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Mini-Review

Brucellosis in Iraq: A comprehensive overview of public health and agricultural challenges

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Abstract

Brucellosis is a significant zoonotic disease that poses serious health and economic challenges, particularly in areas where humans and animals interact closely. This review provides an overview of the epidemiology of brucellosis, the host species it affects, and the diagnostic methods used in various regions of Iraq. Data from 36 reports from 1979 to 2023 reveal a total of 5,663 human cases, with a prevalence of 36.28%, and 12,227 animal cases, with a prevalence of 10.97%. Analysis shows that human cases are more prevalent among females (37.94%) compared to males (20.85%). The highest prevalence was found in animals, such as stray dogs (39.25%) and buffaloes (13.79%). These findings emphasize the need for enhanced diagnostic and control measures, particularly in high-risk groups and regions. The primary diagnostic methods include the Rose Bengal Test (RBT), which is further confirmed by ELISA and PCR. Identifying *Brucella melitensis* and *Brucella abortus* highlights the necessity for targeted interventions to control brucellosis transmission.

Keywords: *Brucella*, Brucellosis, Epidemiology, Diagnosis, Iraq

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Introduction

Brucellosis, a globally distributed infectious zoonotic ailment, impacts the health of both humans and animals (Addis, 2015; Glowacka et al., 2018) and is caused by the genus *Brucella* (*B.*), a non-motile, non-spore-forming, slow-growing Gram-negative organism (Scholz et al., 2016). Brucellosis is commonly referred to as Mediterranean fever, undulant fever, remitting fever, and Malta fever (Addis, 2015). Over 500,000 new cases of brucellosis are reported globally each year, with approximately 10 cases per 100,000 inhabitants (Seleem et al., 2010). However, this statistic may underestimate the true epidemiological scope, with estimates suggesting 5,000,000 to 12,500,000 cases per year (Akya et al., 2020; Habtamu et al., 2013). Twelve species of *Brucella*, exhibiting preferences for various hosts, have been identified (Sabrina et al., 2018). Most human brucellosis cases are linked to *B. melitensis*, *B. abortus*, *B. suis*, and *B. canis* (Pereira et al., 2020). These have been isolated from ungulates, particularly livestock, as the primary source of human infection (Tuon et al., 2017). Specifically, *B. suis* infects pigs, *B. melitensis* infects sheep and goats, *B. abortus* infects cattle, and *B. canis* infects dogs (Bukhari, 2018).

Brucella represents a highly infectious bacterium, with as few as 10–100 cells adequate to induce systemic infection (Al-Mashhadany, 2019; Geresu and Kassa, 2016). Brucellosis inflicts significant losses in domestic animal populations, mainly sheep, goats, and cows, primarily due to abortions occurring commonly in the final trimester of pregnancy, alongside occurrences of stillbirths, weak offspring, and infertility in males, the condition manifests primarily as epididymitis and orchitis, while in females, placentitis during pregnancy leads to the excretion of organisms in milk and uterine discharges (Al-Mashhadany, 2019). This disease constitutes a primary zoonotic concern, capable of causing reproductive disorders in animals with substantial economic and public health ramifications. The disease exhibits a wide distribution across numerous countries, with high endemicity in various regions, resulting in severe economic repercussions in dairy livestock and debilitating human effects (Castillo-Olivares and Wood, 2004). Direct and indirect contact with infected domesticated animals or consuming contaminated dairy products is the primary transmission mode (Tuon et al., 2017). Virulent *Brucella* strains, such as *B. melitensis*, can infect phagocytic and non-phagocytic cells, exploiting the intracellular environment for extensive replication and facilitating bacterial proliferation and subsequent transmission to new host cells (Głowacka et al., 2018).

Human brucellosis presents with diverse clinical manifestations, with nonspecific fever, headache, and muscle and joint pain being the most common symptoms (Dean et al., 2012). A minority of patients experience chronic brucellosis, characterized by persistent symptoms lasting over a year. *Brucella* spp. can affect multiple organs, leading to severe complications such as cardiovascular issues (Lagadinou et al., 2019), neurological complications (Shah et al., 2018), and osteomyelitis (Esmaeilnejad-Ganji and Esmaeilnejad-Ganji, 2019). In untreated or severe cases, mortality can occur (Dean et al., 2012). Brucellosis presents a persistent challenge in regions globally, notably Middle Eastern countries such as Iraq. The country has grappled with brucellosis since its initial isolation in 1937 (Al-Bayaa, 2017; Salih, 2010; Shareef, 2006). In Iraq, the small ruminant sector, comprising sheep and goats, plays a crucial role in upholding the nation's food security. Currently, Iraq is home to an estimated 7–8 million sheep and 1.5–2.0 million goats, serving as a significant source of meat and milk production while also providing livelihoods and stability to those engaged in agriculture (Bechtol et al., 2011). However, the sector faces a considerable challenge due to the prevalence of various endemic animal diseases, with *B. melitensis* remaining a persistent threat to both animal productivity and public health (FAO, 2010; Jabary and Al-Samarraee, 2015). Several factors contribute to the spread and persistence of *Brucella* among animals, including variations in a flock or herd size, animal density, and inter-flock livestock contact (Jabary and Al-Samarraee, 2015; Turgay and Ahmed, 2016).

The incidence of *B. melitensis* infections in humans in Iraq has been estimated to range from 52.3 cases per 100,000 person-years in rural areas to 268.8 cases per 100,000 person-years in semi-rural regions (Yacoub et al., 2006). Diagnosis of brucellosis cannot rely solely on symptoms; detecting *Brucella* spp. in blood or bone marrow is considered the gold standard (Almashhadany, 2014). The Rose Bengal Test (RBT) serves as a screening tool for brucellosis and is widely employed in Iraq for disease detection. This test demonstrates good sensitivity and specificity and is cost-effective and practical (Di Bonaventura et al., 2021; Ruiz-Mesa et al., 2005). However, the lack of active surveillance contributes to a lack of accurate data on human brucellosis in many countries, particularly in developing nations like Iraq (Mantur et al., 2007). Thus, this review aims to provide a glance at the epidemiology situation of brucellosis, the host species affected, and the diagnostic methods used in various regions of Iraq.

Materials and methods

Search strategy

An initial literature search was conducted online using the search terms "*Brucella* in Iraq," "Brucellosis in Iraq," and "Malta Fever in Iraq" on PubMed and Google Scholar. The criteria for the literature search focused on titles, abstracts, and metadata. Only articles published in English that addressed the diagnosis of brucellosis in humans and animals in Iraq were included. All articles related to serology, isolation, identification of brucellosis, or epidemiological studies were considered. However, duplicates, conference abstracts and proceedings, reviews, experimental studies, articles on unrelated topics, and case reports not conducted in Iraq were excluded from the search. Only peer-reviewed original articles published between 1979 and 2023 were selected for analysis (Figure 1).

Data acquisition and analysis

A total of 7,117 records were reviewed from PubMed and Google Scholar to ensure relevance, originality, and completeness. Of these, 7,070 articles were identified on Google Scholar, while 47 were published on PubMed. Out of all the reviewed articles, 36 met the screening criteria:

15 focused on humans, 20 on animals, and one on both humans and animals. Among these, 24 were from Google Scholar and 12 from PubMed. These articles were deemed suitable for inclusion in this review (see Figure 1). Only full-length, peer-reviewed journal research articles were considered. Data regarding geographical areas, host species, and reported seroprevalence were extracted, analyzed, and presented in Table 1.

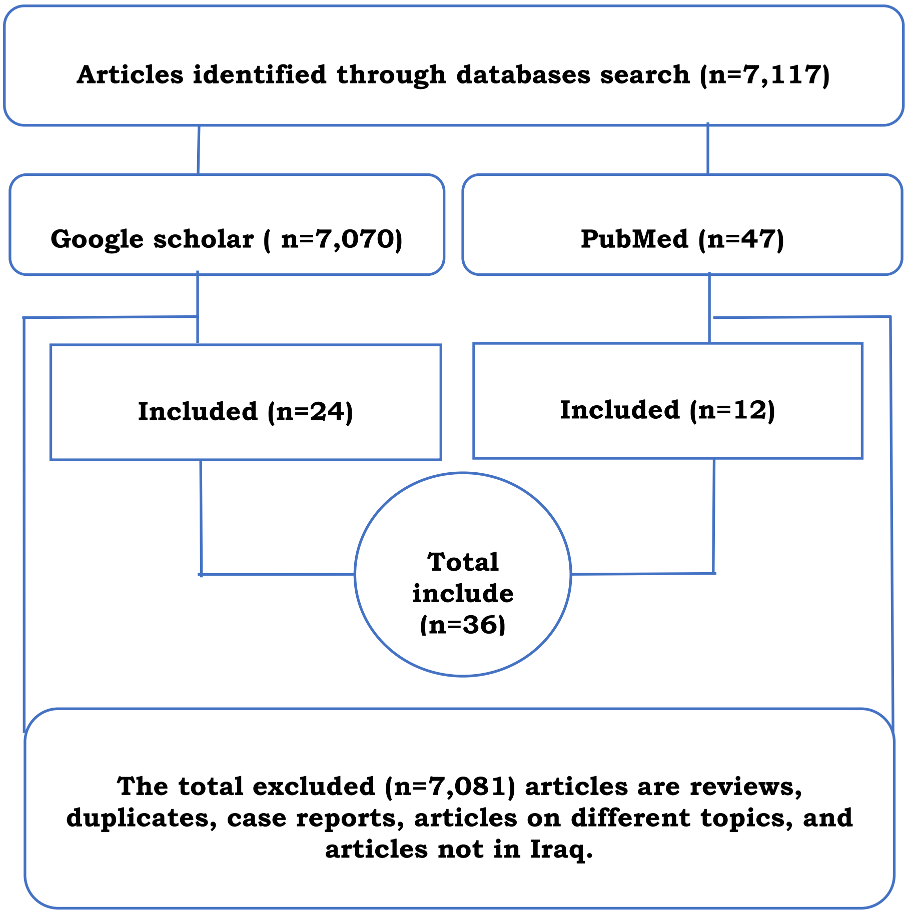

Figure 1: This diagram shows articles found, excluded, and included in this study review.

Results and discussion

Data analysis

The dataset encompasses 36 instances of brucellosis occurrences across various regions of Iraq, including reports from Baghdad (n=4), Basrah (n=3), Duhok (n=6), Kurdistan region (n=2), Mosul (n=3), Kirkuk (n=1), Sulaymaniyah (n=1), Erbil (n=3), Babil (n=3), Anbar (n=1), Wasit (n=2), Salah al-Din (n=1), and Diyala (n=1). Additionally, one report combines data from Erbil, Basra, Mosul, and Salah al-Din, while another covers Baghdad, Wasit, Babil, Karbala, Najaf, Qadisiyah, Muthanna, Basra, and Maysan. A further report includes Karbala and Babil, while another combines Wasit, Dhi Qar, and Qadisiyah. These reports focus on human, animal, and milk product cases of brucellosis, covering both female and male humans and animals, including goats, sheep, cows, buffaloes, stray and herding dogs, and rams and animal products such as cheese. In total, the dataset includes 5,663 human cases (2,672 females, 2,234 males, and 757 unspecified human cases) and 12,227 animal cases, comprising 9,692 goats and sheep, 610 cattle, 1,247 buffaloes, 135 stray dogs, 243 herder dogs, and 250 rams. Additionally, 50 cheese samples were analyzed (Table 1).

Various laboratory techniques were employed across the studies, including the Rose Bengal test, enzyme-linked Immunosorbent assay, polymerase chain reaction, serum agglutination test, blood culture, turnaround time, indirect fluorescent antibody test, 2-mercaptoethanol test, and Brewer's card agglutination test. Most reports utilized the RBT to detect anti-*Brucella* antibodies in human and animal specimens. Approximately half of the isolation reports identified brucellosis at the genus level only, while the other half identified or typed the species, detecting *B. melitensis* and *B. abortus* in samples from both humans and animals using biochemical tests and PCR. All information from old to recent publications has been arranged in the tables chronically (Table 2,3).

Table 1: Prevalence of brucellosis in human and animal populations, showing testing results in human and animal populations, indicating the number of tested positive cases and the prevalence rates.

Host	No. tested	Positive	Prevalence %
Human	**5663**	**2055**	**36.28**
Male	2234	466	20.85
Female	2672	1014	37.94
Unspecified	757	575	75.95
Animal	**12227**	**1342**	**10.97**
Goats and sheep	9692	995	10.26
Cattles	610	83	13.60
Buffaloes	1247	172	13.79
Stray dogs	135	53	39.25
Herder dogs	243	31	12.75
Rams	250	2	0.80
Cheese (Unspecified)	50	6	12

Note: Unspecified means human without specifying the number of each male and female. Unspecified cheese refers to cases where the study mentioned cheese without specifying the animal source.

Brucellosis in humans

Fifteen reports on human brucellosis from various regions across Iraq have been found (Table 2). These included two studies from Baghdad, two from Mosul, two from Babil, and one each from Duhok, Wasit, Erbil, Sulaymaniyah, Anbar, Basra, and Salah al-Din. Additionally, one study covered multiple provinces (Baghdad, Wasit, Babil, Karbala, Najaf, Qadisiyah, Maysan, Muthanna, and Basrah), and another focused on the Kurdistan region. Two studies, one conducted in Baghdad (AL-Rawi et al., 1987) and one conducted in Basrah in 2006 (Yacoub et al., 2006), indicated a high prevalence of *Brucella* infection between young ages with no significant gender differences. Also, they revealed that raw milk consumption or milk products and animal contact are substantial risk factors for brucellosis transmission, highlighting the importance of public health interventions targeting these practices and the importance of food safety measures in preventing brucellosis. Studies in Wasit province (Alqaseer et al., 2023) and a study conducted in Erbil (Almashhadany et al., 2022) further supported the association between raw milk consumption, livestock contact, and *Brucella* infection.

Identifying specific *Brucella* species implicated in human cases provides valuable insights for targeted control and prevention strategies and emphasizes the need for heightened awareness among healthcare providers. Another study in Baghdad by (Al-Rawi et al., 1989), which focused on arthritis patients, demonstrated a significant prevalence of *Brucella* infection among male and female participants. This finding underscores the importance of considering brucellosis in the differential diagnosis of arthritis cases, particularly in regions where the disease is endemic. A study conducted in Mosul revealed a high prevalence of *Brucella* infection among patients, with various diagnostic tests confirming the presence of the pathogen (Dabdoob and Abdulla, 2000).

In Duhok province, a study conducted by (Khalid, 2023) found a notable prevalence of *Brucella* infection among individuals presenting with fever. The study highlighted the higher susceptibility of females and individuals aged between 20 and 40 years, suggesting demographic factors may influence disease transmission and susceptibility. A study in Babylon province conducted by (AL-Khafaji, 2003) found lower brucellosis detection rates by culture compared to serology. The disease was primarily associated with unpasteurized milk from local livestock, affecting children under five, adults aged 26-35, and women more frequently. Rural areas showed higher incidence, with cases peaking in summer alongside increased milk production. The study recommends regular animal testing, milk pasteurization, proper meat cooking, and health education. Studies conducted in Anbar by (Al-Koubaisy and Lafi, 2011), in the Kurdistan region (Al-Bayaa, 2017), and in Salah Eldin by (Hamid et al., 2020) show most cases of *Brucella* infection were among patients from rural areas and brucellosis incidence varied seasonally, peaking in milk seasons and most of the cases were young patients between the age of 15-45 years. The findings suggest most patients had contact with infected livestock. A study conducted in Sulimania province (Aziz, 2022) shows that the rate of positive cases verified by the Rose Bengal test was lower than positive cases verified by ELISA; all control samples tested were negative. In another study conducted in Babil province (Razzaq et al., 2014), RBT showed 100% positive. At the same time, the PCR was positive in only eight blood samples out of the 155 patients with brucellosis. At the same time, it was negative in all the control groups, and isolates belonged to *B. abortus* and *B. melitensis* spp. In a study across several Iraqi provinces (Baghdad, Wasit, Babil, Karbala, Najaf, Qadisiyah, Maysan, Muthanna, and Basrah), 150 serum samples were examined: 64% were RBT positive, and 36% were negative. ELISA assays on positive samples showed 39.5% positive, 44.8% negative, and 15.62% suspected results. PCR identified isolates as *Brucella abortus* and *Brucella melitensis*. Biochemical tests confirmed *B. abortus* biovars (1, 3, 4, 5, 6, and 9) and *B. melitensis* (bv2), consistent with AMOS-ERY test findings (Al-Mossawy et al., 2019).

Brucellosis in animals

Brucellosis presents a significant public health and economic burden in Iraq (Khalid, 2023). Multiple studies have indicated its endemicity and widespread distribution across various regions. This study reviewed 21 reports on animal brucellosis across various regions of Iraq (Table 3). For instance, a study by (Al Hamada et al., 2021) on pregnant small ruminants reported a significant increase in *Brucella* seroprevalence over time. The findings linked *Brucella* seroconversion to adverse reproductive outcomes, highlighting the ongoing negative impact of brucellosis on reproductive performance in small ruminants and its implications for regional food security. Similarly, studies by (Alhamada et al., 2017) and (Ameen et al., 2023) in Duhok province found a high prevalence of *Brucella* antibodies in animals, especially older ones, highlighting age as a key risk factor.

The research on aborted sheep and goats revealed significant brucellosis prevalence, underscoring the importance of timely detection and management to safeguard animal health and productivity. Expanding the scope beyond the Duhok province, (Karim et al., 1979) found varying brucellosis rates in sheep and goats across northern Iraq, emphasizing the need for localized control measures. Furthermore, the study conducted by (Al-Rahman et al., 2022) in Basra province explored the potential zoonotic implications of brucellosis, examining its association with abortions in both humans and cows. A study in Wasit province on 135 stray dogs from rural areas reported infection rates of 28.89% by the Rose Bengal test and 39.26% by ELISA. The study pioneered the detection of IgG antibodies against *B. abortus* in Iraqi stray dogs using the Rose Bengal and indirect competitive ELISA tests, with the latter considered the gold standard (Ali, 2017). A study in Babylon and Kerbala provinces compared the efficacy of the Rose Bengal test (RBT), milk ring test (MRT), and PCR for detecting brucellosis in 141 cattle and buffaloes. RBT gave the highest positive results (42 in cattle, 33 in buffaloes), while PCR showed fewer positives and identified *B. abortus* isolates. MRT and culture showed no significant differences between cattle and buffaloes. The study concluded that RBT, MRT, and culture are useful for routine screening, but PCR is recommended for confirmatory diagnosis in individual animals (AL-Shemmari, 2018).

The study conducted in Ninawa aimed to detect anti-*brucella* antibodies in lambs and goat kids using the Rose Bengal and indirect ELISA tests. The results showed poor agreement between the two tests. The study concluded that indirect ELISA is a more reliable screening and diagnostic method for detecting anti-*brucella* antibodies in lambs and kids than Rose Bengal (Hassain et al., 2010). A study by (Al-Mossawy et al., 2019) analyzed 150 blood samples from suspected brucellosis patients. After serum testing with RBT and ELISA, positive samples were cultured on *Brucella* agar. Biotyping was conducted using conventional methods (e.g., CO_2 requirement, urease) and non-conventional AMOS-ERY PCR. Results showed 96 RBT-positive cases, with ELISA confirming 38 and leaving 43 undetermined. Biotyping identified *Brucella abortus* (biovars 1, 3, 4, 5, 6, and 9) and *B. melitensis* biovar 2. Molecular diagnostics proved effective for identifying *Brucella* biovars.

A study in the Kurdistan region analyzed 1,050 animal samples, revealing an overall brucellosis seroprevalence of 6.2% (95%; CI 4.8%–7.8%). The seroprevalence in sheep (7.4%; 95% CI 5.5%–9.6%) was significantly higher than in goats (3.9%; 95% CI 2.2%–6.5%), with an odds ratio of 1.94 (95% CI 1.1–3.6) (Alshwany and Robertson, 2018). In Mosul, Iraq, 250 blood samples were collected from rams with epididymal-orchitis at 42 commercial farms. Using indirect ELISA, more *Brucella* ovis-negative than positive samples were identified. Among seropositive rams, palpation revealed lesions primarily in the epididymis (66.7%) and testicles (33.3%), with 83.3% of cases being unilateral and 16.7% bilateral (Al-Farwachi et al., 2019).

In Wasit province, a study diagnosed *Brucella* canis infection in dogs using serological tests (Rapid test and indirect ELISA) and confirmed infection in seropositive dogs through molecular PCR analysis. All dogs positive in the Rapid test were also positive in iELISA. Statistical analysis showed significant differences across diagnostic methods and indicated that females had higher infection rates than males. Infection rates were similar in younger age groups but notably higher in older dogs (Alfattli, 2016). A study in Diyala, Iraq, investigated the prevalence of *Brucella* spp. in locally produced cheese made from unpasteurized milk. Fifty samples were collected from Baquba street shops and analyzed using conventional culture methods. *Brucella* spp. was detected in 12% of samples, with *B. melitensis* at 8% and *B. abortus* at 4%, indicating contamination of fresh cheese with these species (Fadihl and Khalil, 2016).

In Basrah, Iraq, 420 raw milk samples from cows, buffaloes, and sheep were tested for *Brucella* antibodies using the MRT, with 24.2% testing positive. Enrichment broth culture identified 62 *Brucella* isolates: *Brucella abortus* (biotypes 2, 3, 4, 6), *B. melitensis* (biotypes 2, 3), and *B. ovis*. Sheep milk showed the highest incidence, followed by buffalo milk. The prevalence was highest in spring and summer, with lower rates in colder months. All isolates grew within 18–44°C and pH 4–9, and antibiotic sensitivity tests were performed (Abbas and Aldeewan, 2009). Studies assessed brucellosis in Basra and Erbil showed higher infection rates in older and pregnant animals, primarily due to *Brucella abortus* and *Brucella melitensis*. Infection rates peaked in autumn. The MRT was recommended for rapid milk screening, and milk pasteurization was advised to prevent transmission (Almashhadany, 2021; Almashhadany, 2021). The study on 100 sheep near Baghdad found brucellosis in 55% of cases by RBT and 12% by ELISA, while ELISA detected chlamydiosis in 21% and mixed infections in 5%. Due to limitations in distinguishing recent from past infections, they recommend confirming serological results with bacteriology or PCR for accurate diagnosis (Salman et al., 2018). Two studies in Duhok, northern Iraq, assessed brucellosis prevalence in livestock. The first study (Ilyas and Karakuş, 2019) tested 600 samples using ELISA and found a 7.3% prevalence. The second study by (Omar et al., 2011), which tested 360 samples, found a 6.38% infection rate by RBT and 0.83% by ELISA. These findings highlight low but present rates of brucellosis, with some variation between testing methods. The study measured the seroprevalence of ovine brucellosis in Baghdad using RBT and ELISA on 300 sheep samples. RBT showed a 42.33% prevalence, with higher rates in ewes (45.18%) and sheep aged 1-3 years (44%). ELISA detected a 32.66% prevalence. The findings indicate a high prevalence of brucellosis in Baghdad (Salman and Mosa, 2015).

Table 2: Literature on human brucellosis in Iraq arranged chronically according to a year of the report.

	Provinces	Host	No. Tested	Test types	No. positive	Prevalence %	Identification	References
1	Baghdad	Humans	58	RBT and SAT	58	100	*Brucella* spp.	Al-Rawi et al. (1987)
2	Baghdad	Humans	17	RBT	17	100	*Brucella* spp.	Al-Rawi et al. (1989)
3	Mosul	Humans	200	RBT, TAT and IFAT	200, 44 of 48 and 159	100, 91.6 and 79.5	*B. melitensis* and *B. abortus*	Dabdoob and Abdulla (2000)
4	Babylon	Humans	369	BAT and Blood culture	369 and 253	100 and 68.56	*B. melitensis* and *B. abortus*	AL-Khafaji et al. (2003)
5	Basra	Humans	1339	RBT	214	15.98	*Brucella* spp.	Yacoub et al. (2006)
6	Mosul	Humans	80	SAT, BAT, 2-ME	80	100	*Brucella* spp.	Al Dabbagh and Rasool (2009)
7	Anbar	Humans	104	RBT, 2-ME, TAT, blood culture, biochemical test, and Gram stain	104	100	*Brucella* spp.	Al-Koubaisy (2011)
8	Babil	humans	340	RBT and PCR	340 and 8/155	100	*B. melitensis* and *B. abortus*	Razzaq (2014)
9	Kurdistan region	Humans	1825	RBT	1825	100	*Brucella* spp.	Al-Bayaa (2017)
10	Baghdad, Wasit, Babil, Karbala, Al Najaf, Qadisiyah, Maysan, Mutanah and Basrah	Humans	150	RBT, ELISA, and PCR	96 and 43/96 and PCR for identification	64 and 44.8/64	*B. melitensis* and *B. abortus*	Al-Mossawy et al. (2019) Al-Rahman et al. (2022)
11	Basra	Human	44	RBT and PCR	6 and 2	13.1 and 5	*B. abortus*	Hamid et al. (2020)
12	Salah Al-din	Humans	130	RBT and Rapid test	130	100%	*Brucella* spp.	Aziz (2022)
13	Sulaimania	Humans	67	RBT and ELISA	14 and 39	20.89 and 58.20	*Brucella* spp.	Almashhadany et al. (2022)
14	Erbil	Humans	325	RBT and Blood culture	40 and 30	12.3 and 9.5	*B. melitensis* and *B. abortus*	Khalid (2023)
15	Duhok	Humans	339	RBT and Blood culture	43 and 34	12.68 and 10.3	*B. melitensis* and *B. abortus*	Alqaseer et al. (2023)
16	Wasit	Humans	276	ELISA and PCR	83	30.7	*B. melitensis and B. abortus*	Al-Rawi et al. (1987)

RBT: Rose Bengal test; ELISA: Enzyme-linked Immunosorbent Assay; PCR: polymerase chain reaction; IFAT: indirect fluorescent antibody test; SAT: standard tube agglutination test; TAT: tube agglutination test.

Table 3: Literature on animal brucellosis in Iraq arranged chronically according to a year of the report.

	Provinces	Host	No. Tested	Test types	No. positive	Prevalence %	Identification	References
1	Mosul, Duhok, Kirkuk, Erbil, Sulaimania	Goats and sheep	5524	Brewer's card agglutination test 163 and SAT, in some cases	163	2.95	*Brucella* spp.	Karim et al. (1979)
2	Basra	Cows, Buffaloes and sheep	420	milk ring test	102	24.20	*B. melitensis, B. abortus* and *B. ovis*	Abbas and Aldeewan (2009)
3	Nainavah	Lambs and goats, kids	135	RBT and ELISA	0 and 35	0 and 25.92	*Brucella* spp.	Hassain et al. (2010)
4	Duhok	Cattles	360	RBT and ELISA	23 and 3	6.38 and 0.83	*Brucella* spp.	Omar et al. (2011)
5	Baghdad	Goats and sheep	300	RBT and ELISA	137, 98	42.33 and 32.66	*Brucella* spp.	Salman and Mosa (2015)
6	Wasit	Herder Dogs	243	Rapid test and ELISA and PCR	14, 31, and PCR 5/31	5.76 and 12.76	*B. canis*	Alfattli (2016)
7	Dyala	Cheese	50	Culture and Biochemical tests	6	12	*Brucella* spp.	Fadihl and Khalil (2016)
8	Duhok	Goats and sheep	432	RBT and ELISA	78 and 78	31.7 and 31.7	*Brucella* spp.	Alhamada et al. (2017)
9	Wasit, Diqar and Al-qadisiya	Stray Dogs	135	RBT and ELISA	39 and 53	28.89 and 39.26	*B. abortus*	Ali (2017)
10	Karbala and Babylon	Cattles and buffaloes	141	RBT, MRT, and PCR	75	53.20	*B. melitensis* and *B.abortus*	AL-Shemmari (2018)
11	Baghdad	Sheep	100	RBT and ELISA	55 and 12	55 and 12	*Brucella* spp.	Salman et al. (2018)
12	Kurdistan region	Goats and sheep	1050	RBT	65	6.20	*Brucella* spp.	Alshwany and Robertson (2018)
13	Duhok	Goats and sheep	600	ELISA	41	6.80	*Brucella* spp.	Ilyas and Karakuş (2019)
14	Mosul	Rams	250	ELISA	12	4.80	*Brucella ovis*	Al-Farwachi et al. (2019)
15	Erbil	Cows and buffaloes	265	RBT and MRT	68		*Brucella* spp.	Almashhadany (2021)
16	Kirkuk	Goats and sheep	430	MRT and ELISA	53 and 46	12.3 and 10.7	*Brucella* spp.	Almashhadany (2021)
17	Duhok	Goats and sheep	240	RBT	13	5.4	*B. melitensis*	Al Hamada et al. (2021)
18	Babylon	sheep	20	PCR	17	85	*B. melitensis* and *B. abortus*	Abdulzahra et al. (2022)
19	Basra	Cows	56	RBT and PCR	16 and 6	30 and 11	*B. abortus*	Al-Rahman et al. (2022)
20	Duhok	Goats and sheep	681	RT-PCR	219	32.16	*B. melitensis*	Ameen et al. (2023)
21	Erbil, Basra, Mosul and Salah Eldin	Buffaloes	935	MRT, RBT, and ELISA	6/80, 27/250 and 20/88	7.5,10.8 and 23.8	*Brucella* spp.	Ranga et al. (2023)

Conclusions

Brucellosis is a pervasive zoonotic disease in Iraq, with a notably higher prevalence in rural regions, certain age groups, and seasonal peaks during warmer months, particularly the milking season. These patterns highlight the role of environmental and occupational exposure in the transmission dynamics. The primary risk factors include consuming unpasteurized milk and direct contact with infected livestock, underscoring the critical need for community-level education and behavioral interventions. Epidemiological studies have consistently identified *Brucella abortus* and *Brucella melitensis* as the dominant pathogens responsible for human and animal infections. Diagnostic methods such as the Rose Bengal Test (RBT), enzyme-linked immunosorbent assay (ELISA), and Polymerase Chain Reaction (PCR) are employed across the country. While RBT remains a practical screening tool due to its cost-effectiveness, ELISA and PCR provide greater sensitivity and specificity, emphasizing the importance of integrating advanced diagnostics into routine surveillance systems. To effectively control brucellosis, a multi-pronged strategy is essential. This includes improving diagnostic capacities, enforcing food safety measures such as mandatory milk pasteurization, and implementing targeted vaccination programs for livestock. Collaborative efforts between public health authorities, veterinary services, and agricultural sectors are crucial to developing sustainable control measures. Strengthening active surveillance systems and enhancing resource allocation for research and control programs will further aid in reducing this disease's prevalence and economic burden. By prioritizing these interventions, Iraq can mitigate the impacts of brucellosis, safeguard public health, improve livestock productivity, and protect the livelihoods of its rural communities.

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