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Original Article

Knowledge, perceptions and practices regarding brucellosis in pastoral communities of Kagera Region in Tanzania

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ABSTRACT

Objective: A cross-sectional study was conducted in June 2017 to assess the knowledge, perception and practices on brucellosis by pastoralists of Kagera ecosystem in Tanzania, using qualitative methods.
Materials and methods: Five focus group discussions of six participants each were conducted with livestock farmers, administration leaders, religious representatives and youth. In addition, discussions with three key informants were conducted, involving officials of livestock, wildlife and public health departments in each district. Data were analyzed using content analysis with inductive and deductive methods.
Results: The study revealed low knowledge regarding brucellosis among respondents. Although participants recognized brucellosis as a zoonotic disease, they consider it of less importance. In addition, participants had low knowledge on causes, symptoms and mode of transmission of this disease. However, they perceived the interactions between humans, livestock and wildlife together with movements between borders to be potential risks for introduction of brucellosis in their communities. Moreover, their habit of drinking unpasteurized milk, the lack of protective gears during assisting animals giving birth and poor vaccination program need to be improved by community health education.
Conclusion: A coordinated One Health approach is needed and further studies are suggested to reveal the status of brucellosis in Kagera ecosystem to guide its control and prevention.

KEYWORDS

Brucellosis; Knowledge; Pastoral communities; Practices

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INTRODUCTION

Brucellosis is a worldwide zoonotic disease for both public health and economic importance, affecting humans, livestock and wildlife. This zoonotic disease has a worldwide distribution where Africa is one of the endemic areas (Corbel, 2006). Different *Brucella* species are identified as causative agents of brucellosis and some of them are known to be pathogenic to humans which include *B. abortus, B. canis, B. inopinata, B. melitensis, B. pinnipedialis, and B. suis* (Tiller et al., 2010; Zheludkov and Tsirelson, 2010; Whatmore et al., 2014). In sub-Saharan Africa, the presence of various *Brucella* species (*B. abortus, B. melitensis, B. suis, B. canis, and B. ovis*) is reported, specifically in domestic animals (Ducrotoy et al. 2017). However, there is a scarcity of knowledge for *Brucella* species in humans and those associated to marine animals in Africa. *B. pinnipedia* and *B. cetaceae* mostly affect marine animals, but they are also responsible of threats in humans (typically neurobrucellosis) (Godfroid et al., 2005). It is known that brucellosis is endemic in several areas in East African region (Chota et al., 2016) where it reduces animal productivity through abortions and weak offsprings; causing a major threat in national and international livestock trade.

In Tanzania, previous studies have reported existence of risk factors for brucellosis transmission in pastoral communities including occurrence of abortions in herds, poor hygiene practices in assisting animals during parturitions, individuals living in close proximity with livestock and animal slaughtering occupation (Swai and Schoonman, 2009; Kunda et al., 2010; Assenga et al., 2016). In some communities, brucellosis transmission in humans was associated with people who drink raw-milk/animal blood, consume raw meat or share a bed or utensils with brucellosis patients (Mubyazi et al., 2013). Previous studies in Tanzania demonstrated higher understanding by pastoralist of the existences of diseases transmitted between humans and animals (Swai et al., 2010; Mangesho et al., 2017). Moreover, livestock keepers could recognize abortions, emaciation, a drop in milk production and fever as clinical signs associated with brucellosis (Shirima, 2005). Despite the good perception and knowledge of common diseases circulating in their area, livestock farmers needs to improve their practices to control those diseases, which most of the times leads to failure at individual and national levels (Chengula et al., 2013). Activities undertaken for controlling brucellosis, may involve capacities for detection of the disease, the participation of stakeholders in mass vaccination or culling, the epidemiosurveillance system based on the perception of the risk for humans, livestock and wildlife in the ecosystem. Despite their knowledge and perception of the threat caused by certain diseases in their communities, pastoralists adopt some cultural behaviors which could favor the transmission of infectious disease in the localities (Musallam et al., 2016). The understanding and the eradication of brucellosis, needs a characterization of the disease, the multidisciplinary actions from different stakeholders in the exposed areas (Zinsstag et al., 2005). Also, the transboundary transmission of zoonotic diseases may be considered and be evaluated from the local understanding of communities. Little is known about the local understanding of brucellosis by pastoralists in Kagera, Tanzania. This study was conducted to assess the knowledge, perception, and practices regarding brucellosis of different stakeholders in the pastoral communities of Kagera Region; an ecosystem located on borders between Tanzania, Burundi, Rwanda and Uganda.

MATERIALS AND METHODS

Study area: This study was conducted in two districts namely Karagwe and Ngara, of Kagera Region, in north-western part of Tanzania (**Figure1**). Livestock contributes significantly to the economy of Kagera region, and animals are exported to neighboring countries (United Republic of Tanzania, 2013). Kagera ecosystem is subdivided into three agro-ecological zones (Lake Shore and Islands, Plateau Area and Lowland) in which crops grown are mainly bananas, cassava, beans, maize, coffee and tea. The area has game reserves such as Kimisi and Burigi in which zebras, impalas, buffalos, elephants, giraffes, leopards, hippos and crocodiles can be found. Health facilities are distributed in all districts and various transport means link Kagera to other regions and neighboring countries particularly Burundi, Rwanda and Uganda. The climate is equatorial with temperatures ranging between 20°C and 28°C. Kagera Region, in general has rainfall ranging between 900 - 2,000 mm per annum.

Study design: A cross-sectional study design was used to assess the knowledge, perception and practices of brucellosis in pastoral communities of Kagera in June 2017, using a qualitative research method.

Participants selection and data collection procedure: Two focus group discussions (FGDs) and one Key Informants Interview (KIIs) were conducted in Ngara district, while three FGDs and one KII were done in

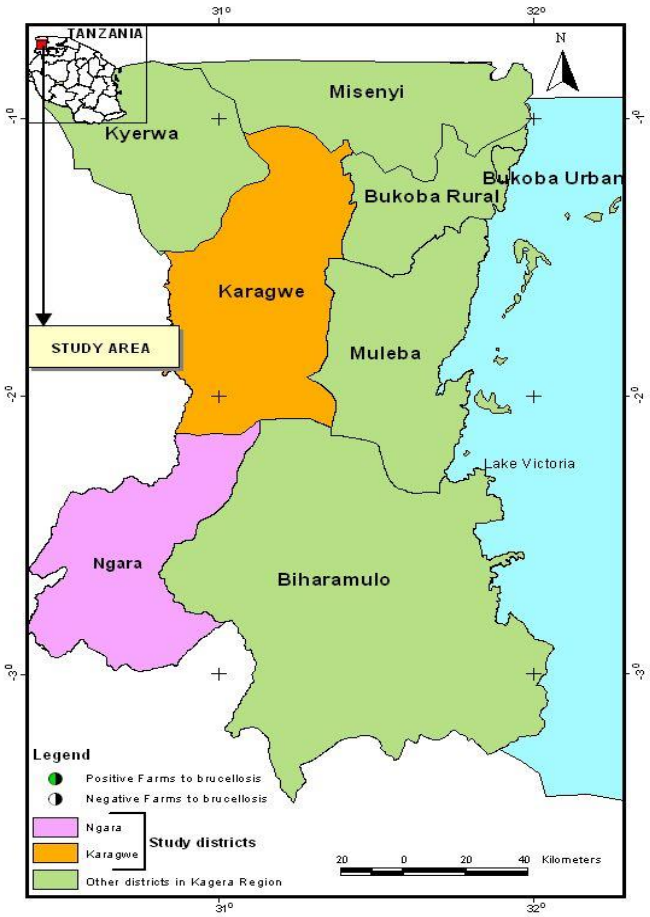

Figure 1. Map of Kagera Region

Karagwe district. Each FGD involved a minimum of six persons selected purposively: three farmers, one representative of local government, one religious leader and youth representative (15 to 24 years old). Discussions with KIs involved three government officials from the animal health, public health and wildlife departments in each district. Participants in this study originated from five villages selected purposively (urban, peri-urban and rural areas) to get a variation of insights on brucellosis from different people according to their location (**Table 1**). FGDs and KIIs approaches were combined to get coverage of information from experts and non-experts regarding brucellosis.

The FGDs and KIIs were conducted in the respective communities of the participants; i.e, ward executive and district official's offices (or hospitals). Digital recording by mobiles phones was used to record discussions and interviews. FGDs were conducted in Swahili language by a facilitator, while interviews with KI were conducted in English by the researcher. The interview guide was structured around four main themes as follows:

(i) Perception of brucellosis by the population in Kagera ecosystem: Participants were asked about the local name of brucellosis, existence of the disease in their locality. The knowledge on the causes, main symptoms, and the mode of transmission of brucellosis were also assessed. Furthermore, the socio economic impact and the prophylactic approach of this zoonotic disease in the ecosystem were discussed.

(ii) Risk factors for brucellosis prevalence in Kagera ecosystem.

(iii) Potential for transmission of brucellosis in Kagera ecosystem due to neighboring with other countries.

(iv) Roles of different stakeholders in the ecosystem in the control of brucellosis.

The facilitator introduced the aim of the study, explaining each theme clearly to participants. The discussions lasted approximately 45 minutes. For the KIIs, interviews were conducted in English by the researcher and both FGDs and KIIs groups were asked the same questions.

Data analysis: Data recorded from FGDs were transcribed verbatim to Microsoft Word and later translated from Swahili to English. The coding of the categories was done manually using Microsoft Excel since the data was small and themes and sub-themes were easily identifiable. Later, the content analysis was done with inductive and deductive methods based on the categories grouped in different themes and subthemes as well as emerging themes. Themes and sub-themes were analyzed in their chronological order of inquiry.

Ethical considerations: This study was approved by institutional review board of Sokoine University of Agriculture , and ethics clearance was also obtained from the Medical Research Coordinating Committee of the National Institute for Medical Research (ref: NIMR/ HQ/R.8a/Vol.IX/2456). Informed verbal consent was obtained before conducting each FGD from all the team members. For confidentiality matter, participants were ensured for none use of their names during analysis, report or publication. Approval by participants for recording was requested prior to this activity.

RESULTS

Socio-demographic description of the participants

Thirty seven participants from six villages of Karagwe and Ngara districts were recruited to participate into Focus group discussions (**Table 1**). The mean age of the participants was 49 years (standard deviation = 10.55) and 30.55% of participants were females. People interviewed were from different tribes specially:

Table 1. FGDs per district and locations.

District	Village	Characteristic	Participants		FGDs conducted
			Females	Males	
Karagwe	Bweranyange	Rural area participants	1	6	1
	Nyagasimbi	Rural area participants	1	5	1
	Nyakahanga	Urban and peri-urban area participants	2	4	1
	Kayanga	Officials from Livestock, Public health and wildlife department	1	2	1
Ngara	Benaco	Rural area participants	3	3	1
	Ngara mjini	Urban and peri-urban area participants	2	4	1
	Ngara	Officials from Livestock, Public health and wildlife department	1	2	1
Total			11	26	7

Wanyambo, Wahaya, and Wahangaza. The focus group discussions involved farmers, youth, religious leaders and local government representatives. Four of the participants had no formal education, 21 had primary education, and 12 had secondary school or higher education. Key informants interviews were conducted in group of three individuals from public health, livestock and wildlife departments at district level. All the key informants were degree holders.

Knowledge and perceptions on brucellosis in pastoral communities of Kagera ecosystem

The understanding of brucellosis among the study participants in Kagera Region was not direct because some of them confused it with the "abortion process". In Tanzania, brucellosis is normally known in Kiswahili as "ugonjwa wa kutupa mimba" meaning the "disease of abortion". Describing the disease to participants, the term abortion was used as a prominent symptom; but it wasn't enough to differentiate brucellosis from other diseases associated with abortion which people are accustomed to encounter or report in humans and livestock. Thorough explanations were needed to make participants distinguish the phenomena of abortions from brucellosis, as this confusing heavily influenced their responses during the focus group discussions.

Participants gave different local names of brucellosis: Amakole, Omwizi, Entandago, Kuramburura, and Kururumura. However, the most common local name of brucellosis used in the two districts was "Kutoroga". The existence of brucellosis in their locality, as well as the zoonotic nature of the disease were acknowledged by all the groups who participated in this study. However, participants provided different causes of brucellosis. Five groups out of seven believed that brucellosis is caused by seasons (three groups mentioned dry season and two groups mentioned rainy season), while three groups said that brucellosis is caused by other diseases (malaria, Foot and Mouth Disease). One group mentioned vectors (tsetse flies, mosquitoes), age, contaminated water, drought and famine as causes of this disease.

> "….. *Few days ago, this disease could occur when cattle were drinking contaminated water with bacteria. Also, dry season causes abortions because of high temperature. There are so many causes including different diseases. That's what I know*." (Farmer1- FGD Bweranyange- Karagwe District).

Six out of seven groups mentioned abortion as a clinical sign of brucellosis in humans and livestock. Other signs in humans were fever, tiredness, skin discoloration. The two key informants groups insisted on the fact that brucellosis may have a resemblance of symptoms with other febrile diseases such as malaria.

In livestock, participants mentioned additional symptoms of brucellosis such as fever, hygroma, vaginal discharges, skin changes, lack of appetite, orchitis, tiredness, general weakness and coughing. Only one group of key informants mentioned hygroma as symptom of brucellosis observed in wildlife.

> *"The signs are the same, cattle can get high fever, then hair rise up and blood start to come out, and abortion can occur almost within two days. We as farmers, we are accustomed to the problems of cows than those riches (cattle owners) who give us the cattle to graze for them."*(Farmer2- FGD Nyakasimbi-Karagwe District -).

The mode of brucellosis transmission involved different ways in humans: consumption of uncooked meat and unpasteurized milk, sexual intercourse and unprotected assistance of their animals during parturition. According to Key informants, milk is mostly consumed directly from animal and locally collected by farmers for informal commercialization. In addition, they mentioned the poor disposal of aborted materials and placentas. In livestock,

participants centered the transmission of brucellosis on the sharing of pasture and water between domestic animals and wildlife, the physical and sexual contact between animals, vectors (mosquitoes and tsetse flies) and contact with vaginal discharges of infected animals. Two groups mentioned the interactions between animals and the dissemination of vaginal discharges as source of contamination of brucellosis in wildlife.

> *"In animals, the transmission can be due to the increase of the number of cattle in the same area where contamination by contact can occur. In addition, the disease can be transmitted during the sharing of pastures with non0-vaccinated animals. It may happen that you perform vaccination very well but the problem arises when sharing pastures with infected herds. This may result in the transmission of some diseases which you cannot recognize"* (Farmer1- FGD - Nyakahanga-Karagwe District).

Throughout the discussions, the participants talked about the social impact of brucellosis in their localities. Participants in three groups believed that brucellosis could affect their willingness of raising animals and could reduce their faith in marriage. In addition, the economic impact of brucellosis was pointed out as a consequence of the loss of milk production, unnecessary expenditure to cover the treatments (incomes decrease), which could also contribute to the inability to pay school fees for their children. All the groups agreed that brucellosis decreases the total number of livestock. Furthermore, participants highlighted the negative impact of brucellosis on their health through the abortion, the deaths and the nutrition problems due to the decrease of milk production.

> *"On medical aspect, first of all, if you fail to diagnose brucellosis timely, you will not treat correctly and result into an avoidable death, if you treat wrongly the patient, thinking that maybe it is malaria or typhoid while it wasn't t, the outcome of improper treatment has bad consequences to the patient, like death; and misuse of medicines."* (KII1-Ngara District).
>
> *"… but this problem can cause the failure of production for both animals and humans."* (Cheikh - FGD Ngara District).

Regarding the prophylactic approach for brucellosis, focus group participants agreed that women are more prone to seeking medical care in health centers and hospitals. Key informants specified the use of antibacterial drugs such as doxycycline and rifampicin as treatment options in case of suspicion of brucellosis, even if according to them, some of these drugs particularly rifampicin were commonly used to treat tuberculosis. For livestock sector, farmers in all groups attested to call for veterinary services; also they confirmed buying drugs themselves and rarely get vaccinations. The use of traditional medicine to treat brucellosis in livestock and humans in case of abortions was mentioned by participants in two groups.

> *"Ah no, when you suspect something even if it is not yet confirmed, but if you see that it is likely to be, you start to treat. So alternatively, we use doxycycline; even if it is not available in the hospital, it is available in the pharmacies."*(KII1-Ngara District).
>
> *"Here the government has never provided such vaccine or medicine but ourselves when the problem occur, we go to the pharmacy to buy some medicines for treating our animals. But about prevention cases from the government; we didn't receive any."* (Farmer2- FGD Bweranyange- Karagwe District).

Risk factors for brucellosis in humans, livestock and wildlife

The important risk factors for brucellosis mentioned by participants (five groups) were: a movement of livestock and wildlife in the ecosystem, the sharing of pastures and drinking points shared between wildlife and livestock.

> *"….because most of the people who are living here close to this Kimisi game reserve are involved in movement of animals inside the game reserve. They take their livestock to graze inside the game reserve. So, the interaction with wildlife can increase the magnitude of the disease. "*(KII-Karagwe District-wildlife official).

KII groups recognized the habits of drinking unpasteurized milk, poaching and the poor disposal of aborted material (placentas and aborted materials are thrown in the environment or given to dogs) as major risk factors for brucellosis transmission in humans in their communities. Climate change, consumption of uncooked meat and sexual intercourse (favored by the movement of people in the ecosystem) were also reported in two groups as risk of introduction of brucellosis in the study area.

The risk for transmission of brucellosis in Kagera ecosystem due to neighboring with other countries

Six groups stated that the interactions observed on borders between livestock and wildlife and the existence of games reserves on borders constitute a risk for transmission of brucellosis from others countries. Furthermore, the movements of people crossing borders for pastoral and commercial activities, the migration of people including refugees' camps were proposed by

different groups as potential risks for the introduction of brucellosis from neighboring countries.

> *"During the conflicts in Rwanda and Burundi I was here keeping goats but this disease was already there before the refugees came here. At the time, there were some refugees who brought some cattle and used to sell them to indigenous people. However, there were no any benefit from it, because all of the purchased animals died. We are not sure if those animals died because of this disease or if the problem was the change of environment. But, I think the problem was the environment, they were not supporting the weather here.* (Pastor- FGD Benaco- Ngara District).

During the discussions, five groups mentioned also the uncontrolled movement of wildlife on borders (wild animals don't know borders) to be a risk of introduction of brucellosis from a country to another.

The role of different stakeholders in the ecosystem in the brucellosis control

Brucellosis is not controlled in the pastoral communities of Kagera. Little is being done for the effective surveillance of this zoonotic disease. All the groups confirmed that few farmers were vaccinating their animals. Otherwise, participants from all groups requested the government to apply for the community health education (trainings and seminars) and they shared the opinion about the necessity of mass vaccination program against brucellosis as it is done for others diseases (Foot and Mouth Disease, East Coast Fever). Two groups implored the improvement of the equipment in health facilities, also solicited the reinforcement of livestock service in the local communities (increase the number of field livestock officers).

> *"….so, it's better if the government can bring the service near and if possible every village should have an animal health center."*(Farmer2- FGD Bweranyange- Karagwe District).

Key informants proposed to build a laboratory for the diagnosis of brucellosis, to conduct research for mapping brucellosis in the area and they advocated for multisectoral collaboration (sharing information between livestock, wildlife and public health department) about brucellosis.

"I think there is a need of conducting research to be sure if really brucellosis is existing or not. We are assuming and assumption can be possible, but from what is happening, it is likely that brucellosis exists. To be sure of that, we need to have a research to confirm, to see the magnitude of the problem." (KII- Ngara District).

DISCUSSION

This study revealed low knowledge, poor perception and practices regarding brucellosis in pastoral communities of Kagera Region, northern Tanzania. Previous studies in Tanzania informed on the magnitude on brucellosis in some areas of the country (Kunda et al., 2005; Kiputa et al., 2008; Roug et al., 2014; Assenga et al., 2016), indicating the disease being one of important threats to both veterinary and public health in the country. Qualitative research studies like the current study are limited but provide better understanding of the problem, and hence, contribute to improving surveillance and management of brucellosis (Mangesho et al., 2017) in affected communities.

All participants described brucellosis as a zoonotic disease and most admitted the presence of the disease in their areas. Nevertheless, the presence of a disease can't be confirmed from mere perceptions of people. For example, some local names like "Okutoroga" didn't mean exclusively brucellosis as a disease, but they were indicating the syndrome of abortion in general, which could be attributed to the existence of other abortive diseases in the area. Respondents in this study perceive brucellosis as a zoonotic disease. On the other hand, a study conducted in Tanga and Arusha revealed that rabies, tuberculosis and anthrax were considered to be the most common zoonotic diseases (Swai et al., 2010). It comes out that farmers understand the possibility of transmission of infectious diseases from animals to humans without much consideration for their threat (Mangesho et al., 2017).

A study conducted in Kenya showed a high level of knowledge of brucellosis in pastoral communities where respondents reported brucellosis to be a zoonotic disease and abortion as its common symptom (Obonyo and Gufu, 2015). But, in Ethiopia, none of the respondents to a study reported the zoonotic importance of brucellosis (Tesfaye et al., 2013). The zoonotic aspect of brucellosis is mostly favored by the lack of awareness of the disease among pastoralists, the scarce collaboration between different sectors and the small investment in the control of the disease by governments in developing countries. In addition, experts stated that the approach used in developed countries (animal slaughter and milk pasteurization) is not suitable for the control of *Brucella* species infections in humans in Africa (Marcotty et al., 2009). Furthermore, diagnostics tools need to be reinforced by rapid and reliable diagnostic tests for effective detection of brucellosis at different stages in human.

In the study area, brucellosis was perceived to be caused by others diseases such as malaria in humans, Foot and Mouth Disease in livestock; which indicates that the disease could be less considered among the principal threats in the study area. In addition, if brucellosis is one of the causes of losses in pastoral communities, this situation could lead to the negligence of its real burden. Although abortion was mentioned as common symptom of brucellosis in humans and livestock, women who participated in this study affirmed not to observe a big number of abortions in humans nowadays and, according to them, the rare cases which can occur could not be associated to brucellosis. Studies also documented that *Brucella* species occasionally are causing spontaneous human abortions, but the contribution of brucellosis to abortions in women is still controversial (Khan et al., 2001; Kurdoglu et al., 2015).

Participants talked mostly about cattle, and this could indicate the major importance attributed to cattle compare to small ruminants as far as brucellosis in concerned. In fact, brucellosis can be transmitted to humans from small ruminants by assisting goats or sheep births in Tanzania (Cash-Goldwasser et al., 2018). However, little is known about the transmission from goat or sheep milk, which could also demonstrate the low awareness of brucellosis and its zoonotic health implication in the study area. Other studies in Tanzania reported findings in which pastoralists did not perceive the products from animal origin to be dangerous (Swai et al., 2010; Mangesho et al., 2017).

Respondents had also knowledge of the impact of brucellosis on their social, maternal, nutritional health and economic situation. Zoonotic diseases like brucellosis can cause losses with far-reaching social impacts (Ducrotoy et al., 2014). Losses particularly due to brucellosis remain to be quantified through epidemiological studies, because abortions due to brucellosis in humans and livestock are not well understood. Furthermore, studies on the economic impact of brucellosis in livestock are reasonably consistent in different production systems in Africa and Asia (McDermott et al., 2013). Economic burden in pastoral areas are also due to other infectious diseases, but generally in Africa, in areas where the infection rate can reach 30% for bovine brucellosis, the economic losses are estimated at 5.8% of gross income per animal reared (Domenech et al., 1982).

Poor prophylactic practices regarding brucellosis were observed in this study. If domestic animals are infected with brucellosis, a direct consumption of milk locally collected by farmers and informally commercialized could increase the risk of brucellosis infections in humans. In Uganda, a study that confirmed the presence of *Brucella* in cattle reported a high risk of human brucellosis associated with informally marketed milk and (Hoffman et al., 2016). A systematic review on treatment of brucellosis in human for the last twenty years, concluded that doxycycline-aminoglycoside combination was the first choice with doxycycline- rifampin and the study recommended doxycycline-cotrimoxazole to be the alternative regimens (Alavi and Alavi, 2013). However, treating suspected cases combined with self-medication by people suggests that population of Kagera Region could be exposed to an antimicrobial resistance threat in humans and their livestock. Tanzania is placed among countries which are in need of standard surveillance of antimicrobial resistance in human and livestock pathogens (Mshana et al., 2013).

Diseases can be misdiagnosed in the population because of the absence of diagnostic tools. Furthermore, sound control of diseases require relevant skills and information about their causes, symptoms and mode of transmission (Lindahl et al., 2015). Animal health strategy for diseases control is well established in Tanzania. However, limitations exist in sensitization campaigns and mass vaccination programs for brucellosis (Matthew et al., 2016). Efforts are needed to sensitize people for mass vaccination against brucellosis which could lead to the control of it zoonotic transmission (Olsen and Stoffregen, 2005). Some participants reported to use local medicines to treat brucellosis in humans and animals. This practice is shared by smallholder dairy farmers in Pakistan (Arif et al., 2017). About 193 plants are documented in the East African region to be used by farmers for treating diseases of their livestock including brucellosis (Katerere and Luseba, 2010). However, these practices are sometimes kept as secrets by farmers and are transmitted from generation to generation. Moreover, traditional medicines are valuable resources for new agents against antibiotic-resistant strains, and studies have been conducted in this aspect (Motamedi et al., 2010; Noudk et al., 2017).

Key informants reported drinking unpasteurized milk and eating non-inspected meat to be among possible factors which could contribute to transmission of brucellosis in humans in the study area. Possible risk factors for brucellosis infections in humans were practices of assisting animals during parturition without any protection and the disposal in the nature of placentas and aborted materials which could be attributed to the lack of

community health education. Protective gears used during assistance of parturition could not be available in pastoral areas; and the limited incomes of small farmers could perpetuate such poor practices. In addition, this behavior can be related to the low risk perception of brucellosis in the communities. Small scale farmers in Tajikistan didn't use any protection when handling cows getting an abortion or when dealing with aborted materials (Lindahl et al., 2015). Other studies in Tanzania revealed a knowledge of pastoralists of the risk for brucellosis infections in humans due to the occurrence of abortions in herds, individuals living in close proximity with livestock and animal slaughtering occupation (Swai and Schoonman, 2009; Kunda et al., 2010; Assenga et al., 2016). The interactions between wildlife and livestock were reported as potential risk for brucellosis transmission to humans and livestock. Scholars have documented the presence of brucellosis in wildlife (Fyumagwa et al., 2009; Godfroid et al., 2010; Muma et al., 2010). However, the role played by wild species in spillover of brucellosis to humans and livestock remains to be clarified. Little was discussed in this study, by participants about the mode of transmission, the risk factors or the impact of brucellosis in wildlife in their communities. In the other hand, respondents in a study conducted in Uganda believed that the proximity of livestock to wildlife contributes to the emergence of brucellosis (Kansiime et al., 2015). Moreover, experts from wildlife sector could increase the diagnosis and surveillance of prevalent diseases and share the information with the rest of stakeholders in the communities.

In the Kagera ecosystem, there are games reserves like Burigi, Kimisi on the Tanzania side; Ruvubu National Park in Burundi, and Akagera National Park in Rwanda where an uncontrolled movement of wildlife species can be observed. These interactions may be controlled to minimize the risk as long as the reservoirs of brucellosis in the ecosystem are domestic and wild animals which may carry Brucella regardless of infection prevalence in the main hosts (Zheludkov and Tsirelson, 2010). Even though the introduction of brucellosis in Kagera region is not documented, observations from a study stated that the potential impact of a disease outbreak can be amplified by interactions of drivers (Suk et al., 2014). Participants to this study mentioned also the movement of refugees with their livestock in the area, together with an increase of sexual intercourses, consequent to cross border exchanges as potential drivers of brucellosis in humans and livestock in their communities. Moreover, the increase in animal product demand can favor the spread of transboundary animal diseases (Otte et al., 2004), including brucellosis.

Participants converged to solicit community education on integrated health management of zoonotic diseases, brucellosis included. Even though, some recommendations were addressed specifically to the Government to control brucellosis in their communities, farmers should act through associations or in their cooperatives where mass vaccination programs can be implemented. Studies suggested the increased knowledge in local communities as a strategy for prevention and control of brucellosis (Obonyo and Gufu, 2015). A reinforcement of livestock personnel skills at community level was proposed. In Uganda, the training and recruitment of more health personnel, the education of the communities about brucellosis diagnosis and vaccination were underlined as important gaps for the prevention of brucellosis in the communities (Kansiime et al., 2015). The exchange of information between neighboring countries at multidisciplinary level could also increase the risk management and control of brucellosis in the ecosystem. A collaboration between veterinary and public health services could also improve human and animal health sectors(Kahn et al., 2007).

Study limitations: During discussions, there were confusions in understanding the differences between brucellosis and other abortive diseases in the area, because in Swahili, brucellosis is called "Ugonjwa wa kutupa mimba"= "Disease of abortions". Participants were requesting for more clarifications to understand differences between abortions as symptom and brucellosis as disease. Discussions with key informants were made in groups of three persons instead of independent interviews due to their limited time. With such approach, participants could influence each other's response during the discussion. However, the information collected from the Key Informants complemented the knowledge from the rest of participants of this study. This research was conducted in pastoral communities, where there are strong interactions between humans, livestock and wildlife in an ecosystem located on borders between four countries (Tanzania, Burundi, Rwanda and Uganda), which is the strength for this study.

CONCLUSION

This study assessed the knowledge and perception regarding brucellosis in pastoral communities of Kagera Region, Tanzania. Focus group discussions and

interviews with keys informants revealed a low knowledge, perception and practices of brucellosis in the study area. Participants possessed low knowledge on causes, symptoms and mode of transmission of brucellosis. However, people from these pastoral communities attributed different local names to brucellosis and they were aware that it is pertaining to zoonotic diseases. Despite their knowledge on the existence of strong interactions between humans, domestic animals and wildlife in the bordering ecosystem, their risk perception of brucellosis is poor due to the neglected and cultural behavior of people in their communities. The improvement of the knowledge and practices regarding brucellosis request a clear community health education program and should involve cross border collaboration with stakeholders in neighboring countries. More research is needed to elucidate the status of this transboundary disease in the pastoral areas of Kagera Region.

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CONFLICT OF INTEREST

The authors have no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

AUTHORS' CONTRIBUTION

This work was a result of the contribution of all authors. JBN designed the study and conducted the interviews and edited the manuscript; JBN and HN coded and analyzed the data; HN, LEM, SIK, EK reviewed the manuscript; EK assisted for funding the research. The authors approved the final manuscript.

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