Chapter

Milk Borne Brucellosis

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Abstract

Milk is full of nutrients, making it an ideal environment for several infectious diseases, that come at the forefront is brucellosis. The zoonotic disease brucellosis in humans is mostly ignored, and the annual number of human cases is commonly reported as 500,000. Consumption of tainted dairy products is the most common vector for the transmission of human Brucellosis. Confirmation of disease via culture is considered the gold standard, but is not always possible. Serological tests and molecular tests are alternative methods. The milk Ring Test is considered the method of choice for the surveillance of dairy herds. The control of risk factors and surveillance are the cornerstones of brucellosis prevention. Eliminating animal infections is the most effective preventative technique. Cattle, goats, and sheep vaccination are advised in enzootic regions with high prevalence rates. The main methods of preventing human infection are public education, food safety measures, occupational hygiene, and laboratory safety. The pasteurization of milk before it is consumed directly or used to make products like cheese is a crucial step in avoiding transmission from animals to people. Both education initiatives and laws prohibiting the sale of unpasteurized milk products can be successful.

Keywords: human brucellosis, unpasteurized milk, *Brucella spp*., surveillance

1. Introduction

The issue of food safety is a serious concern in the world. World Health Organization (WHO) declares that more than 200 diseases are related to the consumption of contaminated food products, and these diseases can cause significant complications in susceptible consumers such as infants, children, the elderly, and pregnant [1].

Historically, milk and dairy products have been significant components in the nutrition of most nations [2]. Milk and dairy products are rich in nutrients, high-quality proteins, micronutrients, vitamins, and energy-containing fats [3, 4]. Therefore, milk is a good environment for the growth of various pathogens [5]. There are many factors that influence the prevalence of pathogens and spoilage microorganisms in milk and dairy products. These factors may include the dairy herd's health, hygiene status in the farm setting, milking and prestorage environment, the availability of

storage facilities and technology, the farming methods used, geographical location, and seasonal differences [6].

Brucellosis is among the most investigated zoonosis. The consumption of contaminated milk or milk products, in addition to direct or indirect contact with infected mammals, leads to the transmission of brucellosis to humans [7]. The proper thermal process of milk can reduce the population of *Brucella spp*.; however, post-contamination of proceeding products or failure in the pasteurization process of the milk could provide an ideal condition for the growth of *Brucella spp*. For instance, *Brucella melitensis* can live in infected unpasteurized milk kept at 4°C for five days, and for nine days at −20°C. In addition, *Brucella*'s life rate improves up to 18 days at the ambient condition in cheese, which is produced by infected unpasteurized milk [8].

Even though brucellosis seldom poses a threat to human life, it is widely seen as a burden for the economy and public health, notably in the Middle East, Mediterranean region, North and East Africa, Southern and Central Asia, India, Central, and South America. According to the European Food Safety Authority, brucellosis incidence rates in developed countries range from 0.3 cases per million per year to over 1000 cases per million in endemic regions [9, 10].

In the dairy food chain, from production through handling and processing to consumption, productivity and safety are inextricably intertwined. Therefore, a continuous system of preventive measures is required to reduce the risk of brucellosis associated with milk and dairy products, starting with the safety of mammal feed and continuing through best farming practices and on-farm control systems, good production and sanitary processes, customer safety awareness, and appropriate implementation of food safety management systems across the dairy chain [11, 12].

Here comes the importance of this chapter to spotlight the complexity of neglected brucellosis. It clarifies the etiology, epidemiology, sources, transmission, clinical features, diagnosis, prevention, and control of this infection.

2. Etiology of human brucellosis

Numerous names for human brucellosis exist, such as undulant fever, Gibraltar fever, gastric fever, Malta fever, Mediterranean fever, Maltese fever, intermittent fever, and rock fever of Gibraltar. It is a zoonotic disease that has been around for a long time; fresh evidence from ancient Egyptian skeletons suggests it is been around since, at least, 750 BC. The Mediterranean, the southern and central United States, Africa, Asia, the Arab peninsula, the Indian subcontinent, and the Middle East all have a higher prevalence of this infection.

Many different kinds of animals are susceptible to the bacterial zoonotic disease known as brucellosis, which can be passed on to people through infected food or by casual contact. The zoonotic disease brucellosis in humans is mostly ignored. In humans, brucellosis begins as a devastating acute infection that can become chronic and have numerous problems; it is a disease of poverty. Infections in animals have a large socioeconomic impact. The annual number of human cases is commonly reported as 500,000, but this is likely an underestimate due to the fact that many of the worst-affected countries lack the resources to properly diagnose the disease, and because the flu-like symptoms are also present in a number of other febrile illnesses [13].

As a bacterial illness with a global reach, brucellosis affects not just individuals but also the livelihoods of entire communities and economies.

Several host-specific *Brucella* species are responsible for this disease. In order to spread throughout the body, only need just 10–100 infective organisms. Brucella species are gram-negative cocci bacilli (GNCB) that are nonmotile, do not produce spores, and are encapsulated. They are named after Sir David Bruce (1855–1931), the man responsible for discovering the brucellosis-causing bacteria. Although aerobic, certain bacteria can only be successfully isolated in the presence of 5–10% carbon dioxide. In mammals, *Brucella* organisms concentrate on the reproductive organs, where they cause abortions and infertility. The animal's fluids, such as urine, milk, and placental fluid, are rich in them [13, 14].

So far, twelve distinct *Brucella* species have been identified; while they can spread to a wide variety of hosts, each species has a preferred host. These twelve species consist of six traditional species and six new species. The traditional species are *B. abortus*, *B. melitensis*, *Br. suis*, *Brucella neotomae*, *Brucella ovis*, and *B. canisand*, while the new species are *B. canisand*, *Brucella ceti*, *B.pinnipedialis*, *B.microti*, *B.inopinata*, *B. Papionis*, and *B. vulpis*. Three of the *Brucella* species are known to be endemic in most countries, and they are highly virulent to both their natural hosts and humans. They include *Brucella abortus*, which mostly infects cattle; *B. melitensis*, which primarily infects sheep and goats; and B. suis, which has a tropism for domestic, feral, and wild pig populations [15, 16].

3. Transmission of human brucellosis

The following is a rundown of the most prevalent ways that humans contract *Brucella* species infections.

3.1 Food borne transmission

3.1.1 Unpasteurized milk and dairy products

Consumption of tainted dairy products is the most common vector for the transmission of brucellosis in humans. Consumption of unpasteurized milk and dairy products is a major route for the transmission of *Brucella* species to humans, as these bacteria are spread from diseased animals to humans through the milk they produce. Unpasteurized cheeses, also known as "village cheeses," are very probably the foods that cause human brucellosis. This is especially true of goat and ewe cheeses. The usual lifespan of Brucella in this cheese is one month, but it can last for as long as three months [17, 18].

3.1.2 Raw or undercooked meat products

In societies where raw or undercooked meat or meat products are highly valued, meat may also be a major source of infection [19].

3.2 Environmental contact with infected animals or their products

Direct inoculation occurs most frequently through cuts and abrasions in the skin. Veterinarians and those working in red meat processing factories or slaughterhouses run the risk of skin wound contamination. Animal tissue, fetal remains, birth

products, blood, urine, and vaginal discharges are all potential vectors for the transmission of disease [20].

Hunters can become infected with *Brucella* by cuts in the skin or from ingestion of the bacteria while cleaning wild pigs, moose, elk, and deer that they have entrapped.

Newly aborted animals or rains running off of contaminated land might contaminate water supplies like wells.

Brucellosis can also be contracted through the inhalation of infected dust, dried dung, or other noxious excrements. *Brucella* species can persist for extended durations in a wide variety of environmental conditions, including dairy, meat, aborted fetuses, dung, dust, soil, slurry, and water, making the problem complicated. A lot of factors, including the type of substrate, the quantity of Brucella, the temperature, the pH, the amount of sunshine, and the presence of other microbial contaminants, all play a role in determining an accurate duration of survival [21].

3.3 Occupational exposure

The risk of brucellosis infection is higher in certain professions. Infection can happen through inhalation, contamination of the conjunctiva, ingestion, contamination of the mucous membranes, contamination of the skin, particularly through cuts or abrasions, and unintentional self-inoculation with live vaccines [22]. These professions involve:

A. Veterinarians and those working in the lab who are culturing *Brucella*.

B. Individuals who deal with animals raised for food.

C. Individuals who are employed in the meat sector.

D. Individuals who are employed by the dairy business.

E. Personnel who work in the upkeep of farms, industries, or facilities that process animal products.

F. Farmers, farm workers, caretakers of animals, and pig keepers.

G. Shepherds, sheep shearers, goatherds, and artificial insemination.

H. Families who raise livestock and are farmers; families who burn dried dung as fuel.

I. Meat packers, butchers, and slaughtermen.

J. Fetal calf serum collectors, wool processors, and hide and skin processors.

3.4 Infection by the inhalation

It is uncommon for people to become infected with *Brucella* bacteria through inhalation, but it can be a serious risk for those who work in particular occupations, such as medical labs, where staff members may be exposed to the aerosol while preparing samples for isolation, in addition to abattoir workers, and those who work with animals used in food production or in the meat business [23].

3.5 Infection through conjunctiva

Vaccines for *B. abortus* include strain 19 and RB-51, and those for *B. melitensis* include Rev-1. Any contact with infected tissue or body fluids, such as a splash onto the conjunctiva of the eye or a needle stick from a vaccine administered when working with animals, can lead to self-inoculation. Vaccines administered via conjunctive splash are likely to be more potent than those administered via injection. That is why it is possible to catch brucellosis through the eyes' conjunctival sac [24].

3.6 Blood and bone marrow transfusion

Contaminated blood and bone marrow transfusions are other potential routes of transmission. This transfusion has a high risk of *Brucella* transmission [25].

3.7 Tissue transfer (transplantation)

A tissue transfer is a form of transplantation. Organs, tissues, or groups of cells are transplanted when they are physically removed from a donor and placed into a recipient, or when they are relocated inside the same body. It is probable that these actions will spread disease [26].

3.8 Person to person transmission

Although cases of brucellosis being transmitted from person to person are extremely unusual, they do occur [25].

3.9 Venereal transmission

Rare reports have also suggested sexual transfer as a possible transmission pathway [26].

3.10 Vertical transmission

Babies of infected moms who are breastfed have a higher chance of acquiring the illness themselves. Birth-related exposure to the mother's blood, urine, or feces can also cause congenital illnesses in infants [27].

4. Clinical features of human brucellosis

Although brucellosis in humans can affect people of any age, it most commonly affects men in their twenties and forties because of the more exposure to occupational risk [28].

Each species of *Brucella* is a facultative intracellular pathogen, meaning that it can live and reproduce within the host cell's phagocytic immune system. Still the ways by which Brucella evades intracellular death are poorly understood. But in the end, *Brucella* organisms are contained within RES monocytes and macrophages in organs including the lymph nodes, liver, spleen, and bone marrow [29]. Brucellosis is a systemic disease that can infect all the organs or tissues of the body. After Brucella enters the body, it goes through three distinct phases: the incubation period, the acute phase, and the chronic phase. The incubation period can vary from five days to five months and is not always straightforward to estimate. However, it is typically two to

four weeks. About half of all cases of the disease have an abrupt beginning within days to weeks after infection, whereas the other half have a more gradual onset within weeks to months following the initial infection. Clinical symptoms might be rather general and diverse. Symptoms may include high body temperature, sweating, weariness, general malaise, lack of appetite, weight, headache, aching joints, and pain in the back. Patients typically improve first thing in the morning and then experience a worsening of their symptoms throughout the day [30].

Fatigue, fever, sweating, splenomegaly, and hepatomegaly are all symptoms and signs that may appear during the acute phase.

Brucella possesses a wide variety of virulence characteristics that allow it to establish persistent infection by hiding within host cells and evading the immune system. Because of the high degree of clinical polymorphism, brucellosis is often missed at the first point of care [31].

Additionally, brucellosis is known to induce serious clinical problems involving the internal organs such as meningitis, encephalitis, arthritis, spondylitis, endocarditis, prostatitis, and orchitis [31].

The need for sleep might be overwhelming and sadness is common. The fever will fluctuate in intensity over the course of several days ("intermittent fever") if it is left untreated.

5. Diagnosis of human brucellosis

Given the large variety of clinical symptoms, most of which are nonspecific, it is impossible to make an accurate clinical diagnosis of human brucellosis; instead, it is required to achieve serological and bacteriological testing, in order to decrease diagnostic errors.

5.1 Culture

Confirmation of disease via culture is considered the gold standard but is not always possible. Clinical samples from sites of the disease's focus, such as bone marrow, spleen, synovial fluid, and abscesses, can be tested for the presence of *Brucella*. Whole blood is typically the biological material of choice for isolating *Brucella*. The following conditions are necessary for cultural isolation to be successful [32]:

A. Disease phase: Isolation rates as high as 40–90% are seen during the acute phase of an illness, whereas rates as low as 20% are seen during the chronic or decline phase.

B. Bacteremia level: Blood is completely sterile in healthy people. In the medical community, blood cultures are the gold standard for diagnosing bacteremia since only living bacteria can survive in the blood.

C. Species of *Brucella*: While *melitensis* species have a high rate of isolation, *non-melitensis* species have a far lower rate of isolation.

D. Culture methodology: *Brucella* can be isolated, purified, and identified using a variety of techniques. The most reliable methods for obtaining sterile cultures are the solid-media, streak-plate, and pour-plate approaches.

5.2 Serological tests

Antibodies against *Brucella* were assessed using a series of serological tests to confirm the presence of infection with this bacterium [32–34].

5.2.1 Rose Bengal test (RBT)

Although this test was developed for veterinary screening, it is now routinely used to diagnose human brucellosis. The Rose Bengal test is a rapid (5–10 minute), simple to conduct, and highly sensitive diagnostic tool for acute brucellosis; nevertheless, it has a high rate of false-negative results in chronic and severe cases, and false-positive results emerge due to cross-reaction with *Yersinia enterocolitica*.

5.2.2 Serum agglutination test (SAT)

Although this test was first introduced in 1897, it still relies upon today for the serodiagnosis of brucellosis. In endemic areas, SAT is the most widely employed serological test. In non-endemic locations, an agglutination titer of 1:160 or higher is regarded as noteworthy, but in endemic areas, a titer of 1:320 or higher is required.

5.2.3 Microagglutination test (MAT)

This exam is a condensed version of the SAT. In comparison to SAT, it can test many samples simultaneously and requires less serum and reagents.

5.2.4 Indirect coombs test

Incomplete, blocking, or non-agglutinating IgG can be detected with the help of the Coombs test, which is an extension of the SAT.

5.2.5 Brucella capt test

When it comes to diagnosing human brucellosis, the *Brucella* capt test has been proposed as an alternative to the Coombs test. This is because it is an immune capture agglutination test. The BRUCAPT test is an immunocapture assay that can detect total anti-*Brucella* antibodies in a single step. The Coombs test was previously the only method for measuring agglutinating and incomplete antibodies; this assay allows the detection of both. To diagnose brucellosis, especially in its more advanced stages, and to monitor its treatment, this test is the gold standard of serological methods; quick and easy, the results will be available in 24 hours. The best possible sensitivity and specificity are achieved without subjecting samples to any kind of washing or dilution.

5.2.6 Enzyme-linked immunosorbent assay (ELISA)

When other tests are negative and there is significant clinical doubt, ELISA is the test of choice for focused, difficult, and chronic patients. This test has high sensitivity and specificity. Moreover, it may detect immunoglobulins (IgG, IgM, and IgA) during 4 to 6 hours. According to the research done in this area, ELISA is a highly effective tool for both the detection of *Brucella* antibodies and the discrimination between the

acute and chronic stages of the disease in large populations. It has been proven by the research community that ELISA assays are quick, accurate, sensitive, and specific. This technique complements agglutination assay in clinical laboratories for the detection of brucellosis and provides an alternative for large-scale screening.

5.2.7 Indirect fluorescent antibody (IFA) test

This test is quick, with findings available in just a couple of hours in the same illustration of ELISA. However, the interpretation of results is subjective, and it might not differentiate between IgA, and research findings have shown that different manufacturers produce varying levels of antibody responses to the same antigens.

5.2.8 Immunochromatographic lateral flow assay

The test is easy to perform and read, simple, and rapid, with high sensitivity and specificity (> 90%).

5.3 Molecular assays

The traditional methods of *Brucella* typing are gradually being replaced by newer molecular technologies. The laboratory diagnosis of human brucellosis has benefited from advancements in molecular-based technology. Pure *Brucella* culture DNA and DNA from clinical specimens can both be amplified and detected using PCR tests. Extracting *Brucella* DNA from whole blood, serum, and tissue samples is now possible with the help of a wide variety of commercial kits.

5.3.1 Standard PCR

A single-pair PCR technique was devised to amplify the target genomic sequence of *Brucella* species for the diagnosis of human brucellosis. It has been shown through research that conventional PCR is a more sensitive approach than culture methods, both for the initial diagnosis of infection and for the early detection of relapses [35].

5.3.2 Real-time PCR

Real-time polymerase chain reaction is an effective method for determining the concentration of nucleic acids in isolated blood specimens. In addition to being quick, sensitive, and specific, it has a high rate of reproducibility [36].

5.3.3 Nested and semi-nested PCR

In nested PCR, two sets of PCR primers are utilized to study the same genomic region. Currently, nested PCR and semi-nested PCR techniques are being developed to detect *Brucella* in human blood samples and are being tested in clinical settings for the diagnosis of human brucellosis. Lin et al. reported a nested PCR for the laboratory diagnosis of human brucellosis. During semi-nested PCR, two sets of PCR primers are used, but one of the primers in the second set is the same as that in the first [37].

5.3.4 Other PCR-based assays

Polymerase chain reaction-enzyme immunoassay (PCR-EIA) was used by Vrioni et al. (2004) for the quick laboratory diagnosis of human brucellosis from peripheral blood. According to the findings, the PCR-EIA assay is a sensitive and specific technique that could help in the quick and precise diagnosis of acute human brucellosis [38].

6. Detection of *Brucella* antibodies in livestock milk

The milk ring test (MRT) was first introduced by Fleischhauer in Germany in 1937; it is the best test for screening the milk of suspected cases of animal brucellosis. MRT is characterized by simplicity, ease, accuracy, and inexpensive method, also MRT is not consumed time. Therefore, MRT is considered the method of choice for the surveillance of dairy herds. This test mainly detects the *Brucella* antibodies IgM and IgA in fresh milk. The sensitivity and specificity of MRT are 85% and 95%, respectively [39–41].

7. Prevention and control of human brucellosis

Milk and dairy products play an important role in the transmission of *Brucella* to humans, and the risks are increased because an infectious dose of just 10–100 organisms is sufficient to cause systemic infection. The genus *Brucella* is composed primarily of mammalian pathogens, and the key species are food-producing animals, especially milk-producing animals [42].

Additionally, Brucellosis' zoonotic status is now established. Therefore, the only way to effectively prevent sickness in humans is to remove the animal reservoir.

Medical, public health and veterinary authorities must often work together to eradicate brucellosis and ensure its prevention and control. The beginning of a good control program begins with this cooperation.

The concept of "One Health" (OH) is a catch-all phrase referring to the commonalities between people, animals, plants, and the environment. Integrative health practices are encouraged by increasing cross-disciplinary communication and coordination.

The following guidelines should be followed to reduce the risk of contracting brucellosis [43]:

7.1 Prevention of food-borne brucellosis

7.1.1 Milk and dairy products

Milk from affected bovines (i.e., cattle, buffalo, camels, sheep, goats, yaks, and reindeer) is a major contributor to the disease of milk-borne brucellosis.

There is a particularly high danger from consuming milk and dairy products like cheese, cream, and ice cream [44]. All milk and dairy products destined for human consumption, whether directly ingested or utilized in the production of other foods, must undergo proper heat treatment in one of the following ways [45]:

- The process of pasteurization.

- Boiling
- Ultra heat treatment (UHT)

Be wary of various kinds of cheese, especially soft cheeses made from raw milk, as they may harbor high numbers of *Brucella* species if they have not been adequately heated. Making cheese in this style should be highly discouraged. We found that the acidity of hard cheese mitigates some of the risks associated with eating it, allowing us to infer that it is safer than softer varieties. The acidification methods used to make sour milk, sour cream, yogurt, and butter; all drastically lower the *Brucella* concentration.

It is also important to keep in mind that the rennet enzyme, if it is made from the stomachs of *Brucella*-infected ruminants, can potentially be a source of infection [46]. Rennet enzyme is a complex set of enzymes, such as chymosin, pepsin, and lipase, naturally present in the fourth stomach or abomasum of an unweaned calf, kid, or lamb. Chymosin essentially turns milk into a soft cheese in the stomach of these young animals so that digestion occurs more slowly and nutrients can be absorbed. Cheesemakers mimic nature by using the coagulating capability of chymosin to separate milk into the solid curds needed for cheesemaking and the liquid whey that is left over. *Brucella* can be transmitted to humans and animals through the watery whey layer that remains after cheese manufacturing. Additionally, if shipping containers are not cleaned properly before use, it could contaminate the contents.

Also, be cautious of ice cream made with milk that has been infected with *Brucella*, as milk can be extremely dangerous, especially when it comes from a variety of sources that may be combined to form a single serving. Heat treatment is required for all milk used in this formulation.

7.1.2 Meat and meat products

Estimates vary but as little as 10–100 *Brucellae* are sufficient to infect a human [42]. Therefore, contaminated meat and meat products may be a vector for spreading the disease, especially if they are sourced from animals slaughtered during the acute phase of the disease and are eaten raw or undercooked. There is arising in a real possibility of transmission of human brucellosis from the consumption of meat and meat products. Household meat and meat product processing procedures can be a source of widespread pathogens exposure risk to the family and the community [47].

Not only the hunters and butchers but also other family members may have contact with the meat. Brucellosis is a disease that can be passed from animals to humans through contact with their flesh, organs (liver, kidney, spleen, viscera, udder, testicles), blood, or even saliva. The killing of an infected animal or the preparation of infected meat can also spread the disease. Most people are not in danger of contracting brucellosis but those who work in the veterinary industry, a slaughterhouse, a meat processing plant, a farm, and a hunting camp or who eat raw or undercooked meat are [47].

The high concentration of *Brucella* species in the liver, spleen, lymph nodes, mammary glands, testes, and bone marrow of the carcasses warrants special attention [48]. In this situation, these tissues, if not appropriately cooked, can cause infection by contact or ingestion.

Contamination of other foods and cooking utensils is possible during the handling and preparation of contaminated meat and offal.

All meat products must be fully cooked prior to consumption because meat borne brucellosis cannot be prevented by using most common meat preservation methods such as salting, drying, smoking, refrigeration, or freezing [47].

7.1.3 Marine mammal brucellosis

Roughly 120 species of marine animals either exclusively inhabit maritime environments or are heavily reliant on marine resources for survival. These animals include pinnipeds (true seals, eared seals, and walruses) [49]; cetaceans (which contain two suborders: Mysticeti (baleen whales) [50] and Odontoceti (toothed whales, which includes dolphins and porpoises) [51]; polar bear (Ursusmaritimus) [52]; sirenians (manatees and dugong) [53]; and several species of otters [10].

Veterinary meat inspectors, researchers, occasional consumers of marine mammal meat, those working with stranded marine mammals, those working with products derived from marine mammals, whale and seal hunters, those working with raw marine products, and people in traditional communities where products from whales and seals are still an important part of the diet are all at risk of zoonotic transmission of marine mammal brucellosis.

In light of the wide variety of human brucellosis symptoms and the relatively recent realization that marine mammals play a role in the transmission of the disease from marine mammals to humans, it is important to pay attention to this type of food and conduct additional research on the virulence of recent *Brucella* species in humans.

7.2 Personal hygiene

Veterinarians, laboratory employees, meat inspectors, abattoir workers, farm laborers, farmers, inseminators, stockmen, and anyone involved in the processing of animal products are at a high risk of occupational exposure to *Brucella* infection. Procedures involving aborting animals, aborted materials, or those in the process of parturition, as well as clinical examination, inspection, shearing, dipping, insemination, treatment, vaccination, and the disinfection and cleaning of contaminated premises pose a particularly high risk of spreading brucellosis. Therefore, the following procedures should be followed by those who are at a high risk of contracting *Brucella* due to their place of employment [54].

A. Everyone working in potentially hazardous environments should dress appropriately and use Personal Protective Equipment (PPE). The uniforms should be kept on the premises and used only for this function. Personal protective equipment (PPE) consists of an overall or coat, a rubber or plastic apron, rubber gloves, boots, a face shield or goggles, and a respirator (a mask) if the mode of transmission is airborne.

B. Handle fetuses, animal placentas, and animal discharges with care.

C. Immediately after coming into contact with the animal, fetus, placenta, or animal secretions, wash hands thoroughly with liquid soap and water.

D. Apply antiseptic (tincture of iodine, for example) and plaster or self-adhering bandage to any wounds or scrapes that you find.

E. If symptoms worsen throughout the incubation period, prompt medical attention should be requested.

F. Work garments should be used only for the work and kept on the Premises; after each use, they should be boiled, steamed, fumigated with formaldehyde, or soaked in a disinfectant solution of suitable concentration, such as phenolic soap, iodophor, hypochlorite, or chloramine.

G. Shoe disinfection is essential to prevent the spread of disease from outside the home or tent to the living space.

H. Sanitize workwear and contaminated spaces following usage.

I. Eye protection is essential because of the high risk of infection from conjunctival contamination, and any infectious material that enters the eye must be removed under clean or aseptic conditions away from the work area.

J. Respiratory contamination is also a high risk in heavily infected environments. Protect yourself from breathing in dust or aerosols created by dried excreta or tissues discharged after abortion, parturition, or slaughter by donning a mask. It is important to frequently replace the bacteria-catching filters and sanitize the apparatus using chemicals or steam.

K. Serological testing at regular intervals is a great way to keep an eye on the health of your workforce. Before commencing work, new hires are encouraged to submit a blood sample as a baseline.

L. Pregnant women and children under the age of 18 should not be allowed to work in hazardous environments.

7.3 Occupational hygiene

Occupational hygiene is the study of how to prevent, detect, evaluate, and remediate risks to workers' health and safety on the job, while also considering the potential effects on bystanders and the larger community. This field of study improves working conditions and practices by raising awareness of potential dangers among employers and workers. Occupational exposure to human brucellosis can occur in the following groups [55]:

Teams whose duties need them to come into contact with diseased animals or animal byproducts. Farmers, stockmen, shepherds, dairymen, goatherds, abattoir workers, butchers, and those who do artificial insemination are among these professionals.

Groups whose work involves the processing of hides, viscera, wool, and skins, as well as individuals involved in the servicing of buildings or machinery used for these purposes.

Another crucial category comprises laboratory workers who may come into contact with infected materials and *Brucella* cultures during diagnostic procedures or vaccine manufacture; the creation and administration of live vaccines also offer some danger.

7.4 Laboratory biosafety

One of the most common and simple laboratory illnesses is brucellosis. *Brucellae* are classified as a high-risk pathogen by the World Health Organization (WHO), placing them in risk group 3. Actually, one of the most common and simple laboratory illnesses is brucellosis.

Although *Brucellae* are rarely present in sufficient numbers to provide a substantial risk to people handling blood samples and biopsy material for either serological or bacteriological diagnosis, these specimens should nonetheless be treated with caution at biosafety level 2. When *Brucellae* have been cultured, however, they multiply to serious levels, necessitating special safety measures. It is also necessary to use biosafety level 3 equipment, methods, and practices [56].

7.5 Farm hygiene

The following are the main points in this context.

A. When working with animals, especially those suspected of having brucellosis, farmhands and animal caretakers should take precautions by wearing protective gear or using other forms of personal protective equipment (PPE).

B. Use an approved disinfectant, such as iodophor, hypochlorite, or phenolic disinfectant, at the prescribed working strength to thoroughly clean any location where an abortion or infected parturition took place.

C. After handling potentially hazardous materials, agricultural equipment should be disinfected by submerging it in a solution of diluted caustic soda, iodophor, or phenolic soap.

D. Liquid manure, which can remain infectious for long periods of time, especially at low temperatures requires special attention, including daily removal, burning, or disinfecting before disposal.

E. Disinfectants should be used in a shallow trough for vehicles entering or exiting contaminated facilities.

F. After cleaning and disinfecting a building that has previously housed animals infected with *Brucella*, the building should not be restocked for at least four weeks.

G. Buildings that have not been decontaminated should not have maintenance employees (such as builders, plumbers, or electricians) present.

H. Preventing rodent and insect entry to buildings should be a top priority for building maintenance.

I. Fly screens, light traps, and insecticides should be used to reduce the number of flying insects and keep rodent populations under control.

J. Making available the best possible living conditions in terms of things like clean water, clean air, and clean storage sheds.

7.6 Hygienic precautions among slaughterhouse

The term "slaughterhouse" or "abattoir" refers to a facility that has been licensed by the appropriate government agency to perform sanitary animal slaughtering and inspection, including pre and postmortem examinations, as well as processing, preservation, and storage of meat products for human consumption. Slaughterhouse operations necessitate the consideration of specific qualification programs, which provide the fundamental environment and operating conditions needed to produce safe meat and meat products. Good manufacturing practices (GMPs), good hygiene practices (GHPs), and standard operating procedures (SOPs) are all examples of such necessary programs (SOPs). Slaughterhouse personnel must adhere to the rules of the expert authority for how to deal with brucellosis to ensure that the postmortem inspection is conducted under proper conditions, and in particular that killed animals may be inspected accurately [57].

At the time of slaughter, *B. melitensis* and *B. abortus* infections in cattle, buffalo, camels, sheep, and goats and *Brucella suis* infection in pigs pose a serious health risk. During the bacteremic stage of the illness, *Brucella* is distributed throughout the body; however, the uterus, mammary glands, and testes may be particularly severely afflicted. Aborted or newly born animals may also have widespread exterior contamination.

Brucellosis-infected animals must be butchered in a separate area of the main slaughterhouse called the "emergency slaughterhouse," where the workforce has received specialized training and has access to specialized equipment [22]. Those are involved in the slaughtering process should dress in personal protective equipment (PPE).

In the workplace, no one should be allowed to eat, drink, or smoke. Required facilities for the disinfection of protective materials and personal washing should be available.

7.7 Precautions when animals under nomadic or migratory conditions

In arid or semiarid regions, livestock management becomes much more complicated when it is performed on a strictly nomadic basis. In these settings, it is difficult at best to practice the level of hygiene recommended to avoid spreading disease [58]. Brucellosis can have a significant impact on society, but it can be mitigated by public awareness campaigns that highlight the disease's key characteristics and its mode of transmission.

Most of the adult population in these areas will have had prior exposure to *Brucella* species infection and hence will have developed some level of immunity. Children are particularly vulnerable to the effects of the sickness and should be kept away from recently born or aborted animals. Raw milk, raw or undercooked meat, and raw or undercooked carcasses should also be avoided. Vaccination is sometimes the only effective intervention for these communities, yet effective vaccinations are currently unavailable.

7.8 Control of reemergence brucellosis

The World Health Organization/Food and Agriculture Organization/World Organization for Animal Health joint consultation on emerging zoonotic diseases, held in Geneva in 2004, defined an emerging zoonotic as "a pathogen that is newly

recognized or newly evolved, or that has occurred previously but shows an increase in incidence or expansion in geographical host or vector range" [59].

Brucellosis is a re-emerging zoonotic infection that transmits in all mentioned routes.

Brucellosis and other zoonotic diseases have emerged as a result of different causes, including global travel and commerce; climate change and weather; changing ecosystems; human demographics and behavior; poverty and social inequality; breakdown in public health measures; the industrialization of food production; globalization; microbial adaptation, in addition, to change in technology and industry; and economic development and land use [59].

Human brucellosis control relies heavily on animal brucellosis control. Effective veterinary and health control of animals (during trading, transport, and slaughter) and animal products (especially meat and meat products, milk and dairy products), education of the community, continuous state financial support, institutional cooperation, and regional cooperation are central to preventative measures.

7.9 Vaccines

Good vaccinations are essential to vaccination efforts. Over the past few decades, small ruminant and bovine brucellosis control programs have had resounding success because of the use of two live vaccines: *B. melitensis* Rev. 1 and *B. abortus* S19 [60]. *B. abortus* RB51 is suggested as a vaccine for bovine brucellosis to be applied in the last stages of protective programs in addition to tests and slaughter [61]. Vaccines can induce brucellosis in humans and can cause abortion in both the animals they are intended for and those that are not. Rifampicin is commonly used to treat human brucellosis, although RB51 is resistant to it. More effective vaccines that are also human and animal-effective are urgently required. New vaccines are being developed, and there are many ongoing efforts to increase the effectiveness and safety of the ones already on the market [62, 63]. The first novel brucellosis vaccine to be licensed will get a sizable prize, and there is now an international call for the creation of such a vaccine. (https://brucellosisvaccine.org/).

7.10 Public health aspects

From a public health perspective, the two most common ways people contract human brucellosis are through their diet or through unprotected, nonmedical contact with animals.

Public health must be focusing on the following aspects:

A. Public health agency collaboration: For these goals to be achieved, it is essential that public health organizations work closely with veterinary services and other relevant agencies.

B. Public health education: Humans are infected by *Brucella spp*. essentially by animal-origin food that is incorrectly prepared and/or preserved. There is a big gap in knowledge among the different sections of the community on the significance of food safety and foodborne diseases.

C. Involvement of local residents is crucial to the success of any health promotion or disease prevention initiative.

D. In order to effectively combat zoonotic and foodborne diseases, health educators should include school teachers in their training and incorporate them into disease prevention and control initiatives (FBDs).

8. Conclusion

One of the most significant and pervasive zoonotic diseases in the world is brucellosis. People who have contact with animals and consume animal products, especially dairy products, are at risk of contracting this illness. To develop effective preventative measures and control programs to enhance the milk production process in endemic regions, all possible risk factors must be thoroughly identified, and their individual and combined influence on milk production must be studied. Additionally, the disease must be managed properly, and both humans and animals should be screened for brucellosis using a combination of specific tests.

The management of brucellosis has been greatly aided by a "one health" plan that includes the extension of health education and the improvement of veterinary capabilities and services. As a result, we suggest control programs based on the principles of "one health" to significantly lower the incidence of brucellosis in dairy farms through national immunization, brucellosis testing, and prevention education, while enhancing public health capabilities and global partnerships across endemic regions.

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