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Research Paper

Sero-prevalence, epidemiology, and public health significance of small ruminant brucellosis

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ABSTRACT

Background: Brucellosis is sort of a common zoonotic illness, and it spreads mostly from livestock like cattle, sheep, goats, pigs, and camels. In practice it happens when people or animals have direct contact with infected tissues, or when contaminated raw products get eaten. For small ruminants, brucellosis becomes a real concern. It brings, public health problems and economic stress, especially in places where it is already endemic.
Objective: The aim here is to go over the present epidemiological picture of brucellosis, underline why small ruminant brucellosis matters for public health, and show the economic weight it creates in both domestic as well as global livestock production systems.
Methods: This is a narrative review, based on existing literature. The focus was on etiology, transmission pathways, clinical findings, diagnostic options, and the control measures that have been discussed. Small ruminant species were especially emphasized in the search and synthesis.
Results: Brucella melitensis and Brucella ovis were pinpointed as the main causes for small ruminant brucellosis. In general, Brucella melitensis is linked with goats and Brucella ovis is linked with sheep. The clinical story often includes late stage abortions, stillborn births and reduced offspring survival in females. In males you can see orchitis, plus epididymitis. As for where the pathogen comes from, it includes aborted fetuses, fetal membranes, vaginal secretions, and also milk, when shedding occurs. Diagnostics can be grouped into organism detection and immune response identification. Treating infected animals is usually not recommended, because failure rates are high, and because eradication programs might be complicated. Vaccination, combined with rigorous hygiene measures, stays the most effective prevention approach.
Conclusion: Brucellosis is a serious zoonotic problem, also a real economic weight, for livestock production systems across the

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whole world. For effective disease control you need collective actions between governments, veterinarians and public health agencies, with a strong focus on prevention in reservoir hosts, plus correct disposal of animals that are infected, and continued vaccination programs that can lower transmission. That way, in the long run, the public health is protected, even when the situation gets stubborn.

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1. INTRODUCTION

1.1. Backgrounds

Africa's greatest livestock producer, Ethiopia is home to 65 million cattle, 40 million sheep, 51 million goats, 8 million camels, and 49 million chickens [1]. Most developing countries' farming systems heavily rely on small ruminants, which make up more than half of all domesticated ruminants in the world [2]. According to a recent estimation, the nation has roughly 51 million goats and 40 million sheep. Native animals make up the majority of the livestock population in Ethiopia. Current estimates for local breeds and hybrids of sheep are 99.6% and 0.3%, respectively. Goats are almost exclusively domesticated breeds (99.9%) [1]. Since small ruminants are crucial to farmers' livelihoods, goat and sheep productivity in poorer nations is still low, largely because of malnutrition, ineffective management practices, and illnesses [3].

Brucella is a gram-negative, intracellular, facultative bacteria that causes brucellosis [4]. There are now nine different species of Brucella, seven of which are known to harm terrestrial animals (B. abortus, B. melitensis, B. suis, B. ovis, B. canis, B. neotomae, and B. microti) and two of which are known to affect marine mammals (B. ceti and B. pinnipedialis) [5], [6].

In addition to late abortion, retained fetal membranes, and, to a lesser extent, orchitis, infection of the accessory sex glands in men, and reduced fertility, brucellosis is an infectious bacterial disease brought on by members of the genus Brucella. The disease primarily affects cattle, buffalo, bison, pigs, goats, sheep, dogs, elk, and camels and occasionally horses [7]. The predilection sites are the male and female reproductive tracts, making it mainly a disease of sexually mature animals. The formation of the simple carbohydrate eryhritol in the fetus and its membranes, however, causes tremendous bacterial proliferation in the uterus and is likely to result in abortion [8]. Animals can contract the disease by licking contaminated placentae, fetuses, or the genitalia of infected female animals soon after abortion or delivery, as well as consuming polluted pastures, feed, and water. Human brucellosis can be brought on by Brucella abortus, Brucella melitensis, Brucella Suis, and Brucella canis, but not by Brucella ovis or Brucella neotomae [9]. Depending on the presenting clinical indications, the organism can be collected from a wide range of materials for brucellosis diagnosis [10]. The high incidence of treatment failure, cost, and potential issues associated with retaining sick animals in the face of ongoing eradication attempts discourage the treatment of infected cattle in general [11].

Effective vaccination and hygienic practices would reduce the disease spreading in/from endemic regions. To control the disease in humans, prevention of the disease in reservoir hosts is crucial. Seropositive animals would be tested, killed, and then properly disposed of to reduce the likelihood of transmission [12]. Brucellosis is listed as the second most significant zoonotic disease in the world by the Office International des Epizooties (OIE), with more than 500,000 human cases occurring each year [13]. Compared to B. abortus, B. melitensis has a more constrained range, and southern Europe and other parts of the Mediterranean are where it is most commonly seen. Additionally, Mexico, countries in South America, countries in Africa, and West and Central Asia all have the infection [14]. As a result, the goals of this paper are to:

- Explain the Current Epidemiological Aspects of Brucellosis and the Importance of Smallruminant Brucellosis for Public Health.
- Briefly illustrate the Economic and Importance of Smallruminant Brucellosis.
- Show the seroprevalencen status of sheep and goat brucellosis in different geographical areas of Ethiopia

2. RELATED WORK

2.1. Etiology

In addition to not producing spores or capsules, Brucella species are facultative intracellular gram-negative cocco-bacilli. Despite the fact that Brucella species are thought to be non-motile, they possess all the genes needed to put together a useful flagellum, with the exception of the chemotactic system. B. abortus, B. melitensis, B. suis, B. ovis, B. canis, B. neotomae, and B. microti are seven of the nine Brucella species currently recognized (Table 1), and B. ceti and B. pinnipedialis are two of the species that harm marine mammals (Table 1). Within the first three species, which are referred to as classical Brucella, seven biovars for B. abortus, three for B. melitensis, and five for B. suis have been identified [15], [16].

Table 1. Brucella Species and their Hosts

Organism	Host
B. melitensis	ovine, caprine and Camel
B. abortus	Buffalo, cattle and Camels
B. canis	Dog
B. suis	Pig
B. neotomaei	Rodent
B. ovis	ovine
B. pinnipediae	Marine animals
B. cetaceae	Marine animals

2.2. Epidemiology

2.2.1. Geographical Distributions

As new foci emerge or reemerge, the geographic distribution of brucellosis is continually shifting. Worldwide in prevalence, brucellosis can affect both domestic and wild animals. Everywhere in the world where animals are raised, it has been recorded [17]. The illness is still a major issue in poor nations, despite the fact that certain industrialized nations in Europe and America have successfully eradicated brucellosis in domestic animals through rigorous control and eradication programs [18], [19]. The most dangerous species of the Brucella genus, B. melitensis, is isolated in small ruminants most frequently in the Mediterranean, Middle East, and Latin America [20]. In addition to being a major zoonosis, brucellosis hinders trade in animals and animal products and results in significant abortion-related losses [21].

2.2.2. Modes of Transmission

The main methods of transmission are contact with intact skin and conjunctiva, intake of contaminated feed and water, inhalation during overcrowding, and infection of lambs while still in the uterus or by nursing on contaminated mother's milk. It seems uncommon for the diseased ram to infect susceptible ewes via venereal transmission. Artificial insemination has the potential to transmit [22]. Fetal membranes, vaginal secretions, contaminated sheep and goat milk, and aborted fetuses are some of the sources of infection. According to studies, direct contact with the skin or mucous membranes causes 70–90% of Brucella infections [23].

2.2. Risk Factors

- **Host Factors:** It is believed that pregnancy and sexual development increase vulnerability is well acknowledged [24]. Only adults (females and males who are sexually mature) who have Brucella melitensis infections get sick. Although they may be infected, young animals often only exhibit a modest and temporary serological reaction [22] and do not exhibit any clinical symptoms. Male sheep and goats are less susceptible than females to B. melitensis infection. Compared to females, Brucella ovis shows a stronger preference for the male reproductive system [25].

2.3. Pathogen Risk Factor

Since Brucella is an intracellular bacterium, it is immune to both treatments and the innate host defense system. In addition, it does not produce humeral antibodies when it is dormant [24]. Brucella is eliminated by disinfectants such caustic soda, formalin 2%, and Lysol 1% [22].

2.4. Environmental Factors

The epidemiology of the disease is significantly influenced by the organism's ability to persist in its environment [26]. For several months, Brucella can remain infectious in water, fetal membranes, excrement, liquid manure, wool, hay, and on objects like furniture and clothing. Brucella may also endure drying, especially when there is extraneous organic material, and it can survive in soil and dust [27]. The environment's humidity and pH have an impact on B. melitensis' ability to survive. The organism is sensitive to pasteurization, disinfectants, and direct sunshine. Under ideal climatic conditions, Brucella can stay alive for up to four months in milk, urine, water, and moist soil [25].

2.5. Pathogenesis

B. melitensis can enter hosts by cuts or scratches on the skin, the conjunctiva, the respiratory tract, the gastrointestinal tract, and the reproductive tract. The ileal Peyer's patch epithelium in the digestive tract is the favoured site for entrance [28]. Polymorphonuclear leukocytes rapidly swallow organisms, which are also phagocytosed by macrophages but typically do not kill them. B. melitensis replicates in areas that house endoplasmic reticulum components in macrophages and prevents the union of the phagosome and lysosome [29]. By focusing on embryonic and trophoblastic tissue in ruminants, Brucella organisms get past the most potent host defenses. The bacteria develop not only in the phagosome but also in the cytoplasm and rough endoplasmic reticulum of the cells that make up these tissues. These tissues allow exuberant bacterial growth in the absence of functional intracellular microbicidal systems, which results in embryonic mortality and abortion [17].

2.6. Clinical Sign and Finding

According to the implicated biovar, the clinical characteristics of B. melitensis infection in smallruminant differ [30]. Any flock with an abortion's history during the last trimester, infertility, orchitis, epididymitis, stillbirths, or neonatal mortality is believed to have brucellosis [31]. Abortion is the primary clinical symptom in the early stages of the illness, however other symptoms could be seen depending on where the organism has spread. These symptoms include subclinical mastitis, orchitis, epididymitis, hygroma, arthritis, and metritis, among others [22]. The organisms are continuously or sporadically lost in milk and vaginal secretions during the second stage, which is either characterized by

the elimination of Brucella or, more frequently, by persistent inflammation of the mammary gland and supramammary and genital lymph nodes. Animals typically have one abortion during the middle part of the gestation, but subsequent pregnancies result in a re-invasion of the uterus with the loss of fluids and fetal membranes. Also possible is a full-term pregnancy [31].

2.7. Diagnosis

- **Bacteriological Methods:** Isolation of the organism is seen to be the most accurate method for diagnosing brucellosis since it is specific and makes it possible to biotype the isolate, which is crucial from an epidemiological standpoint (Al Dahouk). The culture of Brucella spp. is difficult despite its great specificity. Fastidious bacteria like Brucella spp. need rich medium for primary cultures. Additionally, its separation necessitates the presence of several alive bacteria in clinical samples, as well as prompt transport to the diagnostic laboratory and proper storage [32].
- **Serological Methods:** The majority of control and eradication programs for brucellosis depend on these techniques, making serological tests essential for laboratory diagnosis. As antigens for identifying antibodies produced by the host during infection, complete inactivated bacteria or purified fractions (such as lipopolysaccharide or membrane proteins) are utilized. B. abortus, B. melitensis, and B. suis are examples of smooth Brucella species that cross react with antigen preparations from B. abortus, whereas B. ovis and B. canis are examples of rough Brucella species that cross react with antigen preparations from B. ovis [31]. These tests can be considered as screening tests even if there are numerous serological techniques currently accessible [31].
- **Enzyme Linked Immunosorbent Assay:** For serological brucellosis diagnosis, enzyme linked immunosorbent assay (ELISA) has gained popularity as a standard diagnostic. It tests IgG, IgA, and IgM antibodies, which improves clinical situation interpretation. Antibodies to the smooth LPS are used to confirm the diagnosis of brucellosis. When diagnosing brucellosis cases, IgG antibody detection is more accurate than IgM antibody detection, but specificity is similar [33]. ELISA offers a considerable diagnostic advantage in the diagnosis of brucellosis in endemic areas and is more sensitive in acute and chronic instances of the disease than the traditional agglutination methods [34], [35]. The serologic diagnosis of brucellosis in sheep, goats, and pigs has been performed using the indirect ELISA (i-ELISA). Additionally, it has been applied to diagnose conditions using cow's milk or serum [36]. O ELISA-i has been utilized frequently for smooth LPS Brucella spp., and it is sensitive and specific for B. abortus or B. melitensis, but it is unable to distinguish between antibodies produced by the S19 or Rev1 vaccination strains or natural sources of antibodies [37]. The i-ELISA's specificity ranges between 93.8% and 100%, and its sensitivity ranges from 96 to 100% [38]. The competitive ELISA (c-ELISA) uses smooth Brucella LPS as the antigen to detect anti-Brucella antibodies in serum samples from cattle, sheep, goats, and pigs. This test has a sensitivity range of 92 to 100% and a specificity range of 90 to 99%, and it can distinguish between vaccination antibody response and real diseases [39].
- **Rose Bengal Plate Test**: Agglutination tests, such as the Rose Bengal plate test (RBT), are based on the reactivity of antibodies against smooth lipopolysaccharide (LPS). Because of the high sensitivity, false negative results are hardly seen. The test can be used on serially diluted serum samples (1:2 to 1:64) to improve specificity [40]. According to current World Health Organization (WHO) recommendations, serum agglutination tests and other tests should be used to corroborate RBT results [40].

2.8. Treatments

Because Brucella is found inside cells and may adapt to the environmental conditions found in its replicative habitat, such as macrophages [41]. The likelihood of treatment failure and recurrence depends on the drug combination and patient compliance. Due to the significant relapse rates associated with monotherapies employing only one antibiotic, two medicines are combined to create the best treatment regimen for brucellosis [42]. In cases of acute and localized forms of brucellosis, Doxycycline and Streptomycin (DS) is now the best therapeutic option with less side effects and relapses [43].

2.9. Public Health and Economic Impact of Small Ruminant Brucellosis

- **Public Health Impact:** Worldwide, human brucellosis is a common disease. It is regarded as one of the most widely dispersed zonooses in the world by the FAO, the WHO, and the OIE [44]. Animals, particularly goats and sheep, are where the majority of human cases of brucellosis are contracted. With more than 500,000 human cases recorded each year, ovine/caprine brucellosis caused by B. melitensis is the most significant clinically apparent disease in humans and one of the most prevalent zoonotic diseases globally [44], [45]. Among the exposed professions are those that involve working with animals and their products, such as veterinarians, farmers, laboratory technicians, abattoir staff, and others. A large portion of illnesses in abattoir workers are frequently brought on by inhalation. For those who work in meatpacking factories or slaughterhouses, as well as for veterinarians, contamination of skin wounds could be a problem [12].
- **Economic Significance Impact:** Animal movement, animal product trade, and all three of these face obstacles as a result of brucellosis. Reduced milk output, abortions or breeding failure in the affected animal population, reduced milk production in humans, and reduced work capability as a result of the illness of the affected people are all economic losses it causes [46]. In addition, the enormous number of tiny ruminants is significantly hindered in its ability to generate income by brucellosis. Because small ruminants and the goods they produce are a valuable export, keeping seropositive animals in quarantine has a negative economic impact [47].
- **Control and Prevention:** Human brucellosis is primarily brought on by direct or indirect contact with diseased animals or their products, hence prevention efforts must be focused on minimizing this contact. The obvious solution-eradicating the disease from animals-is frequently out of reach for many poor nations' personnel and financial resources. The challenges of eradicating B. melitensis from small ruminants on a social and technological level have even strained the resources of certain industrialized nations.There is frequently no choice but to make an effort to lessen the severity of the illness and the chance of infection through personal hygiene, the adoption of safe work practices, environmental protection, and food hygiene.Prophylaxis currently has a limited impact on human illness prevention [25]. Understanding the regional and local variations in infrastructure, social norms, and epidemiological patterns of the illness may help prevent and control brucellosis in a realistic manner [48]. Quarantining imported stokes and deciding whether or not to immunize negative animals are two major methods used to prevent brucellosis [22]. The effectiveness of disease eradication through testing and slaughter is dependent on the severity of disease prevalence, the economic standing of the nation, and the management of hygienic disposal of aborted fetuses, fetal membranes, and discharges with subsequent cleaning of contaminated areas [25]. All placentas and dead fetuses should be buried on a regular basis in endemic areas. Because the tests are inaccurate, it is advised to screen and eliminate any introduced or resident animals that are likely to be carriers [22]. According to global experience, vaccination is typically the only effective way to control brucellosis in sheep and goats. Immunization using efficient vaccines aids in controlling the infection's transmission, preventing human infections, and minimizing economic losses [49].
- **Prevalence Status of Small Ruminant Brucellosis:** Of the entire national livestock population, the pastoral and agro-pastoral production systems account for about 45–55% of the cattle, 75% of the small ruminants, 20% of the equines, and 100% of the camels. The Somalis (Somali region) in the east, the Afars (Afar region) in the northeast, the Borena Oromos (Oromiya region) in the south and south-east, and the Southern Omo people (SNNPS region) in the south, partially in the Gambela and Benishangul regions, and in the vicinity of the Dire Dawa Administration, make up the majority of Ethiopia's mobile pastoralists. Although the regional cattle population is substantial, its economic contribution to the regional and national economies is little, mostly because of natural and human constraints [50]. The majority of brucellosis investigations that were undertaken relied solely on estimates of the disease's seroprevalence.It was established with absolute certainty that the disease occurs in Ethiopia by a sero-surveillance research done on small ruminants in various regions.Bahir Dar Town in the Amhara Regional State has a low infection incidence [51], according to the most

recent sero-surveillance data for the disease in the nation [52] and the Tellalak District of the Afar Regional State had the highest levels [53], [54] (Table 2).

Table 2. Sero-Prevalence of Sheep and Goat Brucellosis in Different Agro Pastoral and Pastoral Area of Ethiopia

Study Region	Prevalence (%)	Authors and Years
Amhara	0.4 %	[52]
SNNP and Oromia	1.9 %	[54]
Oromia	4.6%	[55]
Afar	13.7%	[53]
Tigray	1.79%	[56]
Somali	1.37%	[57]
Oromia	6.2%	[58]
Oromia	2.9%	[59]

3. CONCLUSION

The frequency of brucellosis is high around the world and in various regions of Ethiopia. Animals and humans can contract brucellosis, which has significant negative effects on the economy and public health. The diseased animal species from which human transmission occurs has a strong correlation with its effect on public health. Several ways exist for the disease to spread from infected animals to people. It poses a unique risk to certain occupational groups. A drop in milk supply and abortion both result in significant losses for tiny ruminants. The following suggestions were made in light of the information provided in the conclusion:

- A national plan should be in place to manage the brucellosis control mechanism in small ruminants.
- A new vaccination beside brucellosis in smallruminant should be created using unrefined strains that do not have the vaccine's drawbacks.
- To lessen the economic and zoonotic effects of brucellosis, the government, public health officials, and veterinarians must collaborate.

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Author Contributions Statement

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Teshale Adere Senbeta	✓	✓	✓	✓		✓		✓	✓	✓	✓			
Legesse Adugna Negash		✓	✓	✓	✓			✓	✓	✓		✓	✓	✓
Belachew Shimelis Tadese	✓	✓	✓	✓			✓	✓		✓	✓	✓	✓	✓
Abdulkadir Hussen Nagow		✓	✓	✓		✓	✓	✓		✓	✓	✓		
Debela Terefa Jambare	✓	✓	✓		✓	✓	✓			✓	✓	✓		

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

Conflict of Interest Statement

The authors declare that there are no conflicts of interest regarding the publication of this paper.

Informed Consent

All participants were informed about the purpose of the study, and their voluntary consent was obtained prior to data collection.

Ethical Approval

Not Applicable.

Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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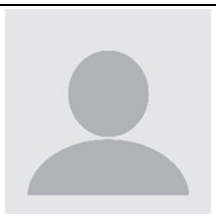	**Belachew Shimelis Tadese,** is a Doctor of Veterinary Medicine from Jimma University, Ethiopia. His professional focus encompasses clinical veterinary practice and animal disease management. He is committed to improving animal health outcomes and advancing veterinary healthcare delivery to support livestock productivity and zoonotic disease prevention in Ethiopia.
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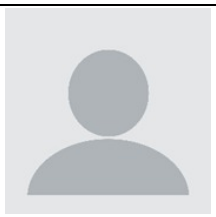	**Debela Terefa Jambare,** holds a Master of Veterinary Public Health from Jimma University, Ethiopia. His work focuses on the intersection of animal health and human wellbeing, emphasizing zoonotic disease prevention and food safety. He is dedicated to strengthening veterinary public health systems and promoting collaborative approaches to disease control across Ethiopia.