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Knowledge, Attitudes and Practices Relating to Brucellosis among Small-Scale Dairy Farmers in Urban, Peri-Urban and Rural Areas of Bishoftu, Ethiopia

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Abstract

Brucellosis is considered as one of the neglected zoonotic infections worldwide, which remains a significant public and animal health concern in many developing countries. Ethiopia is thought to have the largest livestock population in Africa and the majority of its population relies on agriculture as both a source of nutrition and income. Losses through abortion and reduced milk yield due to brucellosis can be a major economic constraint for farmers, as well as the high risk of zoonotic transmission due to the close contact with their animals. Improving the knowledge, attitudes and practices among livestock farmers could have a positive impact on the reduction of brucellosis and other zoonotic diseases. This cross sectional study was carried out in August 2017 among small scale dairy farmers in and around Bishoftu, Ethiopia. In total, 99 farmers were interviewed using a questionnaire to obtain information on socio-demographics, herd characteristics, knowledge, attitudes and practices relating to brucellosis, with the aim of identifying knowledge gaps and the potential risks for contracting the disease that are present for dairy farmers and their families. Descriptive statistics were used to compare the responses from urban and rural participants. Demographically, the main difference found was that the number of people in each household was generally larger in rural than urban areas, and education levels were lower. 90% of rural farmers kept 1-5 cows, whilst there were a higher proportion of larger farms in urban areas. The majority (92%) had never heard of brucellosis, with no difference between urban and rural areas. A higher proportion had heard of a disease causing late term abortion (36% urban, 9% rural), but very few had knowledge of the cause, transmission routes or whether humans could be infected. 26 farmers reported to have had at least one incidence of late term abortion in their herd, and almost everyone wanted to receive more information about the disease. Awareness of zoonotic diseases in general was higher (n=56), with 42 aware that humans can get diseases via consumption of raw milk, and 25 reported the dangers of raw meat, but very few were aware of the risks through direct contact with infected animals. High risk behaviours were found to be common among the farmers; over half (54%) never wear gloves when dealing with calving and aborted material, and very few correctly dispose of the placenta and aborted foetus. Despite the low knowledge levels, almost all respondents (89%) reported to boil milk before drinking it. However, 90% would still consume raw milk products, and 76% consume raw meat. Poor knowledge of the disease and the presence of several high-risk behaviours, but an interest and willingness to learn supports the reasoning for including an education awareness program as part of future control programs, to help mitigate the risks of both human and animal exposure.

Introduction

Brucellosis, caused by the *Brucella* species, is a highly contagious zoonotic disease affecting humans and a wide range of terrestrial animals. It is classified as one of the neglected zoonoses with a serious public health importance worldwide (OIE, 2009; WHO, 2010). The World Health Organisation (WHO) estimates that a quarter of human cases go unreported, yet half a million cases per year are recorded (Corbel, 2006). Historically, it has been called many names including Malta fever and Mediterranean fever in humans and Bang's disease or 'Contagious abortion' in cattle.

The *Brucella* genus are gram-negative, facultative, intracellular coccobacilli comprised of species based on biochemical features and their correlation with preferred host species. Cattle are primarily infected with *B. abortus*, but can also be infected with *B. melitensis* especially when cattle are kept together with small ruminants (OIE, 2009). Sheep, goats, pigs and dogs are amongst the other animals that can be infected by different species of the genus. *B. melitensis* is considered to have the highest zoonotic potential, followed by *B. abortus* and *B. suis* (Alton and Forsyth, 1996).

Primary clinical manifestations of brucellosis among livestock are related to the reproductive tract, with abortion after the 5th month of gestation being the cardinal sign. Retention of the placenta and metritis are common sequels to abortion, both of which can cause prolonged calving interval and permanent infertility (Radostits, 2000). Reduced milk production further adds to the significant loss of productivity caused by the disease, and in males it can also cause orchitis and epididymitis (Radostits, O. M., Gay, C. C., Hinchcliff, K. W., 2007). Females usually abort only once, presumably due to acquired immunity. There is often heavy shedding of bacteria through the placenta, foetal fluids and vaginal exudates. The mammary gland and regional lymph nodes can also be infected leading to bacteria excretion in milk (Oie, 2009). The most common route of transmission between animals is through direct contact with an aborting cow and the aborted foetus or by indirect contact with contaminated fomites. Ingestion of contaminated feed, fodder and water may also play a secondary role (FAO, 2003). Susceptibility to infection depends on age, breed and pregnancy status, with sexually mature animals being much more susceptible to infection (Poester, Samartino and Santos, 2013).

Humans are almost exclusively exposed to brucellosis via contact with infected animal secretions, primarily through calving and abortions, or through the consumption of contaminated, unpasteurized dairy products, or undercooked meat. As a result, people who have frequent contact with animals (e.g. livestock owners, abattoir workers, veterinarians) in areas where brucellosis is endemic are at high risk of contracting the disease. Symptoms of the disease in humans are non-specific, but can include fever, sweating, anorexia, malaise, weight loss, depression, headache and joint pains (Corbel, 2006). The diverse clinical manifestations mean that the disease can often be confused with malaria and influenza, possibly leading to underestimates of the true incidence rates worldwide.

Although brucellosis has been eradicated in most developed countries that have implemented a tight eradication programme (Makita *et al.*, 2008), the economic and public health impact of brucellosis remains of concern in developing countries (Roth *et al.*, 2003). The disease remains endemic among Mediterranean countries of Europe, Northern and Eastern Africa, Near East countries, India, Central Asia, Mexico and South America (FAO, 2003). It's occurrence in many developing countries is increasing, in part due to the import of exotic high production breeds, which are more susceptible to infection (Hirsh and Zee, 1999), as well as the trend for increasing intensification of animal production, which favours the spread and transmission of the infection (Jones *et al.*, 2013). Lack of awareness, policies or appropriate use of resources may also contribute to this development.

Despite the low fatality rate in adult cattle, losses through abortion or calf death is a huge economic constraint for farmers, as well as infertility, delayed heat, reduced meat and milk production, culling and economic losses from international trade bands(McDermott and Arimi, 2002). Ethiopia is believed to have the largest livestock population in Africa, contributing a considerable portion to the economy of the country. The total cattle population is estimated to be about 57.83 million, 98.59 % of which are local breeds, 1.22% are hybrid and 0.19% are exotic breeds. Dairy cows are estimated to be around 11.7% of the total number of cattle in the country (CSA, 2015).

The agriculture sector plays a central role in the life and livelihood of most Ethiopians, where about 12 million smallholder farming households account for an estimated 95 percent of agricultural production and 85 percent of all employment (FAO, 2014). Dairy farming is regarded as one of the few agricultural activities that can provide enough income to maintain the economic viability of smallholder farms (Staal Steven, Delgardo C, 1996), and it has the potential to generate income and employment in order to improve the welfare of smallholders. Dairy cattle production systems in Ethiopia are classified into pastoral and agro-pastoral production, rural smallholder (mixed crop-livestock) production, urban and peri-urban smallholder dairy production and intensive commercial dairy production. This study focuses on small scale (defined as fewer than 20 milking cows in the herd) urban/ peri-urban dairy production and rural mixed crop-livestock production systems, due to high engagement of household members with the animals making them a high risk group. Rural small holdings are generally semi-intensive in highland areas, with grazing of local (Zebu) breeds outside, and possibly some cross bred cows. Urban and peri-urban smallholder dairy production occurs in and around major cities and towns which have a high demand for milk. Holstein- Friesian cross bred cows are usually kept in a zero-grazing system to produce milk both for home use and sale, as a full-time or part time business. Most smallholders buy just one cross-bred cow and expand their herd using artificial insemination. Commercial dairy production is more specialized dairy farming practised by the state sector and very few individuals on a commercial basis. Most of the intensive dairy farms are concentrated in and around Addis Ababa and are purely based on exotic pure bred stock (Yigrem *et al.*, 2008).

Since the first report of brucellosis in Ethiopia in the 1970's, the disease has been noted as one the important livestock diseases in the country (Kebede, Ejeta and Ameni, 2008). Several prevalence studies have been conducted in different agro-ecology of the country, reporting individual seroprevalence ranging from 1.1% to 22.6%, and herd level seroprevalence ranging 2.9%- 45.9% in intensive management systems (Asmare *et al.*, 2014). Seroprevalence within extensive cattle rearing systems has generally been found to be lower than that of intensive systems, with reports ranging from 0.1% to 15.2% (Dinka and Chala, 2009; Asmare *et al.*, 2010; Megersa *et al.*, 2011). A cross-sectional study undertaken in 300 dairy cows in Bishoftu found an overall 2.0% seroprevalence of bovine brucellosis, using the Complement Fixation Test, and 3.3% using the Rose Bengal Plate Test. The seroprevalence was higher in animals above two years than younger animals and a statistically significant difference ($P < 0.05$) was observed in cross breeds than local dairy cattle (Alemu *et al.*, 2014). Another study carried out by (Asmare *et al.*, 2013) found a 5.7% seroprevalence among 70 animals sampled in Bishoftu, and 17.6% herd level prevalence. As compared to study of animal brucellosis, study of human brucellosis in Ethiopia is very sparse, possibly due to absence of appropriate diagnostic facilities, with even less information on risk factors for human infection. A meta-analysis of Ethiopian prevalence studies estimated the prevalence of brucellosis in humans at 17.4% in the pastoral and 3.1% in the sedentary system, and the incidence rates, respectively, were 160 and 28 per 100 000 person years (Tadesse *et al.*, 2016). Studies conducted in high risk groups such as farmers, veterinary professionals, meat inspectors and artificial insemination technicians in Sidama Zone of Southern People Nation and Nationalities State (Asmare *et al.*, 2007) and Addis

Ababa (Kassahun *et al.*, 2006) found a seroprevalence of 3.78% and 4.8% by screening sera from 38 and 336 individuals respectively. Despite sparse information of human brucellosis and the knowledge gap on disease dynamics, distribution and proportion of natural hosts, the continued occurrence of this preventable disease is evocative of its importance in the country in general.

Control of brucellosis in livestock is key to preventing the disease in humans, which could be achieved through a combination of livestock vaccination, removal of infected animals, and improved hygiene practices. However, livestock owner's knowledge and behaviours must be taken into account if sustainable control programs are to be implemented (Kansiime *et al.*, 2014). Lack of sufficient knowledge of the disease accompanied by high risk practices and the absence of effective prevention and management strategies result in a continued disease burden causing economic losses and posing a risk to public health. Knowledge, Attitude and Practices (KAP) studies are a powerful tool in evaluating the vulnerability of livestock owners to livestock disease and can be valuable to policy makers in helping to develop control strategies and education programs for prevention of zoonotic diseases.

Previous KAP studies regarding brucellosis among high risk groups in different endemic settings have found highly variable results. A study conducted in small scale dairy farmers in Tajikistan found poor knowledge of the disease and frequent high risk behaviours (Lindahl *et al.*, 2015). Similarly, a study conducted in Kenya has shown poor awareness of the disease and knowledge of its transmission to humans (Obonyo, 2015). In contrast, a high level of knowledge of the disease has been found in KAP studies carried out in Jordan and in Egypt, although high risk practices were still found to be widely used in these areas, despite knowledge of transmission routes (Holt *et al.*, 2011; Musallam, Abo-Shehada and Guitian, 2015).

The current study aimed to assess the extent of knowledge and understanding of brucellosis in both urban and rural small-scale dairy farmers in and around Bishoftu, Ethiopia, and determine whether herd management and household practices that predispose farm workers to brucellosis from infected animals are common in the area. Wider knowledge about other zoonotic diseases was also assessed. Information gained from this KAP study aims to help guide future control programmes and public health interventions.

Materials and Methods

Study area and population

Bishoftu (formerly Debre Zeit) is located 47.9 kilometres (29.8 mi) southeast from Addis Ababa, in the East Shewa zone of Oromia Regional State. The altitude of the town is about 1920m above sea level. The mean annual rainfall is about 870mm, with the highest amount of rainfall occurring during the rainy season between June and September. The mean annual temperature is about 18.9°C, with the hottest season between March and June (CSA, 2015). The last consensus carried out in 2007 estimated the human population of Bishoftu to be 99,928, of which 79,691 were Orthodox Christians (Central Statistical Agency of Ethiopia, 2007).

The study subjects were small scale dairy farmers in the urban, peri-urban and surrounding rural areas of Bishoftu. According to the Central Statistics Agency 2015 agricultural survey, there are 1,138,454 cattle in the East Shewa zone, 154,362 of which are dairy cows, with an average daily milk production of 1.416 litres (CSA, 2015).

Study design

A standardized, structured questionnaire (available on request), was developed by the author in English. A mixture of closed and open-ended questions were used to collect information on

demographic characteristics, KAP relating to brucellosis in animals and potential routes of transmission to humans, general awareness of zoonotic disease, and herd management and household practices that could pose a risk to brucellosis transmission. For the close ended questions, participants were asked to indicate from a pre-existing set of answers. As well as asking specifically about brucellosis, the participants were also asked about diseases which cause late gestation abortion in general, using the local words of Wurja (Amharic) and Getechisa (Afan Oroma). Knowledge about clinical signs in humans was not included due to the non specific and diverse nature of clinical presentations, making assessment of human disease from the questionnaire too complex because of the similarities with other acute febrile conditions. The questionnaire was pre-tested to assess clarity and time requirements by farmers attending the clinic at the Addis Ababa University (AAU) College of Veterinary Medicine in Bishoftu, and modified in line with feedback from the pre-test.

A list of the households in the area owning livestock was obtained from Bishoftu city council, which identified all the small scale dairy farms in the town surrounding rural areas. From this, 67 households in the urban areas and 32 households in the rural areas were selected by simple random sampling. Study eligibility was based on willingness to be interviewed and being more than 15 years old.

Study procedure

This cross sectional study was carried out during the month of August 2017. An approval letter was sent from the AAU College of Veterinary Medicine to the Bishoftu city council, who were able to approve the study and authorise one of their staff members to accompany the authors to the farms. This figure of authority was needed to ensure that farmers would be willing to participate in the study.

On arrival at the farm/household, the interviewer (Bedaso Mamo) explained to the head of the farm/household the objectives of the survey, that participation was voluntary and that the identity of the participant would not be disclosed. If no members of the household who regularly looked after the animals were available at the time of the visit, the next farm on the list was used. Following verbal consent from the participant, the interviews were performed orally in the native language of the participant, with the interviewer translating the responses orally into English, for the author to record on a paper copy of the questionnaire, precoded with the farm identification. The same person was used to carry out all the interviews.

Ethics statement

All participants were informed about the purpose and methods of the study, that the data would be handled anonymously and that participation was on voluntary basis. Informed verbal consent was obtained from all participants and documented in the questionnaire. Written consent with the participants signature was not possible due to the illiteracy of many of the farmers. Ethical approval was sought and obtained from the University of Cambridge, Department of Veterinary Medicine ethics committee.

Statistical analysis

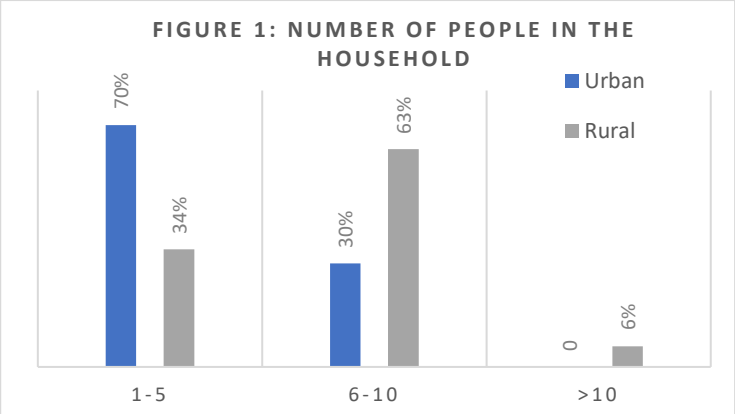
The collected data was stored by the author on Microsoft Excel 2016 and was double checked against paper copies for possible data entry errors. Statistical analysis was conducted using XLSTAT 2017. Descriptive statistics were stratified to identify any differences between urban and rural farms, and also by herd size (1-5 cows or over 5 cows), independent of location, to see whether any differences between urban and rural results were also consistent with differences in herd size.

Results

A total of 99 households were visited during the study period; 67 urban or peri-urban and 32 in rural communities surrounding Bishoftu town. On 3 occasions livestock owners refused to participate and were replaced by the following farm in the sample list.

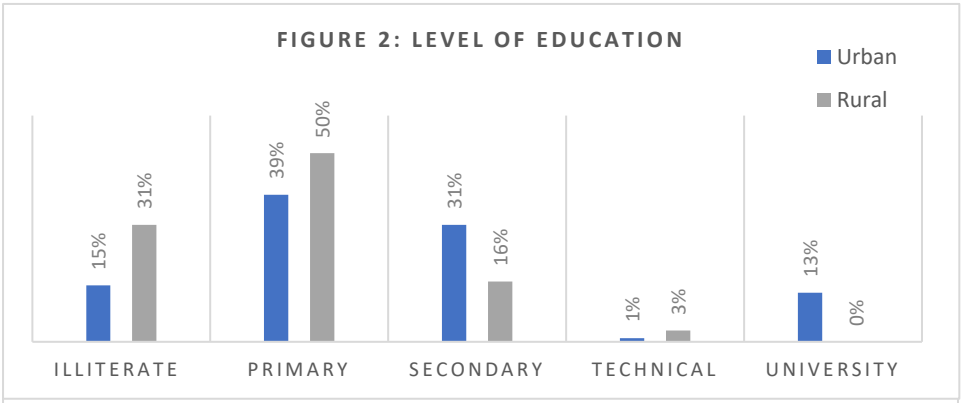
Socio-Demographic Characteristics of the Respondents

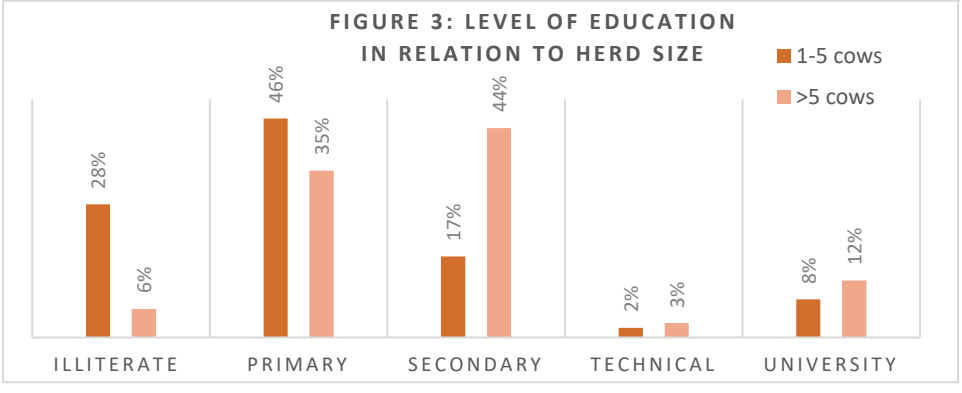
In the majority of both urban and rural households, a female was mainly responsible for the management of the cows (48% and 71% respectively, 53% overall). Most of the participants were in the 25-54 age group. In urban areas, the majority (70%) of households contained 1-5 people, whilst in rural areas the family sizes were found to be larger with the majority (63%) having 6-10 people (Figure 1). 67% of respondents in urban areas reported Amharic to be their native language, whilst in rural areas 78% were fluent in Afan Oromo as their native language. Overall education levels were higher in urban than rural areas (Figure 2). When stratified by herd size, it was found that the education level was generally higher among those with over 5 cows (Figure 3).



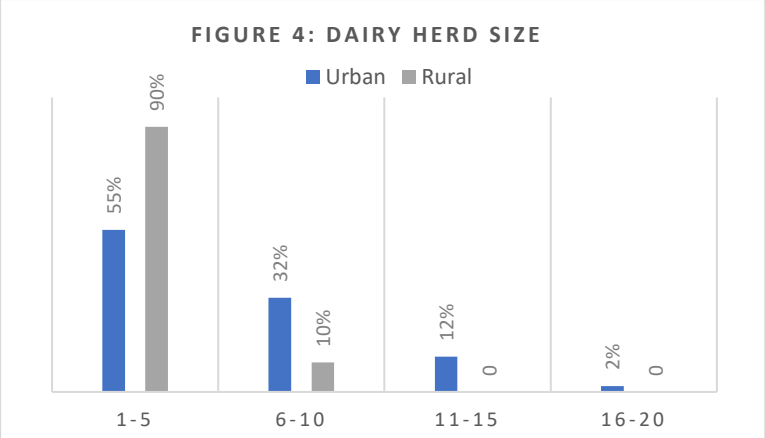
Herd Characteristics

In general, dairy farms in the urban and peri-urban areas are intensive systems with Holstein-Friesian cross bred cattle kept fully housed. Herd sizes were generally larger than in rural areas (Figure 4). Over half of the households did not keep any other ruminants and in 95% of the households the dairy cows were kept separately from any other animals. This was consistent with the results when stratified by herd size, which found that 62% of farmers with over 5 cows did not have any other ruminants, and 94% kept their dairy cows in a separate shed. In the rural communities, farms are usually mixed crop-livestock production systems, with more local breeds than cross bred cows. In our study we found 14% of the households in rural areas to own only cross bred dairy cows, whilst 48% had local dairy cows and 38% kept both, with the majority (90%) having only 1-5 cows. The local breeds are





extensively managed (only housed at night), while most of the cross breeds were housed but almost half were kept together in the same space as other animals, and almost all farms in the rural areas had other ruminants, mainly sheep and oxen (adult male cattle used for draught purposes), as well as the dairy cows. Cross bred cattle in the rural areas had a lower percentage of Holstein- Friesian in them compared to the cross bred cows in the urban dairy farms.



Knowledge of Brucellosis in Animal and Humans

Overall, the majority (92%) of the 99 participants had never heard of brucellosis, with similar results found in both urban and rural areas. The 8% that had heard of brucellosis were all from households with 1-5 dairy cows. Participants were also asked more generally whether they had heard of any disease causing late term abortion, as some people had some knowledge of this without knowing the scientific name for the disease. In urban areas, 36% of respondents had heard of a disease causing late abortion, whilst only 9% of respondents in rural areas reported to be aware of that, and no difference was found between herd sizes. Overall 26 out of the 99 respondents (20 urban, 6 rural) reported to have had at least one incidence of a late term abortion in their herd. Of those who had heard of the disease, or a disease causing late abortion (n=28), over half had received this information from family, friends and neighbours, and only 7 people reported to have received information from a veterinarian or an Animal Health Assistant (AHA). Over half did not know the cause of the disease, with only 1 person correctly reporting it to be caused by bacteria. 2 reported it to be due to poor hygiene and 6 reported the cause as 'Mich', which is a traditional belief thought to be due to a mixture of factors including sunstroke, and is often treated with herbal medicines. The majority (79%) believed it to affect cattle only, and in terms of animal-animal transmission, 7 believed the disease to be non-infectious between animals, 13 did not know and 4 thought it could be transmitted due to poor hygiene. Of the 28, only 3 believed that humans could be infected with the disease from animals, 11 thought that humans definitely could not be infected whilst 10 did not know. Of the 3 people who thought that humans could be infected, only 1 person reported any correct transmission routes.

Knowledge of zoonoses

Over half of respondents (n=56) knew that humans can get diseases from animals, most commonly through consumption of raw milk (n=42) or raw meat (n=25). Only 6 people reported to be able to get disease through direct contact with infected animals. Knowledge of transmission routes was slightly higher among the urban participants. Specific zoonotic disease that some respondents reported to be aware of were tuberculosis, anthrax and rabies. When stratified by herd size, the only slight difference in knowledge between the two groups was that 28% of those with over 5 cows reported to have heard of tuberculosis compared with just 18% of those with 1-5 cows.

Attitudes

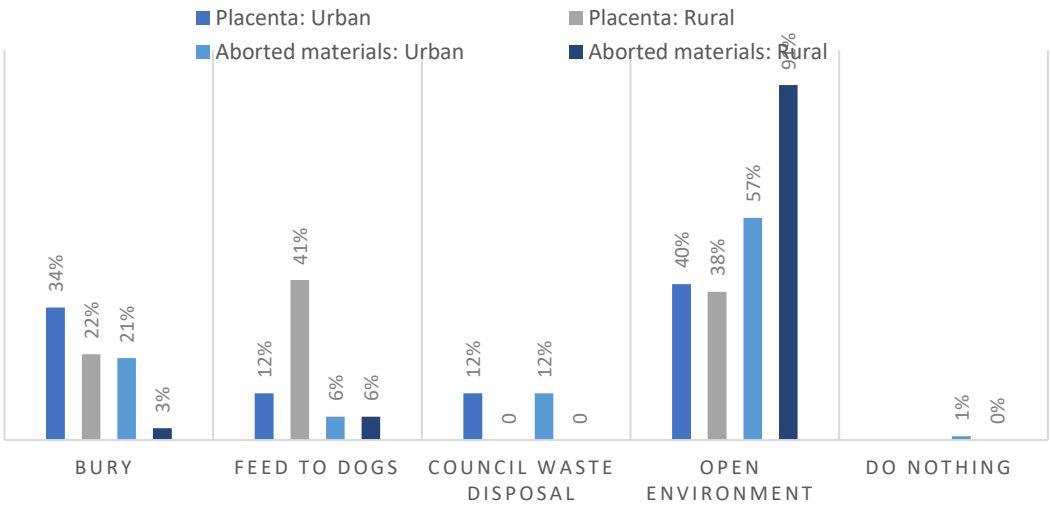
In both urban and rural areas, it was most common for participants to discuss animal health issues with the local veterinarian or AHA. 97 participants wanted more information about

brucellosis, with 32% preferring to receive this information directly from a veterinarian, 29% would prefer to attend a local training course and 15% would prefer the information in an educational booklet.

Participants' Self- Reported Herd Management Practices'

Overall, general farm cleanliness practices were found to be fairly good, with almost all of the farmers reporting to clean up both dung and feed/ water troughs on a daily basis. The majority reported to wash the udder before milking, most commonly with warm water and a towel. 25% of the rural participants did not wash the udder before milking, mostly with the local breeds. Overall over half of the respondents reported that they did not have a separate shed/ space for parturition. Surprisingly, there was no difference found in these results between herd size, and a slightly higher percentage of rural respondents (59%) reported to have a separate space compared to urban (40%). With regards to the disposal of waste materials, only 34% of urban and 22% of rural participants reported to bury the placenta, with riskier practices being more common. In rural areas, 41% of participants claimed to feed the placenta to dogs, and 38% discarded it into the open environment outside the boundaries of their compound. 40% of urban participants also reported this practice, whilst only 12% reported to feed to dogs and 12% put it with the rest of the waste to be collected by the district waste disposal. Methods of disposal of aborted materials were reported to be slightly different to the disposal of the placenta, with 57% and 91% or urban and rural respondents respectively reporting to through it into the open environment. 14 urban respondents (33%) reported to bury aborted materials but only 1 (3%) of rural participants reported this practice (Figure 5). Amongst the urban participants, 60 (90%) either assisted in calving but 54% reported to never wear gloves. 8 respondents would also call for a veterinarian and 7 for an AHA. In rural areas, 31 (97%) assisted in calving and 2 reported to also call for a vet, and 88% never wore gloves. Despite most of the day to day work with the cows being carried out by female household members, assisting in calving was most commonly carried out by males. Almost all the respondents reported to wash their hands after assisting with calving and most attempted to clean the area afterwards. In urban areas the majority (94%) used soap and water to clean the area, whilst only 3 farms reported to use disinfectant. Rurally, 73% used just a brush without any water to clean up the area and no one reported to use disinfectant. Overall, only 2 people reported to separate a cow from other animals after it had aborted, and only 3 would send it for culling, whilst most other people would call a veterinarian or an AHA (55% and 34% respectively). Despite consulting a professional, the majority of respondents would keep the cow to continue milking.

FIGURE 5: DISPOSAL OF PLACENTA AND ABORTED MATERIALS



Participants' Self-Reported Household Practices

Overall only 19% of respondents reported that either themselves or others in the household drink raw milk, while 89% drink boiled milk. Despite this, the majority (90%) consume raw milk products. In urban farms, 19% sell raw milk locally, 46% sell it to a dairy cooperative and 31% sell milk to both. 16% sell raw milk products locally. In rural areas, on the other hand, most milk is kept for household consumption, with only 3% selling milk locally, 3% to a dairy and 13% to both. 38% sell raw milk products locally. Backyard slaughter was found to be participated in by 69% of urban households and 88% of rural households, mainly carried out by males, none of whom reported to wear gloves, but all washed their hands. Overall 75% of households consume raw meat.

Discussion

This study shows that the knowledge of brucellosis is poor among dairy farmers in the urban, peri-urban and surrounding rural areas of Bishoftu, Ethiopia. Several high risk practices were commonly reported among the farmers; most reported assisting in calving and disposing aborted foetuses without wearing protective gloves (65%), and 90% consume unpasteurised dairy products.

It became clear from the study that there were certain gender roles that were common in almost all the households. In general, a female household member was most likely to be the main person responsible for dealing with the cows on a day to day basis, whilst the males were more likely to assist in calving and participate in slaughter.

The finding that the majority of the respondents had never heard of the disease brucellosis, or any diseases causing late-term abortion, is similar to studies in Kenya and Tajisktan (Kang'ethe, Ekuttan and Kiragu, 2008; Lindahl *et al.*, 2015) but in contrast to studies carried out in Egypt and Jordan which showed a high awareness of the disease(Holt *et al.*, 2011; Musallam, Abo-Shehada and Guitian, 2015). The authors of those studies explained this high awareness by an endemic situation of brucellosis in the study area. The low awareness in this study could therefore in part be explained by a lower herd seroprevalence compared to Egypt and Jordan. There was no difference in the proportion of respondents from urban or rural areas who had heard of brucellosis, but a slightly higher proportion of participants in urban areas had heard of a disease causing late abortion compared to rural areas. This could perhaps be explained by the slightly higher proportion of households in urban areas that had experience of a late abortion case within their own herd (30% compared to 19% in rural areas), or the higher education levels found in the urban areas. Although it is impossible to diagnose the definitive cause of these cases of late term abortion, brucellosis is an important differential and the relatively high incidence reported gives good support to improving control measures. Of the participants who had heard of the disease, knowledge about the cause, transmission routes and symptoms was still very poor, with only 1 person correctly identifying that it is caused by bacteria, and 4 others suggested that it is caused by poor hygiene which suggests that they have at least some basic knowledge of the transmission risks. Due to the fact that most knew of the disease in relation to abortion, the majority did not know of any other potential symptoms, very few were aware of the transmission routes andmost thought it could only affect cattle. This is important to note, since brucellosis can also affect other animals, especially small ruminants (most commonly *B. melitensis*), which are kept often in the same areas as the cows by almost of the rural farms. This has been identified as one of the main risk factors for bovine brucellosis (Holt *et al.*, 2011), although more information is needed in this area on the species of *Brucella* present and the prevalence levels. It is unlikely that any control program would be able to prevent rural mixed crop-livestock production systems from keeping both small ruminants and, since they are both important for their livelihoods, but better awareness of the spread of disease between the species could

encourage more farmers to keep the animals separately from each other to reduce transmission risks.

Regarding zoonotic disease risks, only 3 people were aware that humans could become infected with brucellosis from animals. Furthermore, in this study only 56 (57%) of the respondents were aware of the risk of transmission of any disease from animals to humans. Of these, the majority were aware of the risks through raw milk, and 45% knew of the risks of eating raw meat, but very few were aware of the risks of direct contact with infected animals. Lack of awareness of zoonoses in general could contribute to high risk behaviours.

Unsurprisingly, this study found that all farmers were engaged in at least one risky practice conducive to transmission of *Brucella* to other animals and to humans. Knowledge about the disease and preventive herd management practices have previously been identified as the most important factors needed for minimising the disease risk in animals (Díez and Coelho, 2013). Infected female animals excrete high concentrations of organism in their milk, placental membranes and aborted foetus (Radostits *et al.*, 2006). Not having a separate calving space, which only 46% of farmers reported to have, has thus been shown to be an important risk factor for brucellosis transmission to other animals due to environmental contamination, and only 2 farmers reported to separate a cow that had aborted from their other animals. Other than poor knowledge of the risks, this probably also reflects the lack of facilities and space for separation in most small holder systems, with similar results being found in Pakistan (Arif *et al.*, 2017). Surprisingly, more farmers in the rural areas claimed to have a separate calving space than farmers in the urban areas, which could be due to urban farms having less space available than rural farms. Only 24 farmers in this study reported disposing of placental membranes by burying, which is one of the most effective method of reducing disease risks, and only 15 buried aborted materials, with most reporting to discard them into the open environment, outside the boundaries of their compound, or even feed them directly to dogs. Given that the pathogen has been recovered from foetuses that have remained in a cool environment for over 2 months, this also could present a transmission risk to both other animals and humans in the area (Kahn and Line, 2010). Similar results were found in Jordan and Pakistan, but in contrast, a study in Tajikistan found 94% or respondents would bury the placenta and aborted materials (Lindahl *et al.*, 2015; Musallam, Abo-Shehada and Guitian, 2015; Arif *et al.*, 2017). It is interesting to note that often the placenta and aborted foetus are not disposed of in the same way; among farmers who commonly bury the placenta, many would still discard aborted material either to dogs or into the open environment rather than bury. This is perhaps because of the larger size of foetuses making them more difficult to bury, and suggests that those who bury the placenta may not be doing it due to an awareness of disease transmission risks, but rather for other reasons such as practicality. The pathogen can also survive prolonged periods of time in manure, so regular cleaning of dug can help to reduce the build up of the pathogen in the environment, which fortunately almost all the farmers reported to do.

Direct contact with placental membranes and aborted foetuses is a major route of human infection (Corbel, 2006), and it was evident from the responses that most of the farmers were unaware that diseases, not only brucellosis but other zoonoses, could be transmitted in this way. This lack of knowledge could explain the fact that the majority did not use protective gloves when assisting with calving, nor would they use them when dealing with cows having an abortion or aborted materials. This could also in part be due to lack of access to protective gloves, which would have to be bought at the farmers expense. Similar results have been reported from Tajikistan, Egypt and Jordan, suggesting that the use of gloves is not common practice in many lower income countries (Holt *et al.*, 2011; Lindahl *et al.*, 2015; Musallam, Abo-Shehada and Guitian, 2015). Most respondents washed their hands with soap after dealing with such material, but only three farmers reported to thoroughly disinfect the area with disinfectant. In the rural areas, the most common

practice appeared to be using just a brush without any water to clean the area, whilst in urban areas the majority used water or soap. The respondents who used disinfectant all had over 10 cows, suggesting that farmers with larger herds may be more likely to be aware of the benefits of disinfectant, or are in an economically better position to be able to afford it than farmers with smaller herds. The practice on rural farms of cleaning the area with just a brush leaves a very high risk of contamination and bacteria could easily survive in the environment leading to transmission to other animals or humans. *Brucella* in aqueous suspensions are readily killed by most disinfectants (The Center for Food Security & Public Health, 2009), so better access to disinfectants, as well as protective gloves, could be considered as part of a future control program, to encourage farmers to use them more frequently.

Regarding practices posing a risk for brucellosis transmission from animals to humans, consumption of raw milk has been previously described as one of the most risky practices (Kozukeev *et al.*, 2006). This study found that only 19% of households interviewed consumed any raw milk, with the majority boiling milk before consumption. This suggests that the risk of infection via raw milk in the study area is relatively low, which is in contrast to studies in Pakistan and Egypt where it was found the majority of respondents to drink raw milk. Despite this, most respondents lacked knowledge of zoonotic disease transmission, suggesting that the boiling of milk has become a common practice in the community, possible due to previous educational awareness programmes, with the actual reason for boiling the milk not being understood. This may explain the finding that in households where raw milk was consumed, it was often given to the children whilst the adults preferred to drink boiled milk. This supports the idea that there is still a lack of understanding in the community as to the reason for boiling milk, but is a strong advocate for the potential of successful uptake of other risk prevention techniques in the area. In urban areas, almost half sold raw milk to a dairy, which will then be pasteurised before being sold so does not present a disease transmission risk. In rural areas, on the other hand, most milk was found to be kept for human consumption rather than being sold, thus the potential for risky practices with regard to raw milk consumption is higher. In both urban and rural areas, the risk of infection through dairy products is of much more concern, with 87% of urban households and 97% of rural households consuming raw milk products, most commonly yoghurt (ergo), but also butter and cheese (kibe and ayib), which is known to be an important risk factor for human brucellosis (Kozukeev *et al.*, 2006). The survivability of *Brucella* species in different types of dairy products depends on many factors, including the type and age of product, temperature, changes in pH, moisture and conditions of storage. One study found *Brucella* to be isolated from yoghurt after 2-5 days, depending on the fat content of the product (Falenski *et al.*, 2011). Another study found *Brucella* in yoghurt after 9-22 days, depending on the initial concentration of bacteria (Estrada *et al.*, 2005). Consumption of unpasteurised dairy products therefore presents an important risk factor for human brucellosis infection.

Although foodborne transmission occurs more often from consumption of raw milk and raw milk products, on some occasions eating raw meat from infected animals may also result in infection. Raw meat is considered a delicacy Ethiopia, usually in the form of 'kitfo' (raw minced meat, usually beef) or 'tere siga' (raw strips of meat), where it is often eaten on special occasions such as religious festivals and other celebrations. The majority of Ethiopians are Orthodox Christians (79.75% of the Bishoftu population according to the most recent consensus (Central Statistical Agency of Ethiopia, 2007)), who have lengthy fasting periods throughout the year which are celebrated afterwards by participating in slaughter of animals with family and the local community, and consuming the raw meat fresh from the slaughtered animal. Processing of raw meat and animal products can expose humans to brucellosis infection through cuts and abrasions in the skin (Young, 1995). While men normally undertake the slaughtering of animals, none of whom wore gloves, the whole family can be involved in handling of the butchered carcass exposing members, including children, to blood and

raw animal products. *Brucella* only survives for very short periods in meat (The Center for Food Security & Public Health, 2009), but eating it so fresh, as 76% reported to do, still poses a risk of disease transmission. It should be noted however that it is likely that this tradition would continue regardless of any advice or control programs that may be put in place, since it is well imbedded in Ethiopian culture. Nevertheless it is still important to educate people of the risks of eating raw meat so that they are able to make better informed decisions.

In this study it was found to be more common to discuss animal health issues with local veterinarians or Animal Health Assistants than with family or friends and the majority of farmers contacted a veterinarian if an animal was showing signs of disease, which is similar to findings in Tajikistan and Egypt. AHAs are not qualified veterinarians but are able to give advice on basic animal health and management issues and help expand the veterinary infrastructure by providing support in areas where there are insufficient qualified veterinarians. Despite most farmers reporting to contact the local veterinarian or AHA when a cow has an abortion, most of them would keep the cow to continue milking. This is a major risk factor for disease transmission between animals and humans, since although cows with brucellosis usually only abort once, they can continue to shed the organism. This finding also suggests that vets or AHAs are not diagnosing brucellosis and not giving adequate advice and recommendations to the farmers regarding minimizing risk factors, or the farmers may be ignoring advice from professionals after an abortion has occurred due to the economical implications of culling a cow. AHA often reside within the area that they work in and have close relationships with the community, so would not want to advise actions that would be economically detrimental to the farmer. Since most veterinary professionals are affiliated with the government, and have well established relationships with the community, there is opportunity for the government to work more closely with these veterinarians in order to improve the flow of information between themselves and livestock owners.

Since the source of human brucellosis is direct or indirect exposure to infected animals or their products, prevention must focus on various strategies to mitigate infection risks, including reduction in the prevalence of infection in animals. There has not yet been any national or regional programmes proposed for prevention and control of brucellosis in Ethiopia, largely due to lack of facilities and budget. Furthermore, the contradictory and sometimes low prevalence data for brucellosis in Ethiopia means that some responsible bodies may not recognise the significance of the disease. It is therefore crucial to define geographical extent of the problem in order to allocate resources and funds to initiate prevention and control strategies in this country. Whilst vaccination would be the ideal control mechanism, this is not currently available in Ethiopia. A test and slaughter policy could be effective, but this would require adequate funds and organisation from the government to be effective, and may not be economically viable. Without sufficient compensation farmers would most likely be unwilling to have their cattle tested. Yohannes *et al.*, 2013, suggest that the next action steps for brucellosis control in Ethiopia should focus on classification of endemic areas based on prevalence, characterisation of Brucella species, farm biosecurity, and development of the national veterinary extension services to promote awareness of brucellosis, its impact on livestock production and zoonotic risk, thus providing a valuable prevention measure. This is supported by several studies that have shown that improving knowledge of the transmission routes for brucellosis had a protective effect for human infection (Kozukeev et al., 2006), as well as WHO recommendations that public health education focusing on occupational exposure and consumption of raw milk and other dairy products should be an important part of any brucellosis control programme (Corbel, 2006). This appears to be true in the study area where the most important issues to be addressed are the occupational exposure of livestock keepers and their families through direct contact with contaminated material, and food borne infection via consumption of unpasteurised dairy products. The literacy rate among the study population was 85% in urban areas

and 69% in rural areas and almost 100% of respondents wanted more information about brucellosis, with the majority preferring either a local training course or information directly from a veterinarian. This positive attitude towards learning, along with the good relationships between veterinary health professionals and the community, is good indication that there is potential for including information and education campaigns for brucellosis as part of future control programs, promoting improved husbandry and dairy processing practices that could reduce the risk of exposure not only to *Brucella*, but other zoonotic diseases.

Limitations of the study

Although the present study provides important information, it has its limitations. The main limitation of the study was the small sample size, limited by the short time period available to conduct the fieldwork, which could affect the power of the study and external validity of the findings. Ideally, the study would have been conducted across a wider area, but due to the timel limitations and operational convenience it had to be limited to Bishoftu and the surrounding rural areas. Self-reporting on practices by the respondents was also subject to recall bias, which may have been enhanced by the face-to-face interview situation. Potential biases could have arisen if the questions were interpreted incorrectly by the participants. However, to avoid this, the questionnaire was pre-tested and all interviews were carried out by the same person. During the interviews, the questions were continuously evaluated to ensure that the farmers understood them correctly. We therefore consider the results to give a representative picture of local knowledge, attitudes and practices related to brucellosis among small scale dairy farmers in the study area. Another major limitation however is the lack of knowledge of prevalence of the disease in the area, so future seroprevalence studies would be useful to create an overall picture of the disease status in the area.

Conclusion

The findings from this study demonstrate a poor awareness of brucellosis among small scale dairy farmers in Bishoftu and frequent high risk practices on the farm and in the household that pose a risk for disease transmission between both animals and humans. This strengthens the reasoning for including health education as part of future control programmes, focussing on cost effective strategies to reduce occupational exposure and consumption of unpasteurized dairy products to contribute to risk mitigation, not only for brucellosis but also other zoonoses.

Conflicts of interest

The author declares that they have no competing interests.

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Appendix

Table 1: Demographic characteristics of small scale farmers in Bishoftu, Ethiopia

		Urban (n=67)		Rural (n=32)		Total (n=99)	
	Category	**n**	**%**	**n**	**%**	**n**	**%**
Performs most of the work with the cows	Male	20	32%	2	6%	22	22%
	Female	30	48%	22	71%	52	53%
	Both male and female	7	11%	5	16%	12	12%
	Whole Family	6	10%	2	6%	8	8%
Gender interviewed	Male	25	37%	13	41%	38	38%
	Female	42	63%	19	59%	61	62%
Age	15-24	17	25%	2	6%	19	19%
	25-39	24	36%	10	32%	34	34%
	40-54	14	21%	14	45%	28	28%
	55-70	10	15%	5	16%	15	15%
	>70	2	3%	0	0%	2	2%
Number of people in the household	1-5	47	70%	11	34%	58	59%
	6-10	20	30%	19	63%	39	39%
	>10	0	0%	2	6%	2	2%
Level of education	Illiterate	10	15%	10	31%	20	20%
	Primary	26	39%	16	50%	42	42%
	Secondary	21	31%	5	16%	26	26%
	Technical	1	1%	1	3%	2	2%
	University	9	13%	0	0%	9	9%
Native Language	Amharic	45	67%	6	19%	51	52%
	Afan Oromo	21	31%	25	78%	46	46%
	Tgrinya	1	1%	0	0%	1	1%
	Wolayitegna	0	0%	1	3%	1	1%

Table 2: Herd characteristics of small scale dairy farms in Bishoftu, Ethiopia

		Urban		Rural		Total	
	Category	n	%	n	%	n	%
Number of dairy cows in the household	1-5	36	55%	28	90%	64	65%
	6-10	21	32%	3	10%	24	24%
	11-15	8	12%	0	0%	8	8%
	16-20	1	2%	1	0%	2	2%
Breed of cows	Cross	60	90%	5	14%	65	66%
	Local	2	3%	16	48%	18	18%
	Both	5	7%	11	38%	16	16%
Number of years they've kept dairy cows	1-5	22	37%	5	17%	27	30%
	6-10	25	42%	8	28%	33	36%
	11-15	17	29%	6	10%	23	25%
	16-20	2	3%	4	14%	6	7%
	21-25	0	0%	0	0%	0	0%
	>25	3	5%	9	31%	12	13%
Any other ruminants in the household	Yes	24	36%	30	94%	54	55%
	No	42	64%	2	6%	44	44%
Dairy cows kept separately from other animals	Yes	63	95%	17	53%	80	81%
	No	4	6%	15	47%	19	19%

Table 3: Awareness and attitudes towards brucellosis

		Urban		Rural		Total	
		n	%	n	%	n	%
Heard of brucellosis	Yes	5	7%	3	9%	8	8%
	No	62	93%	29	91%	91	92%
Heard of disease causing late abortion	Yes	24	36%	3	9%	27	27%
	No	43	64%	29	91%	72	73%
Previous incidence(s) of late abortion in respondents animals	Yes	20	30%	6	19%	26	26%
	No	47	70%	26	81%	73	74%
Who does the respondent talk to about animal health issues	Friends/ relatives	7	10%	1	3%	8	8%
	Veterinarians	33	49%	18	56%	51	52%
	Animal Health Assistants	27	40%	13	41%	40	40%
Is the respondent interested in receiving more information about brucellosis	Yes	65	97%	32	100%	97	98%
	No	2	3%	0	0%	2	2%
Preferred format	Educational booklet	14	21%	1	3%	15	15%
	Local training course	18	27%	11	34%	29	29%
	Information from veterinarian	17	25%	15	47%	32	32%
	Information from AHA	9	13%	2	6%	11	11%
	Television	5	7%	0	0%	5	5%
	Any	1	1%	1	3%	2	2%

Table 4: Knowledge about brucellosis/late abortion among the respondents who had heard of the disease

	Category	Urban (n=24)		Rural (n=4)		Total (n=28)	
		n	%	n	%	n	%
Information source	Family/friends	16	67%	0	0%	16	57%
	Veterinarian	2	8%	0	0%	2	7%
	AHA	3	13%	2	50%	5	18%
	Training course	1	4%	0	0%	1	4%
	School	2	8%	0	0%	2	7%
	Don't know	0	0%	2	50%	2	7%
Cause	Bacteria	1	4%	0	0%	1	4%
	Hygiene	1	4%	1	25%	2	7%
	Inherited	1	4%	0	0%	1	4%
	Nutritional	2	8%	0	0%	2	7%
	Medicine	1	4%	0	0%	1	4%
	'Mich'	5	21%	1	25%	6	21%
	Don't know	13	54%	2	50%	15	54%
Animal species infected	Cattle only	19	79%	3	75%	22	79%
	Cattle, sheep and goats	2	8%	0	0%	2	7%
	Cattle, sheep, goats, pigs	2	8%	0	0%	2	7%
	Don't know	1	4%	1	25%	2	7%
Symptoms in animals (other than abortion)	Fever	2	8%	0	0%	2	7%
	Nausea	1	4%	0	0%	1	4%
	Anorexia/ inappetence	1	4%	1	25%	2	7%
	Don't know	20	83%	3	75%	23	82%
Knowledge of animal-animal transmission methods	Direct contact/ poor hygiene	4	17%	2	50%	6	21%
	Don't know	13	54%	2	50%	15	54%
	Non- infectious	7	29%	0	0%	7	25%
Knowledge that humans can get the disease from animals	Yes	3	13%	1	25%	4	14%
	No	11	46%	0	0%	11	39%
	Don't know	10	42%	3	75%	13	46%

Table 5: General knowledge of other zoonotic diseases

		Urban		Rural		Total	
		n	%	n	%	n	%
Knowledge that humans can get diseases from animals	Yes	40	60%	16	50%	56	57%
	No	16	24%	8	25%	24	24%
	Don't know	11	16%	8	25%	19	19%
Knowledge of transmission routes	Consumption of raw milk	32	80%	10	63%	42	75%
	Consumption of raw meat	20	50%	5	31%	25	45%
	Direct contact with infected animals	5	13%	1	6%	6	11%
	Don't know	3	8%	2	13%	5	9%
Awareness of specific zoonotic disease	Tuberculosis	18	45%	3	19%	21	38%
	Anthrax	13	33%	4	25%	17	30%
	Rabies	1	3%	1	6%	2	4%

Table 6: Descriptive results of self-reported herd management practices among dairy farmers in Bishoftu, Ethiopia

		Urban		Rural		Total	
		n	%	n	%	n	%
Wash udder before milking	Yes	65	97%	24	75%	89	90%
	No	2	3%	8	25%	10	10%
Separate space/shed for parturition	Yes	27	40%	19	59%	46	46%
	No	40	60%	13	41%	53	54%
Disposal of placental membranes	Bury it	23	34%	7	22%	30	30%
	Feed it to dogs	8	12%	13	41%	21	21%
	Collected by council waste disposal services along with other household waste	8	12%	0	0%	8	8%
	Throw it into open environment	27	40%	12	38%	39	39%
Disposal of aborted foetus/ foetal membranes	Bury it	14	21%	1	3%	15	15%
	Feed it to dogs	4	6%	2	6%	6	6%
	Collected by council waste disposal services along with other household waste	8	12%	0	0%	8	8%
	Throw it into open environment	38	57%	29	91%	67	68%
	Do nothing	1	1%	0	0%	1	1%
Do members of the household wear gloves when assisting with parturition or handling aborted materials	Always	22	37%	2	8%	24	28%
	Sometimes	5	8%	1	4%	6	7%
	Never	32	54%	23	88%	55	65%
Do members of the household wash their hands after assisting with parturition or handling aborted materials	Yes	59	98%	26	100%	85	100%
	No	1	2%	0	0%	1	1%
Cleaning of the area/ environment after parturition/ abortion	Brush only (dry)	1	2%	19	73%	20	24%
	Soap/ water	62	94%	5	19%	67	79%
	Disinfectant	3	5%	0	0%	3	4%
	Don't clean area	0	0%	1	4%	1	1%
Practices with a cow that has aborted	Separate it from other animals	0	0%	2	6%	2	2%
	Give herbal medications	1	2%	1	3%	2	2%
	Call a vet	35	55%	18	56%	53	55%
	Call an AHA	23	36%	10	31%	33	34%
	Sell it for meat	2	3%	1	3%	3	3%
Practices when an animal is showing signs of disease	Call a vet	38	58%	22	76%	60	65%
	Call an AHA	25	38%	7	24%	32	34%
	Treat with medicines from pharmacy	2	3%	0	0%	2	2%
	Slaughter at home	1	2%	0	0%	1	1%

Table 7: Descriptive results of self-reported household practices among dairy farmers in Bishoftu, Ethiopia

		Urban		Rural		Total	
		n	%	n	%	n	%
Consumption	Raw milk	12	18%	7	22%	19	19%
	Boiled milk	63	94%	25	78%	88	89%
	Raw milk products	58	87%	31	97%	89	90%
	Raw meat	50	75%	25	78%	75	76%
Selling raw milk	Locally	13	19%	1	3%	14	14%
	To a dairy	31	46%	10	3%	41	41%
	Both	21	31%	4	13%	25	25%
	Sell raw milk products	11	16%	12	38%	23	23%
Participate in backyard slaughter	Yes	46	69%	28	88%	74	75%
	No	21	31%	4	13%	25	25%
Practices when a household member is unwell	Visit health facility	62	93%	31	97%	93	94%
	Treat with herbal medicines	5	7%	1	3%	6	6%