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REVIEW ARTICLE

Bovine Brucellosis and Its Public Health Significance in Ethiopia

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Abstract

Bovine brucellosis is endemic and widely distributed in Ethiopia. The country has already prioritized top five zoonotic diseases (rabies, anthrax, brucellosis, Rift Valley fever and highly pathogenic avian influenza) in 2019 using reprioritization workshop. So brucellosis is one of the top five neglected zoonotic diseases in the country. According to several studies, the distribution and prevalence of bovine and human brucellosis in Ethiopia varies among regions in terms of animal production and management systems, community living standards and awareness levels. The disease has major zoonotic and economic implications for rural communities, particularly pastoralists. The aim of this article was therefore to review and summarize recent studies (2010–2021) on the prevalence of bovine brucellosis in animals and humans, with reference to Ethiopia. This review describes both bovine and human brucellosis reported from various geographical areas of the country. Reports between the years 2010 and 2021 indicated a prevalence rate between 1.2% and 22.5% at the individual level, and 3.3% and.68.6% at the herd level. However, the human brucellosis seroprevalence rate was 2.15%–48.3% between 2006 and 2021. This increase clearly indicates the expected future threat of this disease in the country. However, control measures and community awareness are lacking. Therefore, actual implementation of prevention and control measures, community awareness, further studies and continual review to provide compiled information for understanding the transmission dynamics of the disease are essential.

Key words: brucellosis, bovine, Ethiopia, public health, significance, zoonosis

INTRODUCTION

Ethiopia, a Sub-Saharan African country, is characterized by a strong correlation between a high burden of zoonotic diseases and poverty, because of the high risk of zoonotic disease transmission and emerging and re-merging pandemic threats [1]. The country has a total of 70,291,776 million cattle, of which 22,598,088 million are dairy animals constituting 32.15% of the total cattle population [2]. Approximately 80% of Ethiopians are dependent on agriculture and have close relationships with their livestock. Consequently, the country is vulnerable to the spread of zoonotic diseases among these populations [3,4]. Many zoonotic diseases occur endemically and threaten the large livestock and human populations in the country. Brucellosis is the main neglected zoonotic disease in Ethiopia, and has major public and economic effects [3].

Ethiopia's cattle population has a high potential for gaining live animal and red meat export markets to the Middle East, Gulf States and some African countries. However, production is challenged by constraints such as shortages of feed and water, poor husbandry management and diseases including brucellosis, thus limiting the export market [5]. Brucellosis, particularly bovine brucellosis, has caused serious economic crises in cattle in countries

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including Ethiopia, owing to indirect losses (morbidity and mortality; reduced fertility, milk production and sale value of infected cows; limitation of trade of live animals and their products; disruption of local markets; and impediments to free animal movement) and direct losses (abortion, neonatal death, replacement costs, treatment costs, emergency slaughtering of infected animals and stillbirths) [4,6-8].

Bovine brucellosis, caused principally by *B. abortus*, and occasionally by *B. melitensis* and *B. suis* [9], is one of the most serious infectious diseases challenging cattle productivity (mainly in the dairy production sector) and public health in Ethiopia [4,10]. The habit of people living near their livestock, traditional raw animal product consumption, regular contact between people and their animals, and improper handling of cases and/or products by occupational workers are the main factors causing this disease to escalate. The widespread prevalence of these factors makes the disease not only endemic but also among the top public health threatening zoonoses in the country [11].

In the past decade, several bovine brucellosis serological surveys conducted in Ethiopia have shown the endemic and widespread characteristics of the disease. Between 2010 and 2021, seroprevalence studies conducted on bovine brucellosis in Ethiopia have reported prevalence rates ranging from 0.4% to 11.9% at the individual animal level [12-14], and 12% to 63.6% at the herd level [15-17]. Most previous studies have been performed in central Ethiopia on institutionally owned commercial, large and medium scale dairy farms, situated in Addis Ababa and its surrounding area [18].

Although studies conducted to date have indicated that brucellosis is endemic in Ethiopia, awareness and communication and/or dissemination of information among the entire community and decision makers has been minimal, thus contributing to the lagging practical implementation of prevention and control measures of the disease. In addition, few or no studies have been conducted on higher risk groups (for example risk groups on abattoirs and laboratories), most pastoral areas and other regions far from the country's capital. Hence, knowledge regarding the current status of brucellosis, with a particular emphasis on bovine brucellosis and mitigating the public health and economic burden of the disease through reviewing previous studies is necessary to provide compiled information for professionals, stakeholders, officials, partners and the community as a whole. Therefore, the objective of this article was to review and summarize recent studies (2010–2021) on the prevalence of bovine brucellosis and its public health significance in Ethiopia.

LITERATURE REVIEW

Background of brucellosis

Brucellosis is an ancient disease caused by gram-negative, facultative intracellular bacteria from the genus *Brucella*; it can be traced back to the 5th plague of Egypt around 1600 BC [19]. Scientific knowledge of the disease was first gathered 18 centuries later, when Sir David Bruce isolated *Micrococcus melitensis* (now *B. melitensis*) from the spleen of a British soldier among the military personnel stationed at Malta, who died from Malta fever (a febrile illness). The zoonotic nature of brucellosis was demonstrated in 1905 following the isolation of *B. melitensis* from goat's milk used for soft cheese production in Malta [20].

In the 1950s, more than 200 cases of brucellosis were caused by ingestion of cheese from Maltese goats. In 1895, 1914 and 1966, *Brucella* species were isolated from aborted bovine, swine and canine fetuses, respectively. In 1953, *B. ovis* was identified as a cause of epididymitis in rams. In the past 15 years, three new non-classical species of *Brucella* have been identified [21,22]. Generally, *Brucellae* are grouped in to six main species: *B. abortus* (cattle, buffalo, elk, yaks, and camels, biovars 1–6 and 9), *B. melitensis* (goats and sheep, biovars 1–3), *B. suis* (pigs, reindeer and hares, biovars 1–5), *B. ovis* (sheep), *B. canis* (dogs) and *B. neotomae* (desert wood rats). *B. ceti* (dolphins), *B. pinnipedialis* (seals), *B. microti* (voles) and *B. inopinata* (reservoir undetermined) are also new members included recently [23,24]. *B. inopinata*, the only species not isolated from an animal reservoir, was isolated from a breast implant infection in a woman [7].

Brucellosis is a neglected zoonotic disease of humans and animals in sub-Saharan African countries including Ethiopia [25]. It is highly contagious and considered (by the World Health Organization, United States Food and Agriculture Organization and Office of International Epizootics) to be one of the most serious zoonoses with considerable public importance worldwide [26]. According to the OIE, brucellosis is the second most dangerous zoonotic disease worldwide next to rabies.

Epidemiology of brucellosis

Bovine brucellosis has been controlled and/or eradicated in most developed countries through extensive control programs. However, it remains an important economic and human-animal health problem in developing countries, where many people rely on their livestock, primarily because of a lack of resources, under-reporting and misdiagnosis of the disease, and the absence of prevention and control programs. It remains a major problem in the Mediterranean region, Western Asia, parts of Africa and Latin America (Fig 1) [28,29].

Risk factors

The initiation, spread, maintenance and/or control of brucellosis are affected by risk factors including the animal population (the genetic content of the susceptible animal population, management), biology of the agent, environmental factors and human related factors, which can be explained by the size and composition of the herd, age of the animals, frequent contact between infected and susceptible herds, poor farm biosecurity and climate change [30,31].

Age, sex and reproductive status are the main host factors, and *Brucella* infection occurs in all ages of animals, most commonly in sexually mature and pregnant animals. Exposure to strains of the organism occurs primarily at the

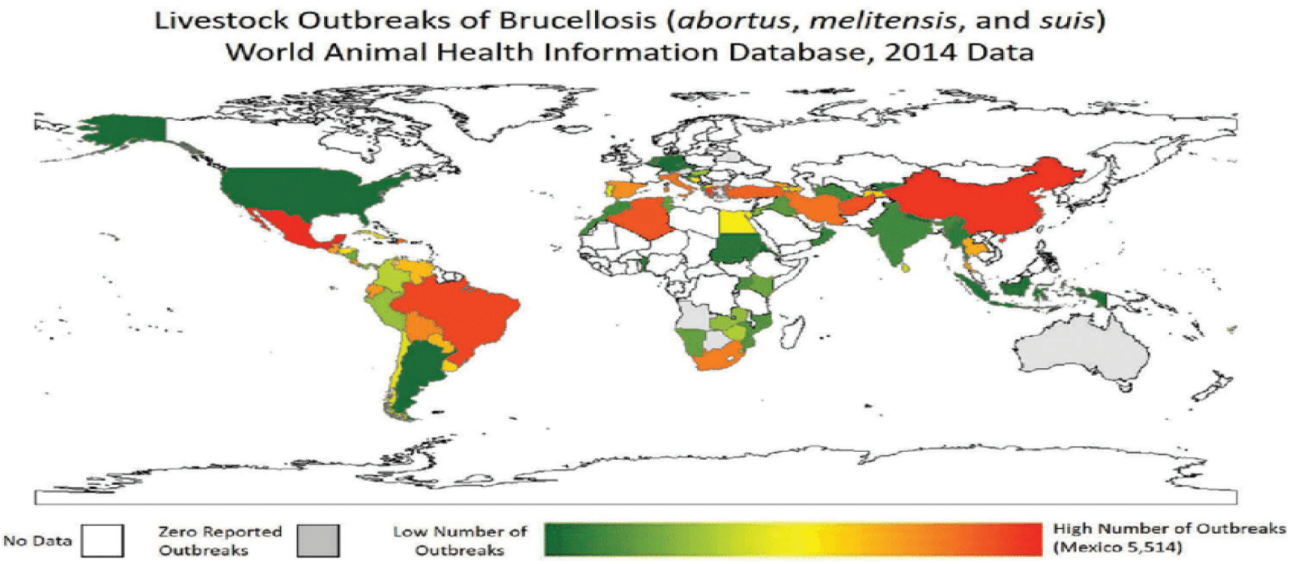

FIGURE 1 | Heat map of brucellosis outbreaks in livestock—WAHIS 2014 [27].

time of parturition of infected cows. The unregulated movement of animals from infected herds to brucellosis free herds is the major means for the spread of the disease. Improper management of reproductive tract excretion, aborted biological materials, lactating cows, and the environment or equipment are major sources of infection [32,33].

The nature of the agent is also the main risk factor. *Brucella* has an outer-membrane lipopolysaccharide, and it uses its phagosome-lysosome inhibition characteristics (virulence and inhibition factors) for intracellular survival and antibiotic resistance. The human related factors, such as age, sex, occupation and cultural habit of living near livestock, raw animal product consumption and contact with aborted biological materials, are the main risk factors for human brucellosis [6,32].

Transmission

The mode of transmission in cattle is mainly through ingestion or inhalation of organisms from different sources, such as contaminated pasture or water with aborted fetuses, fetal fluids and vaginal excretions. Transmission usually occurs from animal to animal, through contact with aborted and/or retained placenta material. Sexual and artificial insemination are also possible modes of transmission [6,13]. Human consumption of unpasteurized milk products, raw blood and meat (mostly liver, kidney and spleen), and contact with infected animal materials, such as aborted biological materials, urine and placenta, during and after the parturition period are major modes of transmission [34].

Clinical signs

Brucellosis can remain a latent infection in animals for several years, and its clinical manifestations are associated with the reproductive tract. Manifestation of the disease in females is usually characterized by third trimester abortion, neonatal weakness, retained placenta, endometritis and reduced milk yield. In highly susceptible non-vaccinated pregnant cattle, abortion after the 5th month of pregnancy is a cardinal feature of the disease. Orchitis, epididymitis and subsequent infertility are also observed in males. Polyarthritis and/or hygroma in chronic cases, vaginitis and bursitis (in horses) are several observed signs in cattle and other animals [32]. The incubation period of brucellosis in humans varies between 7 and 65 days. It can be confused with malaria and influenza, and can progress to a chronically debilitating disease with severe complications, such as bone and joint involvement, neuro-brucellosis and endocarditis [6].

Diagnosis of brucellosis

Several bacteriological, serological and molecular techniques can be used in the diagnosis of the disease. Bacteriological diagnosis, molecular methods such as PCR, and serological tests such as any milk ring test, complement fixation test, rose bengal plate test or enzyme linked Immunosorbent assay (ELISA) can be used [9,35].

Treatment

In humans, attempts have been made to control the illness and prevent complications, relapses and sequelae. The main principles of treatment are the use of combination regimens and prolonged treatment duration. Antibiotic treatment should be implemented as early as possible but is ineffective in animals [36].

Significance

Brucellosis is responsible for considerable economic losses in livestock by causing infertility, decreased milk and mass abortion in herds. Human brucellosis is the most common zoonosis worldwide. Annually, approximately 500,000 new cases are diagnosed globally. It is also an occupational disease, occurring most frequently in veterinarians, farmers, stock inspectors, abattoir workers, laboratory personnel, butchers

and hunters. Because it is highly infectious through aerosol transmission, *Brucella* could be considered a potential agent of biological terrorism, particularly *B. melitensis*, for which only 10–100 organisms have been estimated to be required to cause aerosol infection in humans [6,33].

Prevention and control

The main goal of controlling brucellosis in animals is to reduce the consequences of the disease to human health and the economic losses. As explained in a previous study [37], the most important principles of control measures for animals are testing and isolation and/or slaughter, restriction of animal movement and vaccination**.** Vaccination is the most successful method for prevention and control of brucellosis. Some vaccines available against animal brucellosis are live *B. abortus* strain 19, B. *abortus* strain RB5, *B. suis* S-2, rough *B. melitensis* strain M111 and the attenuated strains of *B. melitensis* strain Rev.1. Killed vaccines, such as *B. abortus* 45/20 and *B. melitensis* H.38, are available. *B. melitensis* strain Rev.1 and *B. abortus* strain 19 have been demonstrated to be superior to all others. Despite extensive research efforts, no vaccine has been approved for the prevention of human brucellosis [38]. In humans, the best methods to prevent brucellosis infection are pasteurization of dairy products, cooking meat carefully, careful handling of aborted biological materials and newborns, wearing protective clothing in at risk areas, taking extreme care at the time of application of S19, RB51 or Rev 1 *Brucella* vaccines, and providing community awareness regarding these factors [6].

Status of bovine and human brucellosis in Ethiopia

In Ethiopia, no documented information is available on how and when bovine brucellosis was introduced and established. However, in the past two decades, several serological surveys have been reported in humans and animals, showing its endemic and widespread characteristics. These studies have indicated that animal and human brucellosis is distributed across various localities, agro-ecologies and production systems [31,39].

The status of brucellosis in Ethiopia, in association with bordering countries, is that of an emerging zoonotic disease threatening both livestock and public health in East Africa, particularly in bordering areas [40]. According to studies conducted in 2010–2019, the cattle brucellosis prevalence varied between 0.2% and 21.9% in Kenya and 29.3% to 31.9% in South Sudan, whereas the reported prevalence of human brucellosis ranged from 0.6% to 35.8% in Kenya (with higher county-level prevalence in Marsabit, one of the counties in Kenya that borders Ethiopia) and 23.3% to 33.3% in South Sudan [41]. In Eritrea, brucellosis is an important disease in both animals and humans; most human cases appear to be associated with the consumption of unpasteurized milk, and a prevalence of 2.77% was reported in 2013 [42]. In Somalia, brucellosis has been reported in humans and all domestic ruminants, and popular awareness is lacking regarding the zoonotic potential of the disease, given the existing habit of raw milk consumption and close contact with domestic animals [43]. A seroprevalence of 9% and 60% has been reported for Sudan abattoir workers and camel nomads, respectively [44]. These reports have indicated the presence of strong associations among Ethiopia and neighboring countries not only geographically but also culturally. Overall, a risk of re-emergence and transmission of brucellosis arises from the co-existence of animal husbandry activities and practicing of social-cultural activities such as traditional unpasteurized milk consumption, and handling of aborted biological materials and reproductive excretions with bare hands. People and animals move freely across the common borders, thus resulting in free contact of herds in grazing land with people, and subsequent effects of disease transmission to both humans and animals in the area.

In Ethiopia, the disease remains a major challenge and is prioritized and/or listed as one of the top zoonotic diseases. Therefore, the government has launched the National Brucellosis Technical Working Group (NBTWG) to spearhead collaborative efforts among government and private sectors, partners and universities, to coordinate and synergistically implement prevention and control efforts through the One Health approach [3]. Although the disease has widespread characteristics in humans and their livestock, particularly in occupational and pastoral communities, limited information is available regarding its prevalence, transmission and risk factors among communities [45].

Status of bovine brucellosis in Ethiopia

Bovine brucellosis in Ethiopia is endemic and widely distributed in urban, peri-urban, highlands= and lowland areas with extensive and intensive farming, as well as smallholder farms and ranches in the country. It has caused high economic losses and is becoming a serious public health threat [14,46,47].

According to studies to date, the distribution and prevalence of brucellosis in Ethiopia varies by location and time, owing to differences in animal production and management systems, multiple livestock species per holding, community living standards, awareness levels as well as agroecological conditions. These aspects also account for the widespread risk factor maintenance and transmission of bovine brucellosis [13,25]. The disease has major zoonotic and economic implications for rural communities. Hence, knowledge of the occurrence of the disease in traditional livestock husbandry practice has considerable importance in decreasing economic and public health impacts [47].

Seroprevalence of bovine brucellosis

Brucella infections in Ethiopian cattle have been serologically demonstrated by various research groups, and a relatively high seroprevalence of brucellosis (above 10%) has been reported from smallholder dairy farms in central Ethiopia [48]. For the past two decades, bovine brucellosis serological studies reported by various researchers have indicated that the disease is endemic and widespread (Table 1). However, the prevalence of bovine brucellosis varies among

TABLE 1 | Bovine brucellosis seroprevalence report from various localities of Ethiopia (2010–2021).

Study area		Year of publication	Number of samples		Type of test	Prevalence and 95% CI based on CFT and ELISA test				Reference
Region	Specific location		IL	HL		CFT test in %		95% CI		
						IL	HL	IL	HL	
Afar	Dubti, Asyta, Chifr	2021	420	-	RBPT, CFT	5.7	-	3.8-7.94		[14]
Afar	(in 7 districts)	2021	488		ELISA	7.2		5-10.2		[45]
Somalia	(in 6 districts)	2021	116		ELISA	6.9		3.5-13		[45]
AA	CH	2021	352		RBPT, CFT	0,6		0.016-2		[47]
Oromia	Jimma	2021	80		CFT	22.5				[17]
Oromia	Borena	2020	750		RBPT,ELISA	2.4	-	1.4-3.7		[25]
Oromia	Adama	2020	384		CFT	1.04	9.5	0.02,2.6	0.2,18	[13]
Oromia	Around AA	2020	503		RBPT, CFT	0.4	-			[49]
SNNPR	Awassa	2019	370		RBPT, CFT	2.7	25.8			[50]
Oromia	Becho	2019	384		RBPT, ELISA	1.04	5.48			[51]
AA	AA	2018	1550		CFT	0.06	0.8			[31]
SNNPR	NNP	2018	268	50	RBPT, CFT	9.7	32	6.4413.8		[52]
Oromia	Asela	2018	304		RBPT, CFT	9.87				[53]
E/E	E/E	2017	967		RBPT, CFT	1.3	6.8	0.72,2.2	4.2,10	[54]
Oromia	Asela	2016	570		RBPT, CFT	1.4		0.24,3.46		[39]
Oromia	West Arsi	2016	421	33	RBPT, CFT	3.3	42.4			[55]
Amhara	Debre-Birhan	2015	415		RBPT, CFT	0.7				[56]
Oromia & Afar	Pastoral areas	2013	384		RBPT, CFT	1.7	35			[57]
Ethiopia	Farm level	2013	2334		RBPT, CFT	1.9	10.6	1.2-2.6	6.9-14	[58]
Amhara	West Gojjam	2013	1152	164	RBPT, CFT	1	4.9	0.5-1.7	1.6-8.2	[59]
Somali	SEE	2013	862	59	RBPT, CFT	1.4	17	0.8-2.6		[60]
Oromia	Borena	2012	575	50	RBPT, CFT	8	51.7	6-10		[61]
Somalia	Jigjiga	2011	435	-	RBPT, CFT	1.38	-	1.35- 1.41		[62]
Oromia	Borena	2011	271	16	RBPT, CFT	4.7	68.6	2.1-7.3		[48]
SNNPR	South Ommo	2011	180	12	RBPT, CFT	3.4	33	0.9-6.1		[48]
Somalia	Shinle	2011	210	15	RBPT, CFT	6.6	40	3.1-10.1		[48]
Somalia	Jigjiga	2011	62	4	RBPT, CFT	3	50	1.7-7.1		[48]
SNNPR	Sidama	2010	1627	27	RBPT, CFT	1.66	13.7			[15]
Tigray	Northwest	2010	848	210	RBPT, CFT	1.2	3.3			[63]

AA (Addis Ababa), CFT (complement fixation test), CH (central highland), CI (confidence interval), EE (eastern Ethiopia) ELISA (enzyme linked immunosorbent assay), HL (herd level), IL (individual level), NNP (Nechisar National Park), SEE (southeast Ethiopia), SNNPR (Southern Nations Nationalities People Region).

farms and areas (Fig 2), and this seropositive prevalence may be due to natural infection, because of the absence of a brucellosis prevention and control vaccination history in Ethiopia [14,25].

Accordingly, a very recent study in Afar, "Integrated human-animal sero-surveillance of brucellosis in the pastoral Afar and Somali regions of Ethiopia," has reported an overall cattle brucellosis seroprevalence of 7.2% and 6.2% in Afar and Somali, respectively% [45] In the same year, Getahun reported an 0.6% prevalence in dairy cows with recent abortion history [47]. Another cross-sectional study in the Jimma Zone, Oromia Region, has reported an animal and herd level cattle prevalence of 16.4% and 4.3%, respectively [64]. Very recent studies have also recorded a

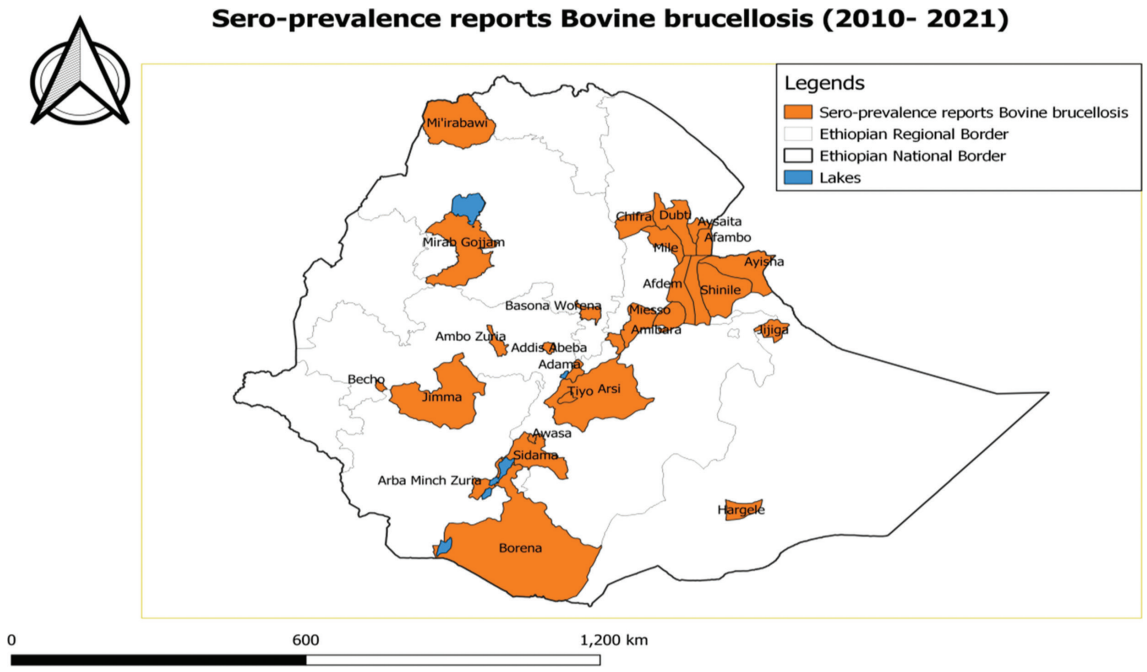

FIGURE 2 | Distribution of bovine brucellosis seroprevalence (2010–2021). Map developed by the authors.

prevalence of 11.9% and 22.5% in Afar National Regional State and East Wollega, Oromia Region, respectively [14,17].

In 2020, a prevalence of 3.2% in the southern region (Borena), 9.5% in Adama and its surrounding dairy farms and 0.4% in the Oromia Region (Sendafa) was reported by several research groups [13,25,49]. The prevalence of bovine brucellosis was reported to be 2.7% and 25.8% for individuals and herds in another study [50]. Tadesse and colleagues from southwest Shewa, Oromia Region, have reported 5.48% herd level and 1.04% animal level prevalence [51]. In 2018, both individual and herd-level bovine brucellosis

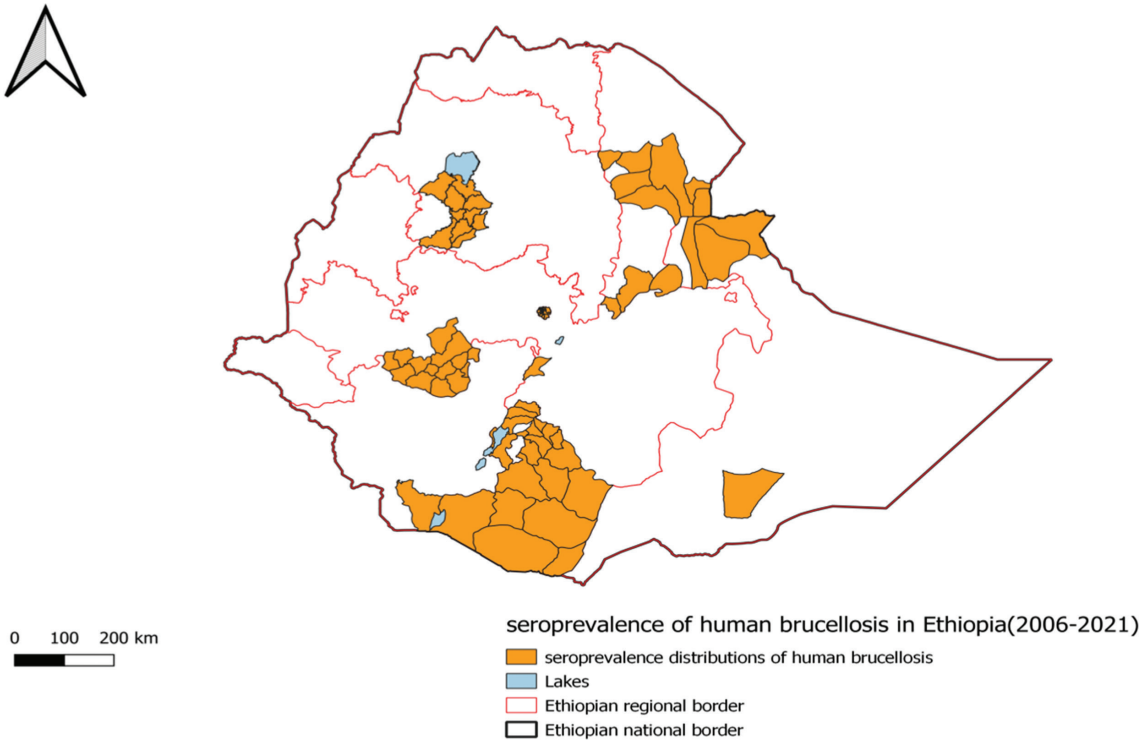

FIGURE 3 | Distribution of small ruminant brucellosis seroprevalence (2015–2021). Map developed by the authors.

TABLE 2 | Seroprevalence of human brucellosis in Ethiopia (2006–2021).

Location of study	Year of study	Study participants	Type of test	Prevalence (%)	References
Afar	2021	Pastoralists	ELISA	48.3	[45]
Somalia	2021	Pastoralists	ELISA	34.9	[45]
Afar	2021	Patient	ELISA	31.5	[67]
SNNPR (Borena)	2020	LS owners	RBPT, ELISA	2.6	[25]
Afar	2018	Patients	CFT	4.4	[69]
SNNPR	2017	Blood donors	NS	10.6	[70]
Oromia/Adamitulu	2014	LS owners	RBPT, CFT	2.15	[66]
Afar	2012	Community	RBPT, CFT	16	[71]
Amhara (West Gojjam)	2009	Patients	RBPT	2.6	[72]
Oromia (Borena)	2009	Patients	LFA	34.1	[65]
SNNP/Hammer	2009	Patients	LFA	29.4	[65]
Oromia/Jimma	2008	Patients	RBPT, CFT	3.6	[73]
Amhara/Bahirdar	2007	HRG	RBPT, CFT	5.3	[74]
Sidama	2007	HRG	RBPT, CFT	3.78	[46]
Addis Ababa	2006	HRG	RBPT, CFT	4.8	[75]

HRG (high risk group), LS (livestock), LFA (lateral flow assay).

seroprevalence (0.06%; 0.8%) were reported in intensive dairy farms of Addis Ababa [31].

From 2016 to 2018, prevalence values of 2.81%, 1.3%/6.8% and 9.87% were reported in dairy farms of Central Ethiopia in three studies [39,53,54]. In Alage and its surroundings, a bovine seroprevalence of 2.4% at the animal level and 45.9% at the herd level have been reported [55]. A study conducted in Debre Birhan and Ambo Towns has reported a prevalence of 0.7% and 0.2% for RBPT and CFT, respectively [56]. From the Arsi milk cooperative association, Tschop and colleagues have reported an individual animal level prevalence of 1.7% and a herd level prevalence of 35% [57]. Seroprevalence values of 8.0% and 51.7% have also been recorded at the animal and herd levels, respectively, from the pastoral region of Borena [61]. An overall seroprevalence of 3.5% and 26.1% at the animal and herd levels, respectively, have been reported from South Eastern Ethiopia [48]. A report from the Arsi–Negele District of Southern Ethiopia has also shown a prevalence of 2.6% and 12% at the individual and herd levels, respectively [15]. High individual and herd-level prevalence (11%, 63.6%) has been reported in smallholder intensive dairy farms of the Tigray region [63].

Human brucellosis in Ethiopia

In Ethiopia, brucellosis has widespread prevalence and endemic characteristics, and is among the major public health and economic problems among rural and urban areas [47], because associated risk factors and health interventions are not routinely determined, appropriate and effective diagnostic facilities are lacking, close contact between humans and their livestock is common, and the country has not yet started a coordinated prevention and control program [65]. According to several seroprevalence studies performed from the mid-2000s to 2021 (Fig 3), human brucellosis has been reported in various geographical areas of Ethiopia with a prevalence ranging from 2.15% to 48.3% [45,66].

The highest prevalence has been recorded in pastoral communities, owing to the habit of unpasteurized dairy product consumption, living in proximity to animals and often having poor access to health services [25,65,67]. To date, isolation of *Brucella* from humans in Ethiopia has not been recorded, except for one report indicating *B. melitensis Biovars 1* isolated in the UK from a man of Ethiopian origin [68] (Table 2).

CONCLUSION AND RECOMMENDATIONS

Brucellosis is considered (by the World Health Organization, United States Food and Agriculture Organization and Office of International Epizootics) one of the most serious infectious diseases. The disease is the second most dangerous zoonotic disease worldwide next to rabies, yet is neglected despite its high public health and economic significance in Ethiopia. Several bovine brucellosis seroprevalence reports from different areas of the country have shown that the disease is endemic and still remains the main zoonotic challenge. These reports have indicated that the disease is causing economic crisis and significant public health risk to the entire community, particularly in high risk groups and pastoralists. This risk may be due to the community's traditional consumption of raw animal products, close contact

with livestock and livestock products (thus clearly indicating the strong relationship between bovine and human brucellosis), a lack of access to health services, and the absence of prevention and control measures. The economic losses due to the disease are most severe in animal production and/or productivity, particularly in dairy cattle, through breeding inefficiency, loss of calves, decreased meat and milk production, and barriers to international trade of live animals and animal products. In most studies, the prevalence of the disease is increasing. The country has prioritized and listed the disease as one of the top five zoonotic diseases followed by the established National Brucellosis Technical Working Group with the aim of coordinating prevention and control efforts through a One Health approach. However, information communication and/or dissemination, community awareness, and practical implementation of national prevention and control measures are lagging. In addition, few or no studies have been conducted in higher risk groups, and in most pastoral areas, which are far from the country's capital. According to our conclusions, we propose the following recommendations:

- prevention and control measures with community awareness should be started
- further studies should be conducted, particularly in higher risk and untouched areas
- Providing current information to understand the transmission dynamics and burden of the disease through continual review is necessary.

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CONFLICTS OF INTEREST

The authors declare that they have no competing interests.

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