Non-biological factors affecting bovine tuberculosis control and prevention in dairy cattle: knowledge, attitude, and practices (KAP) of dairy farmers in Ethiopia

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Abstract

Bovine tuberculosis (bTB) is a serious animal health problem in Ethiopia, ranking among the top three livestock diseases. If conditions that favor the transmission and persistence of bTB are not addressed, the situation will get worse; hence bTB control should be priority. However, interventions are influenced by several "non-biological" factors. A cross-sectional study was conducted to assess farmers` knowledge, attitude, and practice (KAP) using a structured questionnaire administered to 307 respondents. A multi-stage sampling procedure was employed to select study subjects. Accordingly, 55% of participants knew about bTB; of which 36.4% knew basic information, and the remaining (18.6%) knew nothing except the name bTB. Less than 2.0% of the farmers knew about zoonotic importance of bTB. The knowledge among dairy farmers varied depending on farm size, milk-shed (MS), training received, veterinary consultation, and years of farming experience. Using multivariable analysis, farmers from medium and large-scale farms knew more about bTB than those from small scale farms, by a factor of 2.8 and 7.7, respectively. Similarly, farmers who had been farming for more than 6 years and farmers from Selale MS had higher odds of being knowledgeable about bTB, by 5.7 and 10.4 times compared to other MS, respectively. Only 12% of participants were aware of the test and slaughter control method. Likewise, only 18% of the farmers tended to avoid buying cattle from risky sources. The finding revealed a lack of knowl-

edge on the production loss incurred (12%) and the probability of human infection (1.9%); instead, a substantial proportion of farmers (25%) believed that bTB infection could affect the dairy market. In conclusion, the present study highlighted knowledge, attitude, and practice gaps that, if addressed using tailor-made training, might assist in reducing the consequences of the disease.

Keywords: Bovine tuberculosis; Control; Farmers; KAP; Milk-shed.

Introduction

Although bTB is still present in some industrialized countries, currently, it is a disease that mostly affects low-income countries lacking the resources to apply expensive test and slaughter schemes (Bemrew *et al.,* 2015). Recently, bovine tuberculosis has been identified as one of the top three, high-priority, livestock diseases in Ethiopia (Lakew *et al.,* 2022). The existence of potential associated factors would make it conducive for the spreading and persistence of bTB (Ayele *et al.,* 2004; Regassa *et al.,* 2008; Girmay *et al.,* 2012) and making control of bTB priority.

Bovine tuberculosis is a poorly studied and widely underreported zoonosis but is believed to be a significant contributor to animal and human losses (Grace *et al.,* 2012; Liverani *et al.,* 2013). In Ethiopia, the number of *M. bovis* infections in humans has been reported to be low despite it likely to be a substantial and high health risk because of the high prevalence of the disease in livestock (Ayele *et al.*, 2004; Kemal *et al.,* 2019).

According to the World Health Organization (WHO), there is no single intervention that can effectively control bTB on its own, unless able to block all routes of transmission of the disease (WHO, 2023). Conventionally, a typical strategy for bTB control in domesticated animals involves regular tests and slaughter of infected animals However, beyond the high cost incurred, these interventions are influenced by several "non-biological" factors (Ciaravino *et al.,* 2017). For instance, farmers are the actors who regularly interact with veterinarians, and who comply with or resist the legislative basis and biosecurity practices recommended or enforced for disease control. They own the animals which succumb to infection, determine their husbandry and welfare, buy and sell them, present them for disease testing, and take risks of financial loss for affected animals (Robinson, 2017). Hence, the knowledge, attitudes, and

behaviors of dairy farmers is a key factor for successful disease control and surveillance systems (Pfeiffer, 2006; Brennan *et al.,* 2016).

Most high-income countries have successfully controlled bTB based on test-and-slaughter programs, alongside slaughterhouse surveillance, and trade and movement restrictions of affected herds (Napp *et al.,* 2019; OIE, 2019). A test-and-slaughter control method is impractical to adopt in low- income countries due to extensive socioeconomic significance where replacement of equivalent breeding stock might be excessively unaffordable (McCrindle and Michel, 2007). Therefore, the need for evaluation of potential control strategies is critical to minimize the impact of the disease (Lakew *et al.,* 2022). In the past, social factors have not been often given enough attention in the implementation of animal health programs. Inversely, the impact of social factors on public health interventions is well known, and these aspects have been accounted for in several human medicine studies (Berkman *et al.,* 2014; Bach *et al.,* 2017).

Recently, the situation has changed, and social factors have become more relevant for the control of animal diseases. Studies have shown that it is crucial to understand how the different actors involved think and act since their attitudes and behaviors affect the effectiveness and sustainability of such programs (Catley *et al.,* 2012; Enticott *et al.*, 2015; Brunton *et al.,* 2018).

Even though bovine tuberculosis is an endemic disease in Ethiopia, less attention was given to its control because of lack of awareness, policies, and resources. Measuring farmers' knowledge, attitudes and practices (KAPs) is a significant step when developing and implementing disease control and prevention strategies (Balkhy *et al.,* 2010; Brennan *et al.,* 2016).

The knowledge, attitudes, and practices (KAPs) of farmers regarding bovine tuberculosis have not yet been adequately investigated in Ethiopia. Many of the previous studies were fragmented, as they were conducted by different scholars to address only some specific problems. These studies were noted to have limitations either to produce a more comprehensive and representative pooled country level picture, or to generate detailed information that could remarkably impact the application and effectiveness of interventions against bTB, for one or another reason including, differences in the scope of study objectives, the methodology used, the target population and geographic coverage. As a result, additional all-inclusive investigations on the potential source of infec-

tion, public health and economic burden of the disease, the transmission ways, and its control measures are essential to attain a comprehensive and accurate insight into the subject (the gaps in knowledge, attitude and practice) which, if addressed, could help policy makers and researchers to design effective and adaptable intervention strategies. With this understanding, a cross-sectional study was designed to assess farmers' knowledge and attitude associated with bovine tuberculosis and to identify farm practices that potentially resulted in the disease remaining endemic in selected milk-sheds of Ethiopia, where most commercial dairy farms are found.

Material and methods

Study setting and sampling procedure

A multi-stage sampling procedure was applied for the study. Taking the level of intensification of dairy farming into consideration, the four milk-sheds (MS) of Asela-MS, Debre-birhan-MS, Selale-MS and Others-MS were selected for their substantial dairy farm number, different socio-economic and cultural features, facilities, operational safety, and convenience. Since farmers` knowledge of bTB and its possible determinants may vary in different areas, the study was conducted in four different settings. The Selale-MS covers the areas from Addis Ababa, following the major highway, to Muke-turi; Debrebirhan-MS extends from Addis Ababa to the city of Debre-birhan in the north; Asela-MS spans the area from Addis Ababa through Bishoftu and Adama to the town of Asela. Others-MS consists of commercial dairy farms from various regions of Ethiopia (Diredawa, Bahirdar, Gondar, Hawasa, Kombolcha, Harbu /South Wollo). The number of selected farms from each MS ranged between 35 and 108 depending on the number of commercial dairy farms (semi-intensive and intensive dairy farms) with good road access. With regard to herd size, a balanced number of small, medium, and large-scale farms were selected. The classification of herd size into small (1–3 dairy animals), medium (4 − 10 dairy animals), and large farms (more than 10 dairy animals) was made according to the classification made by an FAO report (Sharma *et al.,* 2003). Hence, as part of the survey, we interviewed 111 large-scale, 101 medium-scale and 95 small-scale commercial farmers. A simple random sampling technique was applied to choose dairy farms from each milk-shed.

Number of the study participants was calculated using the formula previously described

$N = (Z^2 P(1-P))/d^2$

Based on the 24.1% awareness of dairy farmers and using 95% level of confidence (CI) and 5% precision in the estimates, the total sample size was determined as 282 dairy farms. To account for an assumed small design effect, we aimed at 307 farmers.

The participants were identified from different randomly selected villages along the study MS, based on their availability and willingness to participate.

Data collection and interview procedure

Using standardized set of questions, we gathered socio-demographic data on determinants that could influence the knowledge, attitude and practice of farmers regarding bTB. This included the age, gender, educational level, participants` role in the farm, training received, veterinary consultation and farming experience of the participants.

Knowledge and attitude on bTB were assessed by asking whether the respondents had heard or knew about bTB or not. The farmers who knew about bTB were further asked some additional questions related to bTB detection, its impacts, transmission, the potential source of infection for their herds, and control measures, through a set of structured questions. Their practices relevant to preventing their herds from getting bTB infection, frequent measures they had taken on reactors and the priority they give to bTB intervention compared to other diseases were also assessed. Furthermore, information on farm size, animal husbandry practices, history of exposure to bTB, their prevailing knowledge and practices towards bTB management, and animals entering and exiting the herd were collected.

The questionnaire was pretested, and interviewing method was validated to have a good insight into commercial dairy farming in the study area. During the pre-test, the questions were evaluated to make sure that the farmers understood them correctly. Using enumerators, dairy farm managers or other persons responsible for the selected farms were questioned in their local language. The enumerators also filled out an observation checklist during the visit. At the beginning of the interview the farmers were informed about the purpose of the study.

Data analysis

The final data were recorded and analyzed using SPSS 16.0. Descriptive statistics were generated for each variable of interest. Percentages and their 95% confidence intervals (95% CI) were calculated. Characteristics of the respondents in terms of age, gender, level of education and farming experience were summarized and presented as percentages and frequency. The selection of variables to be included in the multivariable model was carried out in two steps. Initially, a univariable logistic regression model was built to identify important covariates or determinants that are at least moderately associated with farmers' knowledge, attitudes, and practices, where candidate variables with $p \leq 0.2$ were selected for further analysis based on the Wald test. The multicollinearity between pairs of explanatory variables was assessed by a correlation matrix. The significance of this association was examined using the Chi square test. In the case of a pair of variables with a significant association ($p < 0.05$), the variable judged as the most biologically plausible was used as a candidate in the multivariable analysis. All variables that passed the previous 2 steps were incorporated into the final multivariable logistic regression model. A manual stepwise selection approach was used for the selection of variables in the model using backward variables selection techniques to keep only variables with $p < 0.05$ in the final model.

Results

Demographic characteristics of the respondents

The socio-demographic profile of the respondents is summarized in Table 1. Almost two-thirds (65%) of the study participants were found to be between the ages of 31 and 60 years. Male respondents constituted 69.4%, of which 59.6% (127/213) engaged actively on major dairy farming practices. Only 27.7% of respondents were currently unmarried. Regarding occupational status of the participants, 43.3% (133/307) were owners of the dairy farm, followed by employed staff (31.3%; 96/307). However, a notable percentage, 25.4% (78/307) was unemployed family members.

Table1. Socio-demographic characteristics of study participants.

Variable	Category	Frequency	Percent
Age (years)	18-30	71	23.1
	31-45	98	31.9
	45-60	101	32.9
	>60	37	12.1
Gender	Female	94	30.6
	Male	213	69.4
Marital status	Married	222	72.3
	Unmarried	85	27.7
Occupational status	Employed	96	31.3
	Unemployed/family	78	25.4
	Owner	133	43.3
Role in the farm	Actively engaged	179	58.3
	Supportive staff	116	37.8
	Partime/occasionally	12	1.6

Farmers` awareness on bovine tuberculosis

Nearly 45% of the dairy farmers were not aware of bTB or never heard the name of the disease. Thirty six point four percent of the farmers reported that they knew some fundamental information about bTB, and the remaining 18.6% of the farmers had heard about bTB but needed to learn more in detail. The association between independent variables and knowledge of participants on bTB is shown in Table 2. MS, herd size (scale of the farm), previous experience, training and veterinary consultation had a significant association with participants` awareness of bTB. In Selale MS, more farmers 80% (67/83), knew about bTB than Debre-birhan MS (75%) or other MS (34%). The most common knowledge reported was that bTB could affect cattle and it could be transmitted from infected animals to healthy ones. The source of knowledge was mainly through training (46%), previous experience in dairy farming, and consultation from veterinarians (52%).

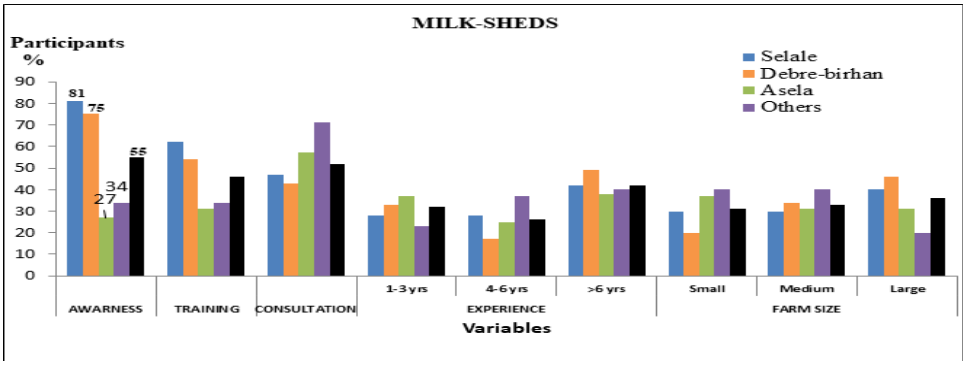

Figure 1. Determinants along the study milk-sheds.

Table 2. Variables having association with farmers' knowledge towards bTB.

Variable	N	X^2-Value	df	*p* value
Milk shed	307	76.34	3	0.000
Educational level	307	24.94	2	0.000
Herd size	307	42.2	2	0.000
Training	307	67.98	1	0.000
Veterinary consultation	307	10.22	1	0.001
Previous dairy farming experience	307	28.55	2	0.000

Multivariable logistic regression analysis revealed that farmers` knowledge of bTB in medium and large-sized farms was almost 2.8 and 7.7 times higher than that of small-sized dairy farms, respectively (Table 3). Dairy farmers who had >6 years of farming experience and farmers from Selale MS had significantly better knowledge about bTB (odds 5.7 and 10.4 times higher in the case of more experienced farmers and farmers from Others MS).

Table 3. Results of multivariable analysis of selected determinants having association with farmers' knowledge towards bTB

Determinants	OR	95% CI	*p* value
Farmers from Selale MS compared to Others MS	10.4	3.8-28.9	0.000
Farmers from Debre birhan MS compared to Others MS	5.8	2.2-15.7	0.001
Medium size (4–10 dairy animals) farms compared to small size (1–3 dairy animals) farms	2.8	1.4-5.9	0.005
Large size (>10 dairy animals) farms compared to small size	7.8	3.6-16.5	0.000
Farmers with 3 - 6 years of farming experience compared to ≤3 years of experience	3.0	1.3-6.8	0.008
Farmers with >6 years of farming experience compare to ≤3 years of experience	5.7	2.8-11.5	0.000

Farmers` knowledge regarding bTB control measures, ways of transmission, its impacts and diagnosis

About 38.8% (117/301) of the participants knew at least some control and prevention methods, of which 30% (36/117) were aware of test and slaughter method as a typical strategy for bTB control and prevention. Likewise, 46% of them preferred to refrain from buying cattle from unknown or potentially infected sources. Farmers` knowledge on bTB control was significantly associated with market sheds, farm size and previous farming experience ($p < 0.05$).

Concerning its modes of transmission, 42.3% (130/307) of participants had some knowledge of how bTB spreads. Knowledge on ways of bTB transmission is summarized in Figure 2. Participants from Selale MS, as well as participants from large-scale dairy farms, had more level of knowledge on bTB transmission ($p < 0.05$). Similarly dairy farming experience had a significant association with disease transmission knowledge.

Less than 2% (1.88%) of the respondents knew the possibility of human infection from infected animals. Only 1.6% of participating farmers knew the skin test as common diagnostic tool for bTB. Similarly, majority of the respondents didn't know its impact on milk and meat production loss (Figure 2).

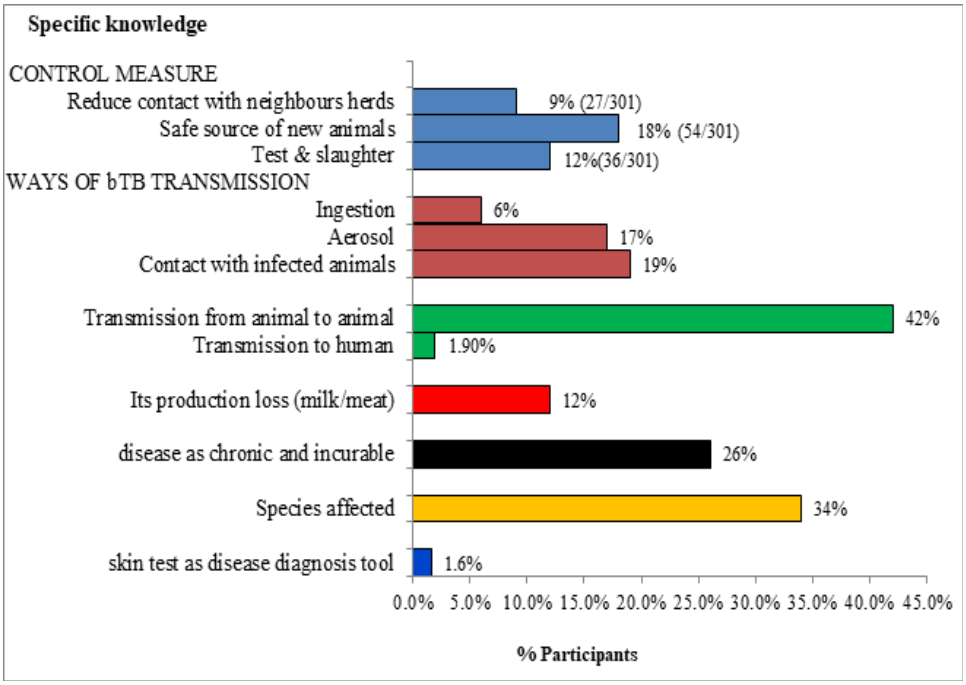

Figure 2. Detail knowledge of participants on bTB control measures, transmission ways, and feature of the disease.

The number of respondents who mentioned aerosol as a mode of bTB transmission, compared to those who mentioned contact with infected animals, was approximately 3 times higher in trained participants compared to those not receiving training (Table 4).

Table 4. The influence of farmers` previous training exposure on their response to the type of mode of transmission.

Farmers' knowledge about mode of transmission	N	OR	CI	*p* value
Contact with infected animal	59	-	-	-
Aerosol	51	3.02	1.27, 7.14	0.012
Ingestion	20	4.17	1.10, 15.78	0.036

Attitudes and practices towards bTB

Results for the responses to questions relating to farmers' attitudes and practices are presented in Tables 5 and 6. Despite only 12% of participants being aware of the production loss incurred by bTB infection, one fourth of the farmers (25%) believed that bTB infection could negatively impact the dairy markets.

Surprisingly, almost none of the respondents (0.98%) believed the test and slaughter method was a feasible and applicable control and prevention measure. Approximately one-fifth of the farmers (22%) thought that improving the community's awareness of bTB is an important element for effective prevention and control. Similarly, 16.3% of respondents mentioned that government or other legal bodies should provide disease free heifers for sale in order to avoid purchasing of cattle from unknown or potentially infected sources. Only few farmers were aware of skin test as a diagnostic tool to identify infected or non-infected animals, and, none of them reported it as a reliable test.

Roughly 21% (64/307) of the farmers listed new animal entry, neighboring dairy farms, and people, equipment and vehicles entering from infected sources as potential sources of infection for their herds, of which introduction of new animals (62.5%) taking the largest share.

Univariable analysis revealed that trained farmers' perception was 12.8 times higher than non-trained farmers, perceiving new animal entry as a primary source for the introduction of the disease into their farms. Farmer's recommending nothing to do to bTB reactors or to sell reactors to others was 11.8 times higher in untrained farmers, while those advised slaughter of reactors for meat was 4.95 times higher in trained farmers.

Among those who knew about bTB, only 1.6% of dairy farmers considered bTB as a prioritized animal health problem, which made majority of the farmers (54%) to do nothing as control and prevention measures. On the other hand, mastitis (50.8%) and abortion (35.5%) were their concerns to tackle. Almost none of the farmers used skin test to screen new entry animals to protect their herd from getting bTB infection; instead, 26.5% of farmers preferred not to buy cattle from unknown or potentially infected sources.

Table 5. Results of univariable model for the association between farmers' attitude and previous training exposure (N=307).

Attitudes	Response	OR	95% CI	*p* value
The potential source of infection for your herds				
	Don`t know	-		
	Neighboring herds	5.03	2.11-11.96	0.001
	Contaminated utility from infected sources	2.9	1.09-8.16	0.032
	New animal introduction	12.8	6.40-25.82	0.000
What do you suggest to prevent or control bTB country wise?				
	Government should provide disease free heifers for sale	2.88	1.51-5.49	0.001
	Strict animal movement restriction governed by rules and regulations	15.85	3.48-72.2	0.000
	Awareness to dairy farmers about the disease	3.66	2.04-6.57	0.000
What do you recommend to reactors?				
	Slaughter for meat	-	-	0.001
	Slaughter & bury/burn	2.59	1.17-5.74	0.019
	Sell	4.95	1.81-13.51	0.002
	Nothing	11.88	1.39-101.33	0.024
In your openion, how could bTB affect your farming?				
	Reduce milk production	-	-	0.48
	Loss from culling animals	1.11	0.275-4.51	0.88
	Marketing	1.65	0.71-3.85	0.24

Despite their knowledge and attitude about control and prevention measure (test and slaughter), the majority of the farmers with reactor cattle (77.8%) did nothing to control/prevent the disease, while some (22.2%) sold the reactors (Table 6).

Table 6. Farmers' practices relevant for control and prevention of bTB

Variable		Frequency	Percentage
Have ever your animal tested for bTB (n=307)			
	Yes	36	11.7
What measure did you take on reactor animals? (n=9)			
	Nothing done	7	77.8
	Sale	2	22.2
Which disease/problem is your priority of concern to intervene in your farm? (n=307)			
	Mastitis	156	50.8
	Abortion	109	35.5
	Bloating	35	11.4
	bTB	7	2.2
What preventive measure you usually take to protect your farm from getting bTB infection? (n=307)			
	Nothing done	218	71
	Screening test/skin test	2	0.6
	Not buying cattle from unknown/risky sources	87	28.3

Discussion

Non-biological factors, such as farmers' knowledge, attitudes, and practices, may remarkably impact the effectiveness of disease control interventions, including against bovine tuberculosis (bTB) (Zahedi *et al*., 2014; Ciaravino *et al.,* 2017; Robinson, 2017).

In the present study, 55% of participants knew something about bTB. Comparable results were reported from Ethiopia in Bahir Dar City (57.2%) (Hailu *et al.,* 2021) and from commercial dairy farmers in Zimbabwe (65.0%) (Mosalagae *et al.,* 2011). However, several lower awareness levels were reported from previous studies conducted in different locations and times in Ethiopia: 13.9% (Kidane *et al.,* 2015), 24.1% (Bihon *et al.,* 2021), 35% (Ameni and Erkihun, 2007), 45.6% (Kuma *et al.,* 2013) and 37.1% (Tigre *et al.,* 2011). This variation may be due to differences in composition of study participants. Inclusion

of participants in the present study from the vicinity of Addis Ababa, from intensive dairy farms with long years of experience in farming, participants with access to veterinary consultation, various trainings and experience sharing visits might have contributed to the observation of better awareness about bTB among farmers in the current study.

In the current study, only 12% of participants were aware of the test and slaughter method. Llikewise, only 18% of the farmers tended to avoid buying cattle from risky sources (potentially infected sources or areas with previous reports of bTB). Consistent with our findings, Kao *et al*. (1997) stated that majority of dairy farmers didn't know that a typical strategy for bTB control involve regular field tests and the slaughter of infected animals. The fact that only small proportion of the farmers paid due care to the health status of herds from which they source replacement animals demonstrated the high risk of spread of bTB from infected herds in the study area. It is well known that introduction **of new animals** is one of the significant risk factors for disease entry into dairy herds (Massó Sagüés *et al.,* 2019). Mekonnen *et al*. (2019) reported movement of infected animals as the most critical source for the spread of bTB. The same authors also stated that the absence of restriction of infected animal movements and quarantine were considered to be the main barriers to the control of bTB.

Contrary to the well-established knowledge about the economic and zoonotic importance of bTB as a significant contributor to animal and human losses (Grace *et al.,* 2012; Liverani *et al.,* 2013). our result revealed a lack of knowledge on the production loss incurred and the probability of human infection by bTB. Instead, a substantial number of farmers (25%) believed that bTB infection could badly affect the dairy business by disturbing their milk markets. In other reports, the majority dairy farmers do not know about tuberculosis in cattle; rather, farmers' knowledge was limited to human tuberculosis, and they had strong perception that tuberculosis was a disease that 'only' humans could get. This poor awareness may be attributed to farmers` perceptions of the benefits of bTB control and prevention, which was believed to be mainly commercial, as bTB was not considered having an impact on public health nor a disease causing production loss (Ciaravino *et al.,* 2017). Furthermore, farmers mainly perceived the control of bTB as an imposition rather than a necessary activity to protect their animals (Ciaravino *et al.,* 2017).

Among the dairy farmers who were aware of bTB, a very small percentage (1.6%) considered it a prioritized animal health issue, leading to a lack of interest in taking preventive and control actions. All these gaps may exacerbate the public health and economic burden of bTB not only on the community but also on the country

Skin test are a common diagnostic tool for bTB, but only 1.6% farmers were aware of it. Actually, farmers do not want to have any bTB-infected animal in their herd, but they want to be sure that the test-positive animal is truly infected. In the present study none of the participants reported skin test as reliable. Even veterinarians and farmers expressed strong uncertainties about the reliability of skin test results (Ciaravino *et al*., 2017). According to our findings, therefore, in the absence of a common conscience on the conventional bTB diagnostic tool and a clear policy to compensate for culled animals, almost none of the respondents (0.98%) thought that test and slaughter method was a feasible and applicable way to control bTB. Instead,16.3% and 22.0% of respondents mentioned that educating the community about bTB and providing healthy heifers from reliable sources may be key factors for a successful bTB prevention and control plan, in a similar pattern reported by another scholar (Kawsar, 2022).

Conclusions

The present study assessed knowledge, attitudes, and practices (KAPs) of the study participants and some important issues that could remarkably impact the application and effectiveness of interventions against bTB in the specific area we examined. MS, farm size, previous years of experience, training received, and veterinary consultation had a significant association with awareness towards bTB. Hence, training and regular consultation with veterinarians could boost the farmers' understanding of bTB. The enhanced knowledge could then help farmers change some of their practices for the better. A tailored education or training program could be developed to raise the farmers' awareness and encourage them to adopt bTB prevention practices.

The scope of this study is limited to commercial dairy farms in the selected milk-producing areas of Ethiopia. To gain a more comprehensive and accurate insight into the subject, further and broader studies are needed to examine the gaps in farmers' knowledge and attitude in both commercial and extensive dairy farming systems.

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