AJAD
AJAD
AJAD
AJAD

Review onStatus of Bovine Brucellosis and Its Public Health Significance in Ethiopia

Adem Edao and Abbas Mohammed

Haramaya University, College of Veterinary Medicine, P.O. Box: Dire Dawa 138

Abstract: Brucellosis is an infectious bacterial zoonotic disease caused by a member of the genus Brucella. Clinical signs are similar for all species and commonly include abortion, stillbirth or weak calves, retained placentas and decreased milk yield. Public health significance includes illness, physical incapacity and loss of manpower which also results in the scarcity of animal proteins due to the loss of meat. The economic importance of brucellosis depends upon the species of animal affected. It can cause considerable losses in cattle as a result of abortion and a reduction in milk yield. The most rational approach for controlling B. abortus infection is by vaccinating young female animals. The occupational risk of brucellosis is important because of the high possibility of direct transmission from infected animals to the people employed in animal husbandry. This exposed group includes slaughtermen, dairymen, herdmen and veterinary clinicians. Various methods are employed to diagnose brucellosis, including microscopic examination and serological and molecular biology. The public health importance of brucellosis is much related to the infected animal species from which human transmission occurs. Public awareness is of vital importance in the successful control and prevention of brucellosis; Isolation of infected animals and females at parturition; proper disposal of the aborted fetus, placental tissue and uterine discharge; disinfecting of contaminated areas and pasteurization of milk. The status of bovine brucellosis is not well addressed in Ethiopia. Studies conducted indicate that the prevalence of the diseaseis distributed in any part of Ethiopia and high in lowlands as compared with highlands. Since brucellosis has no effective treatment; vaccination, hygiene public health education and awareness creation are the best alternative strategies.

Key words: Brucella *Abortus* · Bovine Brucellosis · Public Health · Status In Ethiopia

INTRODUCTION

Ethiopia has the largest livestock population in Africa, with 65 million cattle, 40 million sheep, 51 million goats, 8 million camels and 49 million chickens in 2020 [1]. Livestock is a major source of animal protein, power for crop cultivation, means of transportation, export commodities, manure for farmland and household energy, security in times of crop failure and means of wealth accumulation. The sector contributed up to 40% of agricultural Gross Domestic Product (GDP), nearly 20% of total GDP and 20% of national foreign exchange earnings in 2017 [2]. Oxen provide draught power to cultivate grain crops in rural agriculture, which is the backbone of the economy. Thecomparativelysubstantiallivestock resources of the country and the infectious diseases, among other factors. Bovine brucellosis is one of these infectious diseases and has been reported in several parts of the country [3].

Brucellosis is a highly contagious, zoonotic and economically important bacterial disease of animals worldwide [4]. It is caused by gram-negative Cocco-bacilli of the genus Brucella [5]. Brucella mainly affects cattle, sheep, goats, camels and pigs, as well as causes disease in humans. Humans are susceptible to both B *abortus* and *B. melitensis*. Cattle (Bos Taurus) are natural hosts of *Brucella abortus* [6]. Cattle acquire the infection mainly due to ingestion of feed and water contaminated by aborted fetuses, fetal membranes and uterine discharges. Infection in man can therefore occur by ingestion of raw milk or milk products or handling infected animals [7]. Brucellosis in cattle is primarily caused by the bacterium Brucellaabortus.Currently, ten species including the better-known six classical species comprised of *B. abortus*, *B. melitensis*, *B. suis*, *B. ovis*, *B. canis* and *B. Neotoma* are known. In recent times, other new species of the genus including *B. ceti, B. pinnipedialis*, *B. microti* and *B. inopinata* which affect different species

Corresponding Author: Adem Edao, Haramaya University, College of Veterinary Medicine P.O. Box: Dire Dawa 138.
E-mail: adem.edao143 @gmail.com.

of animals are also identified [8]. All Brucella species are considered potentially pathogenic for humans, with the exceptions of *B. Neotoma*, *B. microti* and *B. ovis* [9].

Bovine brucellosis has been controlled in most industrialized countries, in many developing countries of Africa, Asia, Central and South America, clinical disease is recorded among different animals. The impact of brucellosis on human health is a major issue [10]. It can cause appreciable economic losses in the livestock industry because of abortions, decreased milk production, sterility and veterinary care and treatment costs [11].

In Africa, a high prevalence has been reported in Uganda, Egypt, Sudan and Senegal; moderate prevalence rates were recorded in Nigeria, Tanzania, Zambia, Ghana and Botswana; while a low prevalence was encountered in Kenya Djibouti and Eritrea [12].

In Ethiopia, brucellosis remains endemic and continues to be a major public and animal health problem. Brucellosis has been noted as one of the important livestock diseases in the country as it has been depicted. the first case report of brucellosis in the 1970s in Ethiopia [13]. The main mode of transmission of Brucella bacterium in humans is through the ingestion of contaminated dairy products. Here comes the necessity of the pasteurization of milk and direct contact with the infected animal and its excreta or in minor possibility through aerosols. On the other hand, the animal gets infected through contaminated food, water, fomites, contact with an infected animal, abortion and mating and other routes such as artificial insemination using semen from infected males. The most observed sign of brucellosis is abortion in ruminants, including cows, sheep and goats; other signs include stillbirth, retained placenta and a decrease in milk production [14]. However, in bulls, orchitis and epididymitis are the main clinical signs. For humans, symptoms include undulant fever, joint pain, headache, respiratory distress and septicemia [11].

A precise diagnosis of Brucella species infection is important for the control of the disease in animals and consequently in man. Various methods are employed for the diagnosis of brucellosis including microscopic examination and serological and molecular biology [9]. Various serological tests have been developed and modified to increase sensitivity and specificity. OIE described that no single serological test is appropriate in all epidemiological situations; all have their limitations. Circulating Brucella antibodies have been demonstrated by the Rose Bengal plate test (RBPT), complement fixation test (CFT) and enzyme-linked immunosorbent assay (ELISA), of which CFT has been used as a gold standard anda prescribed test for international trade. The important risk factors for brucellosis include herd size, retained placenta, abortion, number of parity and transhumance at herd level and age attheanimal population level [15].

One of the most effective control methods for brucellosis depends on preventing the exposure of susceptible animals to infection, increasing resistance of the population through vaccination and applying a test and slaughter policy when the prevalence of the disease is low on a given farm. However, there are no vaccines for humans; hence, this emphasizes the need to control this disease in animals and humans [16].

In general, the epidemiology of bovine brucellosis and its awareness of the disease is different fromone place to another. Thus, it is necessary to know the status of bovine brucellosis and its public health in the different parts of Ethiopia.

Therefore, this review is undertaken with the following objective.

To review the status of Bovine Brucellosis in Ethiopia and its public health significance.

Etiology: Brucellae are Gram-negative, facultative intracellular bacteria that can infect many species of animals, including humans. Brucella *abortus* is the causative organism for bovine brucellosis. Brucella *abortus* is mainly infective for cattle, but occasionally other species of animals such as sheep, swine, dogs and horses may be infected [3]. Cattle can also become infected by *B.suis* and B.*melitensis* when they share pasture or facilities withinfected pigs, goats, or sheep. The infections in cattle caused by heterologous species of Brucella are usually more transient than that caused by *B. abortus* [3, 4]. Ten species are recognized within the genus Brucella. There are six 'classical' *species, B.* a*bortus*, *B. melitensis*; *B. suis, B. ovis*, *B. canis* and *B. neotoma* and another four species have been recognized more recently. Non-bovine animals and humans, can also contract the disease, which in turn plays a significant role in its persistence and transmission. Brucella *abortus* infecting cattle has seven recognized biovars, the most reported of which are *biovars* 1, 2, 3, 4 and 9, with *biovar* 1 being the most prevalent in Latin America [8].

Epidemiology

Geographic Distribution: The epidemiology of brucellosis has dramatically changed over the past few years due to improved hygiene, socio-economic conditions and increased international travel. Incidence of human brucellosis has been reported for the first time in the regions of central Asia and some countries. Particularly in Middle East countries, there is a drastic increase in the incidences of brucellosis in humans [10].

Brucella *abortus* is prevalent throughout the world except in Canada, Australia, Cyprus, Norway, Finland, the Netherlands, Denmark, Sweden, New Zealand and the United Kingdom.However, Mediterranean Europe, Central and South America, Mexico, Africa, Near East countries, Central Asia, India and Italy have a significant prevalence of brucellosis. Brucellosis is a reportable and notifiable report considering 19 years (1996–2014) by the World Organization for Animal Health (OIE) regarding 156 countries classified countries into three groups based on the situation of brucellosis among animals [17]. The three categories are: enzootic for brucellosis: countries that are infected or free of brucellosis for less than 3 years time period, non-enzootic for brucellosis: though brucellosis may be present, countries in this category are devoid of disease for 3 years and free of brucellosis: countries devoid of brucellosis throughout the study period of 19 years. The disease-free status countries are situated in Europe and Oceania while high prevalence or enzootic countries are present in Central and South America, Africa and parts of Asia [17, 18]. Brucellosis is endemic in Western Asia, India, the Middle East, Southern Europe and South America [18]. A study in Iran reported that B. *abortus* biovar3 is the most prevalent [19]. Brucellosis is mainly caused by *B. abortus* biovar1 in water buffaloes in parts of Africa, South America, Brazil, Italy, Pakistan and Egypt In Italy, cattle and water buffalos both are affected by *B. abortus* mainly in southern areas [20]. Reports of *B. melitensis* infection in cattle are pouring which is a major threat in Kuwait, Saudi Arabia, Israel and some southern European countries [8]. The epidemiology of this disease remains dynamic and unpredictable as several new strains could emerge and present strains could adapt to new animal species as well as changing situations. The disease is rare in children but in endemic areas, such cases have been reported [21, 22].

Risk Factors: Risk factors associated with bovine brucellosis have been described to include: host, agent, management and survival of Brucella in the environment [23]. The prevalence of those risk factors for infections is best understood for bovine brucellosis and to a lesser extent for ovine and caprine brucellosis[24].

Host Risk Factors: *B. abortus* is the principal Brucella organism that infects cattle. However, *B. suis* and *B. melitensis* may also infect cattle [25, 26]. B. *melitensi*s and *B. suis*can be transmitted through cow's milk resulting in human infection. *B. melitensis* is principally responsible for brucellosis in goats. However, goats may also be infected with *B. abortus* [7]. Camels could also be infected by *B. abortus* and *B. melitensis*. Camel milk is possibly a major source of human infections in Middle East countries. The main causative agent for brucellosis in dogs is *B. canis*; however sporadically, brucellosis in dogs may be caused by *B. abortus, B. suis* and *B. melitensis*. *B. abortus* has also been reported from Yak and seroprevalence of Brucella was studied in Yak [27]. The susceptibility of cattle to Brucella *abortus* infection is influenced by the age, sex and reproductive status of the individual animal. Sexually mature, pregnant cattle are more susceptible to infection with the organism than sexually immature cattle of either sex [27, 28]. Young sexually immature cattle generally do not become infected following exposure or recover quickly. Sexually mature females are more susceptible to B. *abortus* infection than bulls. This susceptibility increases during pregnancy and animals get more susceptible with the advance of pregnancy [23].

Agent Risk Factors: Brucella *abortus* is a facultative intracellular parasite capable of multiplication and survival within host phagocytes [16]. The organisms are phagocytosed by polymorph nuclear leukocytes, in which some survive and multiply. These are then transported to lymphoid tissues and fetal placenta [28].

Management Risk Factors: The spread of the disease from one herd to another and from one area to another has been linked almost always due to the movement of infected animals. The unregulated movement of battle from infected herds or areas to bovine brucellosis-free herds or areas is the major cause of breakdowns in bovine brucellosis eradication programs. Other management factors influencing inter-herd transmission are proximity to infected herds, waterways and scavengers. Various cattle husbandry practices have also been shown to be associated with the spread of B. *abortus* infection within herds [16]. Vaccination level, population density, methods of housing and use of maternity pens influence the probability of exposure to infection. Many factors affect the epidemiology of bovine brucellosis; the most important are herd size and mobility, contiguity to infected herds, the concentration of cattle and nature of production (dairy herds) are more susceptible than beef cattle [29].

Environment Risk Factors: In countries with temperate or cold climates there is a marked seasonal variation in the incidence of bovine brucellosis, with most cases occurring in the spring and summer. The ability of Brucella to persist outside the mammalian hosts is relatively high compared with most other non-spore-forming pathogenic bacteria under suitable conditions. Numerous studies have assessed the persistence of Brucella under various environmental conditions. Thus, when pH, temperature and light conditions are favorable that means pH>4, high humidity, low temperature and absence of direct sunlight *Brucella* may retain infectivity for several months in water, aborted fetuses and fetal membrane, feces and liquid manure, wool, hay, on building, equipment and clothes. Brucella can withstand drying, particularly in the presence of extraneous organic material and will remain viable in dust and soil. Survival is prolonged at low temperatures [30]. The survival of the organism in the environment may play a role in the epidemiology of the disease. A contaminated environment or equipment used for milking or artificial insemination is an additional source of infection. Permanent calving camps and lush pastures, particularly if they are wet and muddy, may play a significant role in the spread of the disease. Brucella is sensitive to direct sunlight, disinfectant and pasteurization [31].

Occupations at Higher Risk: People who work with animals or come into contact with infected blood are at higher risk of brucellosis. Examples include veterinarians, dairy farmers, ranchers, slaughterhouse workers, hunters, microbiologists and farmers and also those handling artificial insemination, abattoir and slaughterhouse personnel working in endemic areas who are at risk [31, 32]. Brucellae are considered potential bioweapons [32].

Pathogenesis: In cattle, infection with B. *abortus* is usually due to ingestion of infected material. The bacteria penetrate the mucosal epithelium of the gastrointestinal tract and are transported to regional lymph nodes, either free or within phagocytic cells. If these bacteria do not remain localized or are not killed, they can spread to other organs, joints and bursa. This bacteremic phase is subclinical and may take several weeks to some months [33].

The bacteria then localize in the pregnant uterus and udder of cows and bulls' testicles and accessory sex glands. In pregnant cows, the chorioallantoic membrane becomes inflamed and ulcerated and bacteria can spread via the blood to the fetus and placenta. The preference of the bacteria for these sites is thought to be due to the presence of the sugar alcohol erythritol, which is a fetal product concentrated in the chorion, cotyledons and fetal fluids. In mature, non-pregnant cows, the bacterium localizes in the udder. Infection of the udder is often clinically inapparent, with no gross lesions. Brucella localizes and replicates primarily in macrophages in mammary secretions or phagocytes; they form an important source of organisms for periodic reinfection (and potentially for infection of calves and humans via the milk). Hence, if the cow later becomes pregnant, the uterus can become infected during a subsequent bacteremic phase [31].

Clinical Finding

In Animals: The incubation period varies between 14 and 120 days. Primary clinical manifestations of brucellosis among livestock are related to the reproductive tract. In highly susceptible non-vaccinated pregnant cattle, abortion after the 5th month of pregnancy is a cardinal feature of the disease [6]. Retention of the placenta and metritis are common sequels of abortion. Females usually abort only once, presumably due to acquired immunity. In general, abortion with retention of the placenta and the resultant metritis may cause prolonged calving intervals and permanent infertility [14]. In cattle, B *abortus* causes abortions, stillbirths and weak calves. The placenta may be retained and lactation may be decreased. *Epididymitis, seminal vesiculitis, orchitis* and testicular abscesses are sometimes seen in bulls. Infertility occasionally occurs in both sexes due to *metritis or orchitis/epididymitis*. Hygromas, particularly on the leg joints, are common in some tropical countries [6]. Arthritis can develop after long-term infections. Systemic signs do not usually occur in uncomplicated infections and deaths are rare except in the fetus or newborn. Infections in non-pregnant females are usually asymptomatic, but pregnant adult females infected with *B. abortus* develop placentitis, which normally causes abortion between the fifth and ninth months of pregnancy. Even in the absence of abortion, there is heavy shedding of bacteria through the placenta, fetal fluids and vaginal exudates. The mammary gland and regional lymph nodes can also be infected and bacteria can be excreted in milk [34].

In Humans: Human brucellosis is primarily caused by *B. melitensis* globally. *B. abortus*, *B. suis* and *B. canis* also cause human brucellosis worldwide. The main source of transmission of *B. abortus* to humans is through consumption of unpasteurized or raw milk or milk products including butter, whey, cheese, yogurt, ice cream, etc. Infection through raw vegetables, water with fecal contamination and consumption of undercooked animal meat are also reported. Sour milk, yogurt and hard cheese result in propionic and lactic fermentation, therefore survival of the organism is comparatively less. Contamination in dairy products, thereby preventing the transmission; is related to the level of poverty [19].

Brucellosis in man is also considered an occupational disease of dairy farmers, milking workers animal handlers, dairy industry workers, slaughterhouse staff, butchers, hunters, shepherds, laboratory personnel, veterinary assistants, scientists and veterinarians. Infection through skin wounds may occur in persons working in the meat industry, veterinarians and livestock handlers. Inhalation is an important cause of infection in slaughterhouse personnel. Laboratory acquired infection is reported as a potential health emergency for the laboratory personnel. Brucellosis is considered a common laboratory-transmitted Infection [21].

Brucellosis may be transmitted from wild animals to domestic animals and ultimately to human beings. Moreover, little knowledge of the disease and its transmission among livestock handlers negatively reflects their attitude and practice toward the disease control strategies [35]. The pathogen has been classified as a category (B) pathogen that can be used as a bio-weapon. *B. suis* was the first agent used by the American army as a biological agent for biological warfare. Human brucellosis may be transmitted between humans, sexually, through the placental barrier, lactation and tissues such as bone marrow and blood transfusion [36].

The most common symptoms of human brucellosis include undulant fever, lack of appetite, weight loss, night sweats, uneasiness, fatigue, chills, insomnia, joint pain, constipation, headaches, myalgia, sexual impotence, nervousness, depression and loss of weight [38]. In humans, the disease symptoms depend on the affected site of infection such as *encephalitis, meningitis, spondylitis, arthritis, osteitis, orchitis, endocarditis, epididymitis and prostatitis* [37]. Sudden abortions during first or second trimesters are observed in pregnant women.Man-to-man transmission of brucellosis is very uncommon. However, sexual and intrauterine transmission to the infant could also be possible, Moreover; infants may get an infection from breastfeeding mothers infected with brucellosis [38].

Transmission: The infection of Brucella species is commonly mediated by direct contact with the placenta, fetus, fetal fluids and vaginal discharges or byproducts (e.g., milk, meat and cheese) from infected animals. This explains why the typical route of infection is either direct ingestion or via mucous membranes, broken skin and in rare cases intact skin. Professional health workers are frequent victims of Brucella infection, especially in regions of prevalent disease and it is documented that nearly 12% of laboratory workers in Spain get brucellosis during fieldwork [39]. In addition, in utero transmission, person-to-person transmission and transmission associated with tissue transplantation have been observed in rare cases. Aerial bacteria also remain a severe threat of infection, either by inhaling organisms or through the conjunctiva. Brucellosis also spreads via vertical transmission, by infecting newborn calves and lambs in the uterus [17].

Diagnosis

Microscopic Staining: The disease can be confirmed by demonstration of the bacteria in smears. The smears are made from vaginal discharges, placenta, colostrum, fetal stomach fluid or of the aborting cow's lochia and the abomasum of the aborted fetus using the modified Ziehl-Neelsen (MZN) stain. a variety of samples can be collected for culture and microscopic examination. Milk samples and vaginal swabs are particularly useful for diagnosis in live cows. Milk samples for culture should contain milk from all four quarters. In addition, B.*abortus* can often be isolated from the secretions of non-lactating udders. This organism can also be cultured from aborted fetuses (stomach contents, spleen and lung) or the placenta [6].

Enzyme-Linked Immune Sorbent Assay (ELISA): Still now, there is only one report [40] suggesting antigen detection by enzyme-linked immunosorbent assay (ELISA) as an acceptable alternative to blood culture for the diagnosis of brucellosis since sensitivity and specificity are 100% and 99.2% respectively. Antigen detection methods are potentially useful but have not been validated. Molecular technique: species of Brucella can be identified by molecular techniques. Molecular detection of Brucella species can be done directly on clinical samples without previous isolation of the organism [41].

Polymerase Chain Reaction (PCR): Polymerase chain reaction (PCR) assays can be used to detect Brucella DNA in pure cultures and clinical specimens, i.e. serum, whole-blood and urine samples, various tissues, cerebrospinal, synovial, or pleural fluid and pus. Direct detection of Brucella DNA in brucellosis patients is a challenge because of the small number of bacteria present in clinical samples and inhibitory effects arising from matrix components. Basic sample preparation methods should minimize inhibitory effects and concentrate the bacterial DNA template [6].

Serology: Serological tests can be divided broadly into two groups and these are screening tests and confirmatory tests. Some screening tests are used in the field clinics or regional laboratories, such as the Rose Bengal, Buffered Plate Agglutination Test (BPAT). The Rose Bengal Plate Test (RBPT) has a very high sensitivity to ensure that infected animals are not missed. The milk ring test is also an excellent screening test for dairy cattle. Indirect ELISA tests are also being used to screen milk and serum. Confirmatory tests include Complement Fixation Tests (CFT), competitive ELISA and Fluorescence Polarization Assay (FPA) are very useful in distinguishing vaccinal antibody responses from those induced by field infections [42].

Complement Fixation Test (CFT): The complement fixation test is the most widely used test for the serological confirmation of brucellosis in animals. Detects specific antibodies of the IgM and IgG1 type that fix complement. The CFT is highly specific but it is laborious and requires highly trained personnel as well as suitable laboratory facilities which makes it less suitable for use in developing countries. Although its specificity is very important for the control and eradication of brucellosis, it may test false negative when antibodies of the IgG2 type hinder complement fixation. The CFT measures more antibodies of the IgG1 than antibodies of the IgM type, as the latter are partially destroyed during inactivation Since antibodies of the IgG1 type usually appear after antibodies of the IgM type, control and surveillance for brucellosis are best done by CFT [43].

Standard Tube Agglutination Test (SAT): SAT is the most popular diagnostic tool used worldwide for the diagnosis of brucellosis due to its simplicity and economy. SAT accounts for aggregated quantity of IgM and IgG, while the quantity of specific IgG is measured by 2-mercaptoethanol (2ME) treatment of serum sample. IgG antibodies are important for the detection of active brucellosis and are an excellent indicator of active brucellosis. A rapid decline in the titer of IgG antibodies is an indicator of successful treatment. The persistence of SAT antibodies in some successfully treated patients indicates over-diagnosis of human brucellosis resulting in wrong treatment [44].

Fluorescence Polarization Assay (FPA): Is one of the diagnostic methods used for detecting antibodies. It is very accurate and the sensitivity specificity can be manipulated by altering the cutoff value between positive and negative reactions to provide a very sensitive screening test as well as a highly specific confirmatory test. The FPA is capable of distinguishing vaccinal antibodies in most vaccinated animals and it can eliminate some cross-reactions as well [23].

Status of Bovine Brucellosis in Ethiopia

Prevalence: Brucellosis has been noted as one of the most important livestock diseases in the country as it has been depicted. the first case report of brucellosis in the 1970s in Ethiopia [13]. However, in the last decades, several serological surveys have shown that bovine brucellosis is an endemic and widespread disease in Ethiopia [14].

Studies conducted on bovine brucellosis in Ethiopia have indicated that seroprevalence of the disease is varied from place to place ranging from 0.20% in Ambo and Debrebirhan [45] to 5.7% in Afar [46] which might be due to the differences in animal production and management systems as well as reasonably difference in agro-ecological conditions of the study places and see (Table 1). Reports indicated that the prevalence of bovine brucellosis was much higher in an area where farmers practice the communal use of grazing land than in clan-based herd segregation areas.Various investigations have shown that Brucella infection in cattle is common in Ethiopia, particularly in pastoral areas. Since an extensive system implies rearing many cattle over a large area and sharing common pastures, the contamination of pastures with discharges from the reproductive tract may lead to brucellosis [47].

The overall seroprevalence of animal and human brucellosis is reported in different areas of Ethiopia at different times by different authorities and these are noted in Table 1 found on the next pages accordingly. Seroprevalence of bovine brucellosis was reported in areas like 1.9% in East Wollega Zone [48]; 2.4% in Borena [49]; 5.26% in the South Omo zone [14], 2.7% in Hawassa [31], 2.0% in Eastern showa [50], 1.2% in Central High Land of Ethiopia (AdeaBerga, Holeta Town and Wolmera) [38], 0.40% inSendafa [5], 5.7% in Afar [51], 0.20 in Ambo and Debrebirhan [46], 1.38% in Jijjiga [52], 4.3% in Jimma [53], 2.08% in Kombolcha [13] and 1.94% in Bench Maji [54]. The result (5.7 %,) reported by [51] in Afar is high prevalence when compared with the other results.

Table 1: Prevalence of Bovine Brucellosis in some parts of Ethiopia

Locations	Serological Prevalence (%)**	Sources
South Omo zone	5.26	[14]
Afar	5.7	[51]
Bench Maji	1.94	[54]
Jimma	4.3	[53]
Central highland of Ethiopia	1.2	[38]
Borena	2.4	[49]
Hawassa	2.7	[31]
Kombolcha	2.08	[13]
Ambo and Debrebirhan	0.20	[46]
Eastern showa	2.0	[15]
East Wollega Zone	1.9	[48]
Jijjiga	1.38	[52]

** All serological prevalence results were confirmed by CFT

Public Health Importance of Bovine Brucellosis: Brucellosis is a significant zoonosis and health authorities must be alerted to the potential for human infection. The major risk to the general public is from the consumption of unpasteurized milk from infected cows. People handling infective material (including vaccines) must be advised of appropriate occupational health and safety requirements [16].

Transmission of brucellosis to humans occurs mainly through the consumption of unpasteurized dairy products especially raw milk, soft cheese, butter and ice cream, through direct contact with infected animal parts (such as the placenta by inoculation through ruptures of skin and mucous membranes) and the inhalation of infected aerosolized particles. Brucellosis is an occupational disease in shepherds, abattoir workers, veterinarians, dairy industry professionals and personnel in microbiologic laboratories [23]. However, consumption of hard cheese, yogurt and sour milk is less hazardous, since both propionic and lactic fermentation takes place. Bacterial load in animal muscle tissues is low, but consumption of undercooked traditional delicacies such as liver and spleen has been implicated in human infection [43].

Most common symptoms of brucellosis include undulant fever in which the temperature can vary from 37°C in the morning to 40°C in the afternoon; night sweats with a peculiar odor, chills and weakness, insomnia, anorexia, headache, arthralgia, constipation, sexual impotence, nervousness and depression [38]. Human brucellosis is also known for complications and involvement of internal organs and its symptoms can be very diverse depending on the site of infection and include encephalitis, meningitis, spondylitis, arthritis, endocarditis, orchitis and prostatitis. Spontaneous abortions, mostly in the first and second trimesters of pregnancy, are seen in pregnant women infected with Brucella. Symptoms and signs of brucellosis usually referred to as fever of unknown origin can be confused with other diseases including enteric fever, malaria, rheumatic fever, tuberculosis, cholecystitis, thrombophlebitis, fungal infection, autoimmune disease and tumors [41]. Because of these rather non-specific signs, brucellosis is constantly misdiagnosed as malaria, which is very prevalent in sub-Saharan Africa. Person-to-person transmission is not a significant problem except through blood or organ transfer which should be subject to proper control [43].

Public health significance includes physical incapacity, illness and loss of manpower and the Occupational risk of brucellosis is significant because of the high possibility of direct transmission from infected animals to the people employed in animal husbandry [38].

For the prevention of brucellosis in humans, No vaccine is available. Therefore, preventive measures will be essential to minimize the risk of infection in the human population. Such measures should include improved food hygiene, including the pasteurization of milk and protection from infection of high-risk groups such as milkers and other people working in the dairy industry [55].

Economic Importance: Economic importance on an average, an outbreak of bovine brucellosis resulted in a loss of milk production of the herd as much as a 20% and this can reach 40-50% in early abortion. In addition to the loss of milk production, there is the loss of calves and interference with the breeding programs. This is of greater importance in beef herds where calves represent the sole source of income. The common sequel of infertility increases the period between lactations and in an infected herd the average inter calving period may be prolonged by several months [56]. The economic losses due to bovine brucellosis include losses of calves due to abortion, reduced milk yield, culling and condemnation of valuable cows because of breeding failure, endangering animal export trading of a nation, loss of manpower, medical costs and government cost for research and eradication programs [24].

In Ethiopia, information on losses specifically through brucellosis in the different types of production systems is sparse, except for Tariku (1994) who reported an annual loss from brucellosis estimated to be 88, 941.96 Ethiopian Birr ($5231 equivalent) among 193 cattle, largely due to reduced milk production and abortions (Chaffa State Farm, Wollo, from 1987 to 1993)[6]. When brucellosis is detected in a herd, flock, region, or country, international veterinary regulations impose restrictions on animal movements and trade, which result in huge economic losses. In general, economic losses due to brucellosis are, Losses due to abortion, Diminished milk production, Cull and condemnation of animals due to breeding failure, Endangering animals export trade of a nation, Human brucellosis causing loss of some hours and medical costs, Government costs on research and eradication schemes [56].

Prevention and Control

In Animals: Prevention and control of brucellosis can be adopted realistically through an understanding of local and regional variations in animal husbandry practices, social- customs, infrastructures and epidemiological patterns of the disease. The common approaches used to control brucellosis include quarantine of imported stocks, hygienic disposal of aborted fetuses, fetal membrane andischarges with subsequent disinfection of contaminated areas. Animals that are in advanced pregnancy should be kept in isolation until parturition [57]. Moreover, replacement stock should be purchased from a herd free of brucellosis and decide for or against immunization of negative animals. Eradication by test and slaughter of positive reactor is also possible [58].

In Humans: The most rational approach for preventing human brucellosis is to control and eradicate the infection in animal reservoirs. In addition, there is a need to educate the farmers to take care in handling and disposing of an aborted fetus, fetal membrane and discharges as well as not to drink unpasteurized milk and abattoir workers in the transmission of infection, especially via skin abrasion [44]. The drug recommended is rifampicin at a dosage of 600-900 mg combined with doxycycline at 200 mg daily. Both drugs are given in the morning as a single dose and relapse is unusual after a course of treatment continued for at least 5 weeks [59].

Vaccination is generally recommended for seroprevalence rates between 2 and 10%. vaccines like B. *abortus* strain 19 (S19), which is a live vaccine and is normally given to female calves aged between three and six months as a single subcutaneous dose of $5\text{-}8\times10^{10}$ viable organisms[24].

Whether a strategy of test and segregation alone for high seroprevalence rates is sufficient may depend on the farming conditions. This might be appropriate for farms in conjunction with appropriate hygienic measures, but supplementation with vaccination may be required to control the disease in extensive livestock conditions. Application of farm bio-safety measures: Implementation of measures to reduce the risk of infection through personal hygiene, adoption of safe working practices, protection of the environment and food hygiene should minimize risks of further infection. Under appropriate conditions, Brucella organisms can survive in the environment for prolonged periods. Their ability to withstand inactivation under natural conditions is relatively high compared with most other groups of nonsporingpathogenic bacteria [56].

Treatments: Due to the intracellular localization of Brucella and its ability to adapt to the environmental conditions encountered in its replicative niche e.g. macrophage [43]. Treatment of domestic animals with antibiotics is not usually successful. Even though treatment failure and relapse rates are also high in humans, treatment depend on the drug combination of doxycycline with streptomycin which is currently the best therapeutic option with fewer side effects and fewer relapses, especially in cases of acute and localized forms of brucellosis [58].Neither streptomycin nor doxycycline alone can prevent the multiplication of intracellular Brucella (Antibiotics are usually the mainstay of treatment; long-term treatment may be required. Some forms of localized disease, such as endocarditis, may require surgery [6]. In underdeveloped countries, the treatment of cattle is not a common practice; however, the infected animals are isolated, culled, or slaughtered to prevent the spreading of infection to other herds and at substantial veterinary costs [41].

CONCLUSION AND RECOMMENDATIONS

Brucellosis is a bacterial disease of worldwide distribution that causes the most important public health problem in developing countries. It is a significant public health problem and an economically significant disease in Ethiopia. People living in pastoral rearing systems areas where humans closely live with animals are more likely to have brucellosis. Humans are infected if there is contact with animals at abortion, parturition, or post parturition from splashing infected droplets into the eye or drinking unpasteurized milk or milk product. Work-related exposure is observed in people who interact with diseased animals or their tissue. This disease is the most important cause of reproductive inefficiency and abortion in animals. *B. brucellosis* can be eradicated by isolating diseased animals, giving the vaccine for young female animals and test-slaughter methods. Microscopic examination and serological and molecular techniques are the common diagnostic method for the diagnosis of bovine brucellosis. The disease has a high economic impact by reducing reproductivity and productivity of the animal and has zoonotic importance.Studies conducted indicate that the prevalence of the disease is distributed in any part of Ethiopia and high in lowlands as compared with highlands. The status of bovine brucellosis is not well studied in Ethiopia and much is remained to address the problem.Based on the above conclusion, the following recommendations are forwarded;

- More research is to be done on bovine brucellosis to know its status and economic and public effect.
- Public education on the transmission and source of infection of the disease needs to be taken.
- The government, Public health officers and Veterinarians have to work together to reduce its economic and zoonotic impact.
- Pasteurization of milk should be widely practiced to prevent human infection,
- Isolation of aborted animals and proper disposal of aborted fetuses and fetal membranes, Preferably, by incineration.
- Eradication programs should be enforced to protect human health.

REFERENCES

1. CSA, 2020.Agricultural Sample Survey 2019/20 [2012 E.C.]. Volume II report on livestock and livestock characteristics (private peasant holdings). Central Statistical Agency (CSA): Addis Ababa, Ethiopia.
2. World Bank, 2017. International Development Association: Project Appraisal Document on a Proposed to the Federal Democratic Republic of Ethiopia for a Livestock and Fisheries Sector Development. Washington DC
3. Beruktayet, W. and C. Mersha, 2016. Review of cattle brucellosis in Ethiopia. Academic Journal of Animal Diseases, 5(2): 28-39.
4. Office of International Epizooties, 2009. Bovine brucellosis, OIE, Paris, France.
5. Bifo, H., G. Gugsa, T. Kifleyohannes, E. Abebe and M. Ahmed, 2020. Sero-prevalence and associated risk factors of bovine brucellosis in Sendafa, Oromia Special Zone surrounding Addis Ababa, Ethiopia.
6. Pal, M., F. Gizaw, G. Fekadu, G. Alemayehu and V. Kandi, 2017. "Public Health and Economic Importance of Bovine Brucellosis: An Overview." American Journal of Epidemiology and Infectious Disease, 5(2): 27-34.
7. Terefe, Y., S. Girma, N. Mekonnen and B. Asrade, 2017. Brucellosis and associated risk factors in dairy cattle of eastern Ethiopia". Tropical Animal Health and Production, 49(3): 1-5.
8. Yilma, M., G. Mamo and B. Mammo, 2016. Review on brucellosis seroprevalence and ecology in livestock and a human population of Ethiopia. Achiv Life Science, 10(1): 80-86.
9. Asfaw, G. and K. Mamo, 2016. Review-on-diagnostic-methods-of-brucellosis (7), 3, 323 ref.86.
10. Sulaiman, M.A.S., B. Roop Singh, S.M. Jamal Sabirand M. Mohamed, 2020. Brucellosis: current status of the disease and future perspectives. ostêpy mikrobiologii – Advancements of Microbiology, 59(4): 337-344.
11. Hassan, H., A. Salami, N. Nehme, R. Al-Hakeem, J. El-Hage and R. Awada, 2020. "Prevalence and prevention of brucellosis in cattle in Lebanon." Vet. World, 13(2): 364-371.
12. Jergefa, T., B. Kelay, M. Bekana, S. Teshale, H. Gustafson and H. Kindahl, 2009. Epidemiological study of bovine brucellosis in three agro-ecological areas of central Oromiya, Ethiopia." Rev. Sci. Tech., 28(3): 933-943.

13. Tesfaye, A., H. Dejene, B. Admassu, T. Adugna, D. Asfaw and A. Bitew, 2021. seroprevalence of bovine brucellosis in Ethiopia?: systematic review and meta-analysis', pp: 1-6.
14. Sorsa, M., G. Mamo, H. Waktole, F. Abunna, A. Zewude, T. Mohammed and G. Ameni, 2021. "Seroprevalence and Associated Risk Factors of Bovine Brucellosis in South Omo Zone, Southern Ethiopia." European Journal of Experimental Biology, (11)3: 12.
15. Alemu, F., P. Admasu, T. Feyera and A. Niguse, 2014. 'Seroprevalence of bovine brucellosis in eastern Showa, Ethiopia', 3(3): 27-32.
16. Hussen, A., Z. Nigussie and A. Agonafir, 2020. "Review on Bovine Brucellosis and its Current Status in Ethiopia." Journal of Veterinary & Marine Sciences.
17. CFSPH and OIE, 2018. "Brucellosis: Brucella abortus."Center for food security and public health
18. Franc, K.A., R.C. Krecek, B.N. Häsler and A.M. Arenas-Gamboa, 2018. Brucellosis remains a neglected disease in the developing world: a call for interdisciplinary action. BMC Public Health, 18(1): 125.
19. Dadar, M., R. Tiwari, K. Sharun and K. Dhama, 2021. Importance of brucellosis control programs of Livestock on the Improvement of One Health.
20. Garofolo, G., E. Di Giannatale, I. Platone, K. Zilli, L. Lorena Sacchini, A. Abass, M. Ancora, C. Cammà and T. Foster, 2017. Origins and global context of Brucella abortus in Italy. BMC Microbiol., 17(1): 28.
21. Centers for Disease Control and Prevention, 2017. Brucellosis reference guide. Exposures, testing and prevention. Available at: https://www.cdc.gov/brucellosis/pdf/ brucellosi-reference-guide.
22. Sandip, K., A. Sehrawat, R. Tiwari, M. Prasad, B. Gulati, M. Shabbir, R. Chhabra, K. Karthik, K. Shailesh and W. Chaicumpa, 2021." Bovine brucellosis a comprehensive review", Veterinary Quarterly, 41(1): 61.
23. Addis, M., 2015. Public Health and Economic Importance of Brucellosis: A Review, Public Policy and Administration Research, 5(7): 2225-972.
24. Dubie, T., M. Adugna, T. Sisayand Y. Mukitar, 2014. The economic and public health significance of brucellosis "Global Research Journal of Public Health and Epidemiology: ISSN-2360-7920:, 1(7): 054-064.
25. CFSPH, 2018. Brucellosis: Brucella suis. Http://www.cfsph. Iastate.edu/Factsheets/brucellosis_suis
26. CFSPH, 2018. Brucellosis: Brucella melitensis. Http://www. Cfsph.iastate.edu/Factsheets/ brucellosis melitensis.
27. Jiangyong, Z., D. Ciren, Y. Zhenjie, Y. Silang and F. Weixing, 2017. Seroprevalence and risk factors for bovine brucellosis in domestic yaks (Bosgrunniens) in Tibet, China, 49: 1339-1344.
28. Lopes, L., R. Nicolino and J. Haddad, 2014. 'Brucellosis - Risk Factors and Prevalence: A Review', The Open Veterinary Science Journal, 4(1): 72–84.
29. Office of International Epizooties, 2000.Ovine Epididymitis (*B. ovis*) Manual of standard for Diagnostic Test and Vaccines. 3rd ed. OIE, Paris, France, pp: 467-474
30. Defra, 2002. Department for Environment, Food & Rural Affairs (DEFRA): Notifiable diseases, disease information-Brucellosis (Brucella abortus).
31. Abera, A., Y. Deneke and T. Tolosa, 2019. Bovine brucellosis: Seroprevalence and its potential risk factors in smallholder dairy farms in Hawassa Town, Southern Ethiopia', Ethiopian Veterinary Journal, 23(2).
32. Alemu, Y. and R.C. Markel, 2013. Sheep and goat production handbook for Ethiopia.
33. Poester, F.P., L.E. Samartinom and R.L. Santos, 2013. Pathogenesis and pathobiology of brucellosis in livestock. Revue Scientifique et Technique, 32: 105-115.
34. Office of International Epizooties, 2010. Bovine brucellosis, Chapter 2.4.3. [Version adopted by the World Assembly of Delegates of the OIE in May 2009]. In Manual of Diagnostic Tests and Vaccines for Terrestrial Animals. OIE, Paris.
35. CDC, 2008. Laboratory-acquired brucellosis Indiana and Minnesota.Morb Mortal Wkly Rep., 57: 39-42.
36. El-Wahab, E., Y. Hegazy, F. Wael, A. Mikeal, A.F. Kapaby, M. Abdelfatahm, M. Bruce and M. Eltholth, 2019. Knowledge, attitudes and practices (KAPs) and risk factors of brucellosis at the human-animal interface in the Nile Delta, Egypt. BioRxiv.
37. Gondolfo, R., F. Tuon and N. Cerchiari, 2017. Human- to- human transmission of Brucella a systematic review. Trop Med. Int. Health, 22(5): 539-546.

38. Getahun, T.K., 2020. 'Seroprevalence of Bovine Brucellosis and its Public Health Significance in Central High Land of Ethiopia', Research Square, 1: 41.
39. Rahdar, H.A., M. Kodori, M.R. Salehi, M. Doomanlou, M. Karami- Zarandi, S. Jasemi and M. Feizabadi, 2019. Multiple myeloma or brucellosis: a case report. Infect Disord Drug Targets, 20(1): 102-105.
40. Yang, H.X., J.J. Feng, Q.X. Zhang, R.E. Hao, S.X. Yao, R. Zhao, D.R. Piao, B.Y. Cui and H. Jiang, 2018. A case report of spontaneous abortion caused by Brucella melitensis biovar 3. Infect Dis Poverty, 7(1): 31.
41. Khan, M.Z. and M. Zahoor, 2018. "An Overview of Brucellosis in Cattle and Humans and its Serological and Molecular Diagnosis in Control Strategies." Trop Med. Infect Dis., 3(2).
43. Nelson, K., 2016. "Review on bovine brucellosis: epidemiology, diagnosis and control options." arc Journal of Animal and Veterinary Sciences, 2(3).
44. FAO, 2003. Guidelines for coordinated human and animal brucellosis surveillance.Animal production and Health Protection, 156: 45FAO, 2002. Bovine brucellosis in Sub-Saharan Africa: Estimation of seroprevalence and impact on meat and milk offtake potential.
45. Mantur, B.G., M.S. Birada, R.C. Bidri, M.S. Mulimani and P. Kariholu, 2006. Protean clinical manifestations and diagnostic challenges of human brucellosis in adults: 16 years experience in an endemic area. J. Med. Microbiol., 55: 897-903.
46. Bashitu, L., B. Afera, G. Tuli and F. Aklilu, 2015. Sero-Prevalence Study of Bovine Brucellosis and its Associated Risk Factors in Advances in Dairy Research, 3(1): 1-4.
47. Tolosa, T., 2014. seroprevalence study of bovine brucellosis and its public health significance in selected sites of Jimma zone, western Ethiopia.
48. Moti, Y., M. Tesfaye, D. Hailu, T. Tadele and W. Mezene, 2012. Bovine Brucellosis: Serological Survey in Guto- Gida District, East Wollega Zone, Ethiopia. Global Veterinary, 8(2): 139-143.
49. Edao, B., G. Ameni, Z. Assefa, S. Berg, M. Adrian and N. Wood, 2020. Brucellosis in ruminants and pastoralists in Borena, Southern Ethiopia."PLOS Neglected Tropical Diseases.
50. Petros, A., F. Alemu, T. Feyera and A. Niguse, 2014. Seroprevalence of Bovine Brucellosis in Eastern Showa, Ethiopia, 3(3): 27-32.
51. Negash, W. and T. Dubie, 2021. Study on Seroprevalence and Associated Factors of Bovine Brucellosis in Selected Districts of Afar National Regional State, Afar, Ethiopia'.
52. Hailu, D., Y. Moti, M. Mohamed and H. Mussie, 2011. Seroprevalence of bovine brucellosis in agro-pastoral areas of Jigjiga zone of Somali National Regional State, Eastern Ethiopia, 15: 37-47.
53. Dereje, T. and B. Deresa, 2020. Epidemiological investigation of brucellosis in breeding female cattle under the traditional production system of Jimma zone in Ethiopia, 16(9): 100117.
54. Kenea, T. and B. Megersa, 2021. Bovine brucellosis: Seroepidemiology and herder's knowledge, attitude and practices in Bench Maji zone, southern Ethiopia. Ethiopian Veterinary Journal, 25(1): 23-42.
55. Yohannes, M., H. Degefu, M. Mohamud and M. Hailemelekot, 2013. Distribution of brucellosis in different regions in Ethiopia. African Journal of Microbiology Research, 7: 1150-1157.
56. Mantur, B.G., S.K. Amarnath and R.S. Shinde, 2007. Review of clinical and laboratory features of human brucellosis.Indian J. Med. Microbiol., 25: 188-202.
57. Radostits's, C.C., K. Gay's, W. Hinchcliff and D. Constable, 2007. Veterinary Medicine. A textbook of the diseases of cattle, horses, sheep, pigs and goats. Edition: 10th.
58. Seleem, M.N., N. Jain, N. Pothayee, A. Ranjan, J.S. Riffle and N. Sriranganathan, 2009. Targeting Brucella melitensis with polymeric nanoparticles containing streptomycin and doxycycline. FEMS Microbiol. Lett., 294: 24-31.
59. Radostits, O.M., C.C. Gay, D.C. Blood and K.W. Hinchcliff, 2007. Veterinary medicine: a textbook of the diseases of cattle, sheep, pigs, goatsand horses. Harcourt Publishers Limited, London, pp: 882-885.