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RESEARCH ARTICLE

BRUCELLOSIS: A COMPREHENSIVE REVIEW OF EPIDEMIOLOGY, PATHOGENESIS, DIAGNOSIS, TREATMENT, AND GLOBAL PREVALENCE

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Abstract

Brucellosis, a zoonotic disease caused by the genus Brucella, presents a significant public health concern globally, particularly in regions where animal husbandry is common. This narrative review aims to provide a comprehensive overview of the epidemiology of brucellosis, the different species of Brucella, diagnostic approaches, treatment options, and a synthesis of previous studies on its prevalence. Brucellosis affects both animals and humans, leading to economic losses in livestock and chronic health issues in humans. The review highlights the global distribution of the disease, the various Brucella species that infect different hosts, and the clinical and laboratory diagnostic methods used for detection. The treatment strategies, including the use of antibiotics, and the challenges of managing brucellosis in endemic areas are also discussed. In addition, the review consolidates findings from previous studies, particularly focusing on the prevalence of brucellosis in different geographic regions, identifying key risk factors, and suggesting areas for further research and control measures.

Keywords: Brucellosis; Epidemiology; Prevalence; Diagnosis.

Background:

An infectious zoonotic disease called brucellosis is brought on by bacteria belonging to the genus Brucella. It is a major public health concern in many parts of the world, particularly in developing countries [1]. The disease is commonly transmitted from animals to humans through consumption of contaminated animal products or direct contact with infected animals. Humans are normally exposed to Brucella spp. by consuming unpasteurized milk products or handling contaminated tissues such as aborted livestock placentas [2]. Those exposure pathways put raw milk–product consumers, livestock owners, abattoir workers, and veterinarians at high risk of acquiring the disease within endemic areas Brucellosis presents with non-specific symptoms such as fever, headache, muscle pain, and fatigue, making it challenging to diagnose without specific laboratory tests [3]. If left untreated, brucellosis can lead to debilitating chronic conditions and long-term health complications. Therefore, early detection and appropriate management are crucial for minimizing the impact of this disease on affected individuals and communities.

Brucellosis is the most prevalent zoonotic infection, with estimate of human brucellosis incidence and associated risk for persons worldwide, suggesting a reality that at least 1.6–2.1 million new cases of human brucellosis likely occur every [4]. The burden that the disease places specifically on low-income countries has led the World Health Organization (WHO) to classify it as one of the world's leading 'neglected zoonotic diseases [5].

Human brucellosis, was first recognized in Malta during the 1850s. It can affect people of all ages and sexes. Brucella species, which are members of the phylum proteobacteria's class alpha proteobacteria, are responsible for the infectious illness brucellosis. These are gram-negative facultative intracellular pleomorphic bacteria. There were number of synonyms for this infection: Malta fever, Mediterranean fever, Gibraltar fever, Cyprus fever and undulant fever, later referred as 'brucellosis'. It was first isolated by sir David Bruce in 1887 from a British soldier, who was dying of a Malta fever. In 1920, Mayer and Shaw discovered the genus 'brucella'[6, 7].

Human brucellosis, considered one of the most serious zoonotic diseases, is manifested in humans by an acute or sub-acute febrile illness usually marked by an intermittent or remittent fever accompanied by malaise, anorexia, and prostration. In the absence of specific treatment, the acute phase may progress to a chronic one with relapse, development of persistent localized infection, or a non-specific syndrome resembling the chronic fatigue syndrome [2, 8].

In animals brucellosis causes extensive economic losses due to serious disease , characterized by reproductive disorders including abortions, infertility, and retained placenta [9]

Brucellosis is a result of infection with the gram-negative, facultative, intracellular bacteria brucella spp. Animals primarily contract the disease through exposure to infected aborted material, ingestion of contaminated pastures or milk, and sexual transmission [10]. Humans acquire the infectious agent through consumption of unpasteurized dairy products, direct contact with infected animals, inhalation of contaminated aerosols, and rarely human-to-human transmission.

1.0 The Epidemiology of Brucellosis:

Brucellosis is endemic in many parts of the world, including Resource-limited regions such as the Mediterranean region, the Middle East, Central Asia and certain parts of Africa [4]. The prevalence of brucellosis varies widely between regions, with higher rates reported in countries with intensive animal farming and limited resources for disease control and prevention. Human brucellosis cases often correlate with the presence of infected livestock, including cattle, goats, sheep, and pigs. Additionally, occupational exposure, such as veterinarians, farmers, and slaughterhouse workers, is a significant risk factor for brucellosis transmission [11]. The burden of brucellosis is further exacerbated by factors such as poverty, inadequate sanitation, and limited access to healthcare services, particularly in rural communities [12]. Brucellosis is characterized by undulating fever, fatigue, joint pain, and other nonspecific symptoms [13].

Several species of Brucella can cause infection in humans, with *Brucella abortus* from cattle, *B. melitensis* from goats and sheep, and *B. suis* from pigs) being the most common [14]. Each species of Brucella has its distinct epidemiology, clinical manifestations, and geographical distribution. *B. melitensis* is considered the most pathogenic species in humans and is responsible for the majority of brucellosis cases worldwide [15]. However, *B. abortus* and *B. melitensis* also pose significant public health threats, especially in regions where these species are prevalent in livestock [16, 17].

Human exposure to Brucella spp. occurs primarily through the consumption of unpasteurized milk products and contact with infected organs, such as placentas from aborted pregnancies [18]. These two routes of exposure allow the infectious agents to enter the bloodstream and spread throughout the body by penetrating mucosal barriers.

There are several similarities between human and animal brucellosis. Both diseases show a tendency for the bacteria to persist in tissues of the mononuclear phagocyte system, including the spleen, liver, lymph nodes, and bone marrow [19]. Additionally, the skeletal system and male reproductive tract can be targeted by the bacteria in both humans and animals [20].

Brucellosis can manifest in different periods in three clinical forms, acute, sub-acute and chronic, around 50% of cases, symptoms persist for up to three months, leading to acute brucellosis [21]. However, chronic cases, lasting for more than six months, require prolonged chemotherapy treatment and can impose additional burdens on both the patient and the health care system [22].

2.0 Types of Brucella

The infection in humans is primarily caused by direct contact with infected cattle (B. *abortus*), sheep and goats (B. *melitensis*), pigs (B. *suis*), dogs (B. *canis*), desert rats (B. *neotomae*), or by ingesting unpasteurized and contaminated animal products. B. *melitensis* is the most common cause of reported human brucellosis cases and the most severe form of the disease [23]. Several species of Brucella infect human and mammals as shown in Table 1.

Table 1: The current known brucella species [24].

#	Species	Colony Phenotype	Preferential Host(s)/sour Ce	Human Pathogenicity
1	B. Melitensis	Smooth	Sheep, goat	High
2	B. Abortus	Smooth	Cattl	High
3	B. Suis	Smooth	pig wild. Boar, hare Reindeer, caribou Rodent	High Moderate High None
4	B. Ovis	Rough	Sheep	None
5	B. Neotomae	Smooth	Desert wood Ra	Moderate
6	B. Canis	Rough	Dog	Moderate

3.0 Diagnosis of Brucellosis:

The diagnosis of brucellosis can be challenging due to its non-specific clinical presentation and the variable sensitivity of available diagnostic tests [3]. Laboratory confirmation of brucellosis typically involves the detection of specific antibodies (e.g., agglutination tests, enzyme-linked immunosorbent assay) or the isolation of Brucella bacteria from clinical specimens (e.g., blood, bone marrow, or tissue samples) [25]. Molecular techniques, such as polymerase chain reaction (PCR), have also been increasingly used for the rapid and accurate detection of Brucella DNA in clinical samples [26]. However, the interpretation of diagnostic test results must consider the endemicity of brucellosis in the patient's geographical area and their exposure history to infected animals or animal products.

3.1 Clinical Manifestations:

Symptoms of brucellosis usually appear within five days and can appear after several months of infection. In the early stage, symptoms may include: malaise, lethargy, headache, muscle pain, fever, chills, severe headache and backache, nausea, vomiting, and diarrhea. As brucellosis progresses, it causes a severe fever [27].

Subclinical brucellosis is usually asymptomatic, lasting more than a week but less than a month, chronic brucellosis is typically made after symptoms have persisted for one year or more. Low-grade fevers and neuropsychiatric symptoms predominate [28].

The diagnosis of a patient with a possible case of brucellosis necessitates the integration of a number of techniques, including the medical history, clinical examination, routine hematological and biochemical laboratory tests, radiological investigation, and, most importantly, established and recently developed brucella-specific culture, serological, and molecular tests [29].

3.2 Laboratory Diagnosis of Brucella:

Brucellosis is a worldwide zoonotic infection caused by the Gram-negative bacterium Brucella. Rapid and accurate diagnosis of this disease is crucial for the effective management of the infection. Various diagnostic tests have been developed, including the Rose Bengal test, slide agglutination test, polymerase chain reaction (PCR), enzyme-linked immunosorbent assay (ELISA), and culture [30]. This literature review aims to explore the utility, sensitivity, specificity, advantages, and limitations of these diagnostic tests for brucellosis.

3.2.1 Bacterial Culture Techniques:

A culture is considered the “gold standard” for the laboratory diagnosis of brucellosis. As human brucellosis pathogenesis is always characterized by an initial bacteremic phase, peripheral blood cultures (bc) should always be performed as soon as brucellosis is suspected. This represents an important method to confirm the disease, although it shows a sensitivity ranging from 10 and 90%. However, drawbacks include the lengthy process for conclusive identification, which often takes two weeks [31]. Human brucellosis is diagnosed by isolation of Brucella spp, from blood culture and by serological tests that demonstrated the presence of specific antibodies in the serum of patients [32].

Solid media are necessary for direct isolation and culture, which prevents the growth of non-smooth mutants and excessive amounts of pollutants. For large samples or enrichment purposes, liquid media are advised.as a brucella medium basis, tryptose (or trypticase)-soy agar (tsa), a dehydrated basal medium, is marketed. Different basal media supplemented with 2–5%bovine or equine serum, with or without appropriate antibiotics to suppress the growth of contaminant organisms, may be used [33].

Because of the suboptimal recovery rate of brucellae from blood, it has been suggested that cultures of bone marrow[34], liver tissue or lymph nodes, may improve the recovery rate of the organism [20].

Brucellae are intracellular organisms and the serum of patients with brucellosis may have antibacterial activity, blood culture method is less sensitivity and more labor-intensive [35]Escamilla *et al.*, 1986),.however, several automated blood culture technologies has accelerated the diagnosis of human brucellosis [34].

In comparison to Farrell’s medium (fm) and modified Thayer martin (mtm), the modified Agrifood Research and Technology Center of Aragon (cita) medium (mcita) performed better for the selective isolation of Brucella spp. However, because Farrell’s medium for fungi to be inhibited during isolation, brucella spp. May be isolated using either mcita or fm [36]. When serological test results are still negative or indicate low or borderline

antibody titers in the early stages of the disease, the presence of brucella in blood cultures also makes it feasible to confirm the disease's existence [30].

3.2.2 Serological Tests:

Serological tests play a crucial role in the diagnosis of brucellosis. These tests detect the presence of antibodies produced by the immune system in response to Brucella infection [3]. Common serological tests include the Rose Bengal test, standard agglutination test, and enzyme-linked immunosorbent assay [25]. These tests are important for accurately diagnosing brucellosis, especially in regions where laboratory facilities for culturing the bacteria may be limited [37].

3.2.2.1 The Rose Bengal Test (RPT)

The Rose Bengal test is a rapid and simple serological test that is widely used for brucellosis screening. It detects the presence of specific antibodies, particularly IgM, in the patient's serum [38]. The test employs a suspension of killed Brucella antigens and a rose bengal dye. Positive samples display agglutination or clumping, indicating the presence of antibodies [30]. This test has good sensitivity. However, false-positive results can occur due to cross-reactivity with other microorganisms, such as Yersinia and Francisella, requiring confirmation with additional tests.

3.2.2.2 Slide Agglutination Test:

The slide agglutination test, also known as the standard tube agglutination test (STAT), is another widely used serological test for brucellosis diagnosis. It is based on the agglutination of Brucella antigens in the presence of patient serum containing specific antibodies [37]. Similar to the RBT, the STAT relies on the agglutination reaction between brucella antigens and patient serum. The slide agglutination test can be performed using standard tubes or plates, making it suitable for high-throughput screening. Despite its simplicity and low cost, the STAT may not be as sensitive as other serological tests, leading to the potential for false-negative results, particularly in the early stages of infection.

3.2.2.3 Enzyme-Linked Immunosorbent Assay (ELISA)

ELISA is a serological test widely used for diagnosing infectious diseases, including brucellosis. ELISA detects Brucella-specific antibodies from patient serum using a Brucella antigen-coated solid phase. ELISA is a highly sensitive and specific serological test used for the detection of Brucella-specific antibodies in patient serum. ELISA can detect both IgM and IgG antibodies, allowing for the differentiation between acute and chronic infections. It is less prone to cross-reactivity and can differentiate between acute and chronic infections. However, ELISA also allows high-throughput screening of samples. However, ELISA can show false-negative results during the early stages of infection.

3.2.3 Polymerase Chain Reaction (PCR)

PCR-based assays have revolutionized the diagnosis of infectious diseases, including brucellosis. PCR amplifies specific DNA sequences of Brucella, enabling highly sensitive and specific detection. PCR can be performed using various targets such as the bcsp31 gene, omp2, and IS711[37]. PCR-based assays have shown high specificity and sensitivity compared to serological tests. Additionally, PCR can differentiate between different species and biovars of Brucella, providing valuable information for epidemiological studies. However, PCR requires well-equipped laboratories, technical expertise, and can be time-consuming, limiting its use in resource-limited settings

3.3 Treatment:

Prompt and adequate treatment of human brucellosis continues to be the most important strategy in its management, as eradication of animal brucellosis is not possible so far, and there is no adequate vaccine for humans. The goal of anti-brucellar treatment is to alleviate and shorten the symptomatic period and reduce complications, relapses, and chronicity [39].

The management of brucellosis typically involves antimicrobial therapy. The first-line treatment includes the combination of doxycycline and rifampicin for 6 weeks. Alternative antibiotic choices may include fluoroquinolones, trimethoprim-sulfamethoxazole, and aminoglycosides [39]. However, the duration and choice of antibiotic therapy may vary based on the severity of the disease, complications, and individual patient factors [40]. Additionally, supportive care and management of symptoms such as fever, joint pain, and fatigue play a crucial role in the comprehensive treatment of brucellosis [41].

The gold standard treatment for adults is daily intramuscular injections of streptomycin 1 g for 14 days and oral doxycycline 100 mg twice daily for 45 days (concurrently). Gentamicin 5 mg/kg by intramuscular injection once daily for 7 days is an acceptable substitute when streptomycin is not available or contraindicated [39].

3.4 Risk Factors of Brucellosis:

Several risk factors contribute to the prevalence of brucellosis among febrile patients. Occupational exposure, such as working in veterinary clinics or slaughterhouses, is a significant risk factor. Consuming unpasteurized dairy products, contact with infected animals or their products, and living in rural areas with high livestock density are also associated with an increased risk of infection. Additionally, poor sanitation

practices and lack of awareness contribute to the dissemination of the disease.

Several risk factors are associated with the transmission and acquisition of brucellosis. These include occupational exposure to infected animals or animal products, consumption of unpasteurized dairy products, travel to endemic regions, and inadequate veterinary and public health measures, unhygienic dairy farms [42]. Additionally, individuals involved in the livestock industry, such as farmers, veterinarians, and abattoir workers, are at heightened risk of brucellosis [43]. Additionally, personal protective equipment (PPE) was also associated with the occurrence of brucellosis, which may be due to use of PPE after infection or improper use of PPE [44]. A very recent report shows that the incidence of brucellosis was higher in men who consumed relatively more of goat milk [45]. Understanding these risk factors is essential for the development of preventive strategies and targeted interventions to reduce the burden of brucellosis.

3.5 Previous Studies on Prevalence of Brucellosis:

Several studies have investigated the prevalence of brucellosis among febrile patients in different geographical regions. Studies such as these emphasize the need for continued surveillance and awareness programs to combat this infectious disease.

Numerous studies have investigated the prevalence of brucellosis among febrile patients in various geographic regions and populations. These studies have documented the varying prevalence rates of brucellosis, highlighting the significance of the disease in different settings. Factors such as geographical location, animal husbandry practices, and socioeconomic factors have been implicated in the prevalence of brucellosis. Furthermore, these studies have emphasized the importance of surveillance and monitoring programs to accurately assess the burden of brucellosis and guide public health interventions.

A cross-sectional sero-epidemiological study was conducted in Aseer Central Hospital, South Saudi Arabia, between 2014 and 2018 among 7567 febrile patients. The prevalence of brucellosis among the admitted suspected 7567 cases was 12.8%. A higher rate of brucellosis was observed among males than females ($p < 0.05$), and most cases were reported during the summer season ($p < 0.05$). The highest prevalence rate was observed in the age group 21–40 years (40.5%) followed by 41–60 years (27.7%). The lowest prevalence rate was noticed in old and young children (15% and 3%, respectively). Cross-transmission of brucellosis was seen within the family (1%), and high titers (> 1280) were noticed in 22% of the hospitalized patients. The major symptoms were fatigue, hyperhidrosis, fever, and joint pain [46].

A cross-sectional study was conducted at Rushere community hospital, in south western Uganda, among 480 febrile patients. The prevalence of brucellosis was 14.9%. The factors independently associated with brucellosis were consumption of raw milk, history of brucellosis in the family, and selling hides and skins [47].

Another study was conducted at Endulen Hospital in the Ngorongoro Conservation Area, northern Tanzania, among 230 febrile patients. The prevalence of the study was 3.9%. Risk factors identified for brucellosis included age and herding, with a greater probability of brucellosis in individuals with lower age and who herded cattle, sheep or goats in the previous 12 months. greater probability of brucellosis in male participants [48].

The prevalence of brucellosis among 446 febrile patients in Pakistan was 10.1% by the RBPT. Contact with infected animals, consumption of raw milk, and socioeconomic status showed a highly significant ($p < 0.05$) correlation with seropositivity. Elderly patients and females were at high risk of brucellosis [49].

The prevalence of brucellosis was 12.3% among 325 participants seeking care and reporting fever at Rizgary Teaching Hospital, in Iraq. The majority of cases were in the age group of 18-39 years. Brucellosis was significantly associated with raw milk consumption and contact with livestock [50].

Another cross-sectional study was conducted in West Darfur State, Sudan. The results showed 55 (36.6%) samples positive by RBT; 67 (44.6%) samples positive by SAT, and 72 (48%) positive by ELISA for the presence of antibodies against Brucella, whereas molecular testing (73.3%) samples were positive by PCR [51].

Another study was conducted in Jazan Region, Saudi Arabia, among Malaria Negative Febrile Participants. The overall occurrence of brucellosis detected by real-time PCR among 120 Participants was 10%. Significant findings with p value < 0.05 were detected among shepherd occupation (40%), compared with other occupational groups, 83% were male compared with female, and within the age range of 46 to 55 years old. No significant differences were detected between raw milk drinkers and direct animal contact participants [52].

In a cross-sectional study conducted in Egypt, 4490 patients with acute febrile illness were evaluated in 2002 and 2003. Of these, 321 patients (7.2%) met the case definition for brucellosis. In 2002, 135 patients were diagnosed with laboratory-confirmed brucellosis, resulting in an estimated incidence of 64 per 100,000. In 2003, 186 patients were diagnosed with laboratory-confirmed brucellosis, resulting in an estimated incidence of 70 per 100,000. Out of the 321 patients with laboratory-confirmed brucellosis, 115 (36%) were

diagnosed by culture and 206 (64%) were diagnosed by serology only [53].

A cross-sectional study in Yemen using the serum agglutination test (SAT), it examined 1405 samples of human serum and found 0.4% of them to be positive This study found prevalence in three separate localities: Sana'a (0.7%), Taiz (0.8%), and Hajja (0.35%). STA was used to analyze 385 samples of human serum from Yemeni slaughterhouse employees, who showed a 27% frequency of Brucella antibodies. In Sana'a, Aden, Taiz, AL- AL-Hodeidah, Ibb, and Hajjah, respectively, the positive rates were 32.3%, 25.5%, 25.7%, 26.2%, and 22.2% [54].

A cross-sectional study was conducted among 749 asymptomatic individuals in Al-Dala'a governorate to assess the seroprevalence of brucellosis and to examine risk factors for human brucellosis. The prevalence was 6.7%. High significant risk of contracting brucellosis was found to be associated with ownership of livestock animals and with direct contact with animals' excrement or products, animal slaughter, and indirect contact with livestock [55].

Effective assistance factors for patients with brucellosis encompass various aspects, including healthcare accessibility, early diagnosis, appropriate treatment, and follow-up care. Access to healthcare facilities with trained personnel for diagnosis and management of brucellosis is essential. Additionally, educational programs to enhance public awareness regarding the disease, its symptoms, mode of transmission, and preventive measures can contribute significantly to reducing the prevalence of brucellosis. Moreover, establishing public health policies that prioritize early detection, treatment, and monitoring of brucellosis cases can improve patient outcomes and limit the spread of the disease.

In conclusion, the prevalence of brucellosis among febrile patients is influenced by various factors. Serology tests are pivotal in diagnosing brucellosis, while appropriate antimicrobial therapy is necessary for effective treatment. Risk factors associated with brucellosis transmission need to be addressed through improved sanitation practices and public health awareness. Previous studies have shed light on the brucellosis burden in different regions, emphasizing the necessity for ongoing surveillance. Continued research into diagnostic methods and tools can enhance early detection and control efforts. Furthermore, ensuring access to healthcare facilities and implementing assistance factors for patients can improve overall outcomes in brucellosis management.

Human brucellosis has a wide distribution in Yemen, but the prevalence of the disease is unclear due to the limited number of epidemiology studies on the prevalence of brucellosis in the general human population. In 2000, the study was conducted to test 385 human serum samples from slaughterhouse workers in different areas in Yemen, who reported high prevalence of brucella antibodies was 27%. 32.3%, 25.5%, 25.7%, 26.2%, and 22.2% positive in Sana’a, Aden, Taiz, Al- Al-Hodeidah, Ibb, and Hajjah, respectively [54].

A cross-sectional study was conducted in two health institutions; Al-Jumhouri Hospital and Al-Thawra Hospital, in Sana'a, Yemen between January 2021 to January 2022 among 241 pyrexia of unknown origin cases patients, the risk factors for brucellosis among the PUO patients was handling of animals during parturition, the prevalence rate of brucellosis was 29.1%, B. *abortus* positive rate was 17%, and B. *melitensis* positive rate was 2.9% and mixed of both. There was no significant association between residency, occupations, and education with contracting brucellosis among PUO patients [56].

Conclusion:

Brucellosis remains a critical public health issue in many regions of the world, primarily due to its zoonotic nature and the challenges in controlling transmission between animals and humans. This review underscores the importance of accurate and early diagnosis, effective treatment regimens, and public health measures aimed at controlling animal reservoirs. The variability in prevalence across different regions, as revealed by numerous studies, highlights the need for localized control efforts and better awareness of the disease. Continued research into improved diagnostic tools, vaccine development, and strategies to reduce animal-human transmission is essential for effective management and eventual eradication of brucellosis in endemic areas.

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مقالة بحثية

داء البروسيلا: مراجعة شاملة للوباء، آليات الإمراضية، التشخيص، العلاج، والانتشار العالمي

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المُلخّص

يُعد داء البروسيلا (بكتيريا البروسيلا) مرضًا حيوانيًّ المصدر يحتلُّ أهمية كبيرة للصحة العامة عالميًا، لاسيما في المناطق التي تنتشر فيها تربية الماشية. تهدف هذه المراجعة السردية إلى تقديم عرضٍ شاملٍ عن وبائيات داء البروسيلا، وأنواع بكتيريا البروسيلا المختلفة، وطرق التشخيص السريرية والمختبرية، وخيارات العلاج المتاحة، بالإضافة إلى جمع نتائج الدراسات السابقة حول مدى انتشاره. يُصيب الداء حيوانات المزرعة والإنسان على حدٍّ سواء؛ مما يسبب خسائرَ اقتصاديةً فادحةً في الثروة الحيوانية ومشكلات صحية مزمنة لدى المصابين. تستعرض هذه المراجعة التوزيع الجغرافي للمرض حول العالم، والأنواع الرئيسية لبكتيريا البروسيلا التي تُؤدي إلى الإصابة في مضيفات مختلفة، وكذلك الوسائل التشخيصية المستخدمة لاكتشاف المرض. كما تُناقش استراتيجيات العلاج بالمضادات الحيوية والتحديات التي تواجه السيطرة على المرض في المناطق الموبوءة. علاوةً على ذلك، تُلخّص المراجعة نتائج الأبحاث السابقة مع التركيز على معدلات انتشار داء البروسيلا في مناطق جغرافية متنوعة، وتُبيّن عوامل الخطر الرئيسة، وتقترح اتجاهات للأبحاث المستقبلية والإجراءات الوقائية الفعّالة.

الكلمات المفتاحية: داء البروسيلا؛ الوبائيات؛ الانتشار؛ التشخيص.

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