through the test-and-slaughter policy is not yet established. Most commonly culling of infected animals (especially in government: owned farms) and improving sanitary and hygienic standards in other dairy farms is the actual control measure of BTB infection. Currently there is an attempt to establish an infection/disease free area (Sileshi, Ministry of Agriculture and Rural Development, 2005, personal communication), which enables the country to control zoonotic and economic important diseases including BTB.

8.2. Control in the human populations

The health policy in Ethiopia, dating 1993, gives priority to the control of communicable diseases, including tuberculosis and *HIV/AIDS*. The health system is being progressively decentralised under the country's primary health-care delivery strategy and the system of tuberculosis control has been designed (Ministry of Health, 1993; WHO, 2005). The DOTS strategy is being implemented in most districts and almost all hospitals and health centres provide DOTS services, although basic health services are not yet accessible to about 40% of the population (WHO, 2005).

In general, tuberculosis can be effectively controlled through BCG vaccination and employment of chemotherapy. The conventional anti-tuberculosis drugs (isoniazid, rifampicin, pyrazinamide, thiacentazone and ethambutol) are used to control and prevent the spread of the disease. The treatment course can be either short (2 months) or the standard treatment regime (6 to 8 months). Treatment success among new patients was only 76% in the 2002 cohort, considerably lower than Ethiopia's maximum of 80% reported for 2000 (WHO, 2005). Furthermore, the country has carried out the first ever drug resistance survey and found with a preliminary results indicating 1.7%, the multi-drug resistance (MDR) among new cases is somewhat lower than the WHO estimate of 2.3% (WHO, 2005).

Moreover, health education is practicing as one of the pivotal means to control through sensitisation and increasing awareness of the community about the epidemiological characters of the disease and other effective measures are being made to ensure better access through out the country.

8.3. Recommendations

For the effective control of BTB in Ethiopia, it is worthwhile to apply the following measures as fundamental practice:

(i) Identification of animals: Before embarking on any control programme it is essential that all dairy farms (because of high prevalence) should be registered and that all dairy cattle older than six months of age are identified with permanent marks, at least tagged with ear tags. At present, tagging is practiced in intensive dairy farms, but it does not yet cover all dairy farms, small holders in particular.

(ii) Improvement of management and hygienic practices: In most parts of Ethiopia, animals are kept near dwellings and maintained under very poor management and hygienic status, thus increasing the risk of acquiring infection for animals and humans as well. Therefore, creating awareness among the people, to meet the standard hygienic requirement and to improve husbandry practices is of paramount importance. In intensive dairy farms, building of the new premises needs to be done according to designs appropriate to dairy farms taking into account space per-cow, proper manure disposal, good ventilation and lighting systems. Pasteurisation of milk and milk products should be done as routine practice most notably in rural communities.

(iii) Legislation: For enabling enforcement of control measures, there is a need for a legislation that makes it obligatory to register dairy farms and to notify the veterinary personnel about any animal purchase, sales or transfer of farms. These measures can be gradually expanded to the traditional integrated extensive farm systems. Test-and-slaughter policy should be designed and started as a major control measure to avert the spreading of the BTB infection.

(iv) Insurance of dairy farms: Although this principle is not yet familiarised; however, insuring dairy farms may encourage owners to cull their infected cattle after testing for BTB and other economically important contagious diseases.

(v) Sound testing and meat inspection: Based on a proper strategy, regular tuberculin skin testing should be continued in large with significant efforts in all animal production systems nationwide. Similarly, routine abattoir meat inspection procedures have to be made for the detection of tuberculous lesions and special attention has to be given while a large number of animals are examined in particular. The result can be upgraded when Ziehl-Neelsen staining is simultaneously used. There is also the need to have the qualified veterinary staff at the slaughterhouses so that quality data can be generated for effective control measures. It is equally important to take strict control and quarantine measures during the importation of animals and animal products.

(vi) Establishment of areas and/or farms free of BTB: A bi-annual testing programme could be introduced to establish a "provisional disease free status in some herds/farms or areas". Under this scheme a herd with a negative result in two successive tests could be declared provisionally free from BTB. If this strategy is started, it should then be strengthened with a frequent follow up to make sure that these farms are not re-infected.

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