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Research Article

Serological prevalence of Brucella at the livestock-human interface in northeast of Deir al-Zor in Syria

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Abstract

Brucellosis, a zoonotic bacterial infection primarily affecting livestock, poses significant health risks to humans, particularly in regions reliant on animal husbandry. This study investigates the seroprevalence of brucellosis among symptomatic individuals in Hajin, located in northeastern Deir al-Zor, Syria, an area where livestock farming is a predominant economic activity. Conducted from March 2023 to May 2024, the cross-sectional study involved the collection of 100 serum samples from patients presenting clinical symptoms suggestive of brucellosis. All samples tested positive for Brucella antibodies via the Serum Agglutination Test (SAT), indicating a critical public health concern within this community. The analysis revealed that 80% of infections were attributed to the consumption of contaminated animal products, primarily unpasteurized dairy items. Demographic data indicated a higher prevalence among males aged 19 to 45, aligning with occupational exposure patterns common in agricultural settings. The study also identified a peak in infection rates during October, likely linked to seasonal agricultural practices. These findings underscore the hyper-endemic nature of brucellosis in Hajin and highlight the urgent need for enhanced public health interventions. Recommendations include the implementation of systematic vaccination programs for livestock, improved surveillance, and educational campaigns focused on the importance of pasteurization and safe food handling practices. The results of this investigation provide critical insights into the epidemiology of brucellosis in northeastern Syria and emphasize the necessity for a comprehensive "One Health" approach to mitigate the disease's impact on both human and animal populations.

Keywords: Brucellosis, Zoonotic, Seroprevalence, Northeast of Deir al-Zor Syria, Livestock, Public health, Infection transmission

Introduction

Brucellosis is a zoonotic bacterial infection primarily affecting livestock but has significant implications for human health [1-5]. The disease can be transmitted to humans through the consumption of unpasteurized milk and dairy products, as well as through direct contact with infected animal tissues or products [6-9]. This pathogen presents considerable health risks and economic burdens, particularly in the Mediterranean region. Historically, brucellosis was first identified by David Bruce in 1886 in Malta, following an outbreak that resulted in numerous fatalities, hence the alternative term "Malta Fever" [10-17]. Clinically, brucellosis manifests with symptoms such as intermittent fever, fatigue, headaches, weight loss, and arthralgia, which may persist for weeks to months. Brucella spp. are small, Gram-negative bacteria that belong to the family Brucellaceae [18-24]. The genus comprises six species, with Brucella abortus (primarily associated with cattle) and Brucella melitensis (often referred to as Maltese brucella, primarily associ-

ated with goats and sheep) being the most pathogenic to humans. Infection routes include the oral intake of contaminated food, direct contact during the slaughtering of infected animals, and possible airborne transmission [24-30]. Among these transmission pathways, consumption of raw milk from infected animals remains the most significant risk factor [31-38]. Environmental conditions also play a crucial role in Brucella survival; optimal growth occurs at a pH greater than 4, in high humidity, and at lower temperatures [39-45]. Conversely, exposure to temperatures of 60°C for 10 minutes or a pH below 4 effectively inactivates the bacteria. Brucella can persist in the environment, surviving in dust or soil for 2 to 3 months and even longer in aborted tissues, particularly under cooler conditions [46-52]. The bacteria are sensitive to various disinfectants, including cephalosporins, ampicillin, tetracycline, ciprofloxacin, and chloramphenicol [53-59]. The invasive capability of Brucella allows it to penetrate various body tissues, particularly targeting the endothelial lining through mucosal membranes in the oral cavity, respiratory tract, and reproductive system [60-67]. Following mucosal invasion, Brucella is phagocytosed by neutrophils and macrophages, which transport the bacteria to regional lymph nodes and subsequently into systemic circulation [68-74]. If the host's immune response is inadequate within 1 to 3 weeks post-exposure, the bacteria can localize within the endothelial cells of vital organs, including the liver, spleen, and bone marrow [75-83]. This colonization may result in granuloma formation, leading to persistent bacteremia and potential infection of prosthetic devices [84-90]. The axial skeleton and large joints are common sites of infection. Bacterial culture remains the gold standard for definitive diagnosis of brucellosis; however, this method is labour-intensive and requires specialized laboratory conditions due to the slow growth rate of Brucella [91-99]. While culture positivity is high in acute infections, it significantly declines in chronic cases, and the procedure is often discouraged during antibiotic treatment [100-109]. In clinical practice, indirect serological methods, such as Serum Agglutination Tests (SAT), are frequently employed for diagnosis. Effective prevention of brucellosis hinges on awareness of transmission dynamics [110-117]. Key measures include the thorough boiling of milk and the use of pasteurization techniques, avoiding unpasteurized dairy products, and ensuring proper cooking of meat to a minimum internal temperature of 74°C [118-124]. Additionally, individuals handling livestock, particularly those with injuries, should employ protective gear to mitigate the risk of infection [125-133]. Data on brucellosis seroprevalence in Syria are scarce and largely outdated [134-143]. However, reports from the World Organization for Animal Health indicate that Syria has the highest annual incidence rate of human brucellosis globally, with an alarming rate of 1,603 cases per million individuals [144-151]. The village of Hajin in northeastern Deir al-Zor, located along the Euphrates River, has a population of approximately 30,000, predominantly engaged in livestock farming. Given their reliance on cattle, sheep, and goats for sustenance, the study aims to investigate the prevalence of brucellosis among the residents of Hajin, particularly focusing on symptomatic individuals from March 2023 to April 2024. Brucellosis remains a critical public health challenge that necessitates ongoing surveillance, effective diagnostic strategies, and comprehensive educational initiatives to mitigate its impact on human health and the economy [152-158].

Materials and Methods

Study Design and Area

This cross-sectional study was conducted to investigate the serological prevalence of human brucellosis in the Hajin area, a region in the northeast of Deir al-Zor, Syria, where livestock farming is a primary economic activity. The study period extended from March 2023 to May 2024.

Sample Collection and Patient Data

A total of 100 serum samples were collected from patients who were referred to the central hospital in Hajin. The inclusion criterion for the study was the presence of clinical symptoms suggestive of brucellosis, such as fever, fatigue, and joint pain. For each participant, demographic data including age and gender were recorded. Furthermore, patients were interviewed to obtain information regarding potential routes of infection, with a focus on dietary habits (e.g., consumption of unpasteurized dairy products) and direct contact with livestock.

Serological Analysis

All collected serum samples were subjected to serological analysis to detect the presence of antibodies against Brucella. The Standard Agglutination Test (SAT) was employed for this purpose. The test was performed using a series of dilutions (1/40, 1/80, and 1/320) to determine the specific antibody titer for each patient sample. A positive result was determined based on the agglutination titer in conjunction with the patient's clinical presentation.

Data Analysis

The collected data were analysed to determine the seroprevalence of brucellosis within the study cohort. The results were stratified and examined based on gender, age group, and the month of sample collection to identify demographic risk factors and temporal variations in infection rates. The distribution of self-reported transmission routes was also compiled and analysed to ascertain the primary sources of infection in this population.

Results and Discussion

Results

This study investigated the seroprevalence of brucellosis among 100 symptomatic patients referred to the central hospital in Hajin, Syria, between March 2023 and May 2024. All 100 individuals (100%) included in the cohort tested positive for Brucella antibodies via the Serum Agglutination Test (SAT), indicating a significant burden of disease among those presenting with clinical suspicion in this region Table 1.

Table 1: Results of sample analysis showing analysis date, the patient's gender, age and analysis result.

Patient number	Date	Gendre	Results	Age	Patient number	Date	Gendre	Results	Age
1	2023/3	Female	1/40-1/40	22	51	2023/10	Female	80/1-80/1	27
2	2023/3	Male	1/80-1/80	16	52	2023/10	Female	80/1-80/1	16
3	2023/3	Male	1/40-1/40	23	53	2023/10	Female	40/1-40/1	23
4	2023/4	Male	1/80-1/80	33	54	2023/10	Male	80/1-80/1	21
5	2023/4	Male	1/40-1/40	32	55	2023/10	Female	80/1-80/1	34
6	2023/4	Male	1/80-1/80	26	56	2023/10	Male	40/1-40/1	12
7	2023/4	Female	1/40-1/40	19	57	2023/10	Female	40/1-40/1	43
8	2023/4	Male	1/80-1/80	22	58	2023/10	Male	1/320-1/320	26
9	2023/4	Female	1/40-1/40	43	59	2023/10	Male	80/1-80/1	26
10	2023/4	Male	1/80-1/80	25	60	2023/10	Male	1/320-/320	41
11	2023/4	Female	1/40-1/40	9	61	2023/10	Female	40/1-40/1	43
12	2023/4	Female	1/80-1/80	15	62	2023/10	Male	40/1-40/1	31
13	2023/5	Male	1/40-1/40	23	63	2023/10	Female	1/320-/320	29
14	2023/5	Male	1/80-1/80	13	64	2023/10	Male	40/1-40/1	13
15	2023/5	Male	1/320-/320	19	65	2023/11	Male	40/1-40/1	23
16	2023/5	Male	1/40-1/40	43	66	2023/11	Male	80/1-80/1	11
17	2023/5	Female	1/40-1/40	12	67	2023/11	Female	80/1-80/1	27
18	2023/6	Male	1/80-1/80	10	68	2023/11	Female	40/1-40/1	13
19	2023/6	Female	1/40-1/40	23	69	2023/11	Female	40/1-40/1	17
20	2023/6	Male	1/320-/320	57	70	2023/11	Male	40/1-40/1	27
21	2023/6	Female	1/40-1/40	25	71	2023/11	Female	1/320-/320	17
22	2023/6	Male	1/40-1/40	56	72	2023/12	Male	40/1-40/1	34
23	2023/6	Female	1/80-1/80	46	73	2023/12	Female	40/1-40/1	25
24	2023/6	Male	1/40-1/40	60	74	2023/12	Male	80/1-80/1	31
25	2023/7	Female	1/40-1/40	23	75	2023/12	Male	40/1-40/1	19
26	2023/7	Male	1/80-1/80	12	76	2023/12	Male	80/1-80/1	20
27	2023/7	Male	1/40-1/40	27	77	2023/12	Female	80/1-80/1	19
28	2023/7	Male	1/320-/320	15	78	2023/12	Male	40/1-40/1	22
29	2023/7	Male	1/40-1/40	29	79	2023/12	Female	80/1-80/1	27
30	2023/7	Male	1/40-1/40	9	80	2023/12	Male	1/320-/230	31
31	2023/7	Female	1/80-1/80	19	81	2024/1	Female	80/1-80/1	19
32	2023/7	Female	1/40-1/40	60	82	2024/1	Male	40/1-40/1	23
33	2023/8	Female	1/40-1/40	12	83	2024/1	Female	1/320-/230	30
34	2023/8	Male	1/40-1/40	34	84	2024/2	Male	1/320-/230	16
35	2023/8	Male	1/80-1/80	13	85	2024/2	Female	40/1-40/1	22
36	2023/8	Male	1/40-1/40	63	86	2024/2	Male	40/1-40/1	14
37	2023/8	Female	1/40-1/40	22	87	2024/2	Male	80/1-80/1	23
38	2023/8	Male	1/80-1/80	45	88	2024/2	Male	40/1-40/1	31
39	2023/8	Male	1/40-1/40	36	89	2024/4	Female	80/1-80/1	19
40	2023/8	Female	1/80-1/80	63	90	2024/4	Male	80/1-80/1	22
41	2023/8	Female	1/40-1/40	22	91	2024/4	Female	40/1-40/1	43
42	2023/9	Male	1/80-1/80	45	92	2024/4	Male	80/1-80/1	23
43	2023/9	Male	1/40-1/40	36	93	2024/4	Male	1/320-/230	24
44	2023/9	Female	1/80-1/80	37	94	2024/4	Male	40/1-40/1	21

45	2023/9	Female	1/80-1/80	23	95	2024/4	Female	80/1-80/1	23
46	2023/9	Male	1/40-1/40	34	96	2024/4	Male	80/1-80/1	12
47	2023/9	Female	1/80-1/80	27	97	2024/4	Male	1/320-/320	22
48	2023/9	Male	1/320-/320	18	98	2024/5	Male	80/1-80/1	12
49	2023/9	Male	1/40-1/40	29	99	2024/5	Male	80/1-80/1	16
50	2023/9	Male	1/40-1/40	9	100	2024/5	Male	40/1-40/1	23

Investigation into the probable routes of transmission revealed that the consumption of contaminated animal products was the predominant risk factor, implicated by 80% of the patients (n=80). The remaining 20% of participants reported varied potential exposure pathways, including inhalation of aerosols, direct contact with infected animal tissues through open wounds, and, less commonly, perceived transmission from infected individuals or vertical transmission (Figure 1).

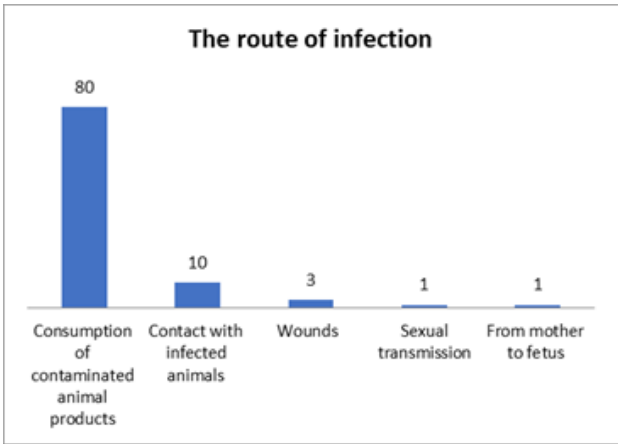

Figure 1: Distribution of samples according to the route of infection.

The study population comprised 61 males (61%) and 39 females (39%), with an age range spanning from 9 to 64 years. Analysis of demographic data revealed specific risk stratifications. A notable gender disparity was evident, with males representing a larger proportion of the seropositive cases (Figure 2). The highest incidence of infection was concentrated within the 19-to-45-year-old age group, which constituted the majority of cases (Figure 3).

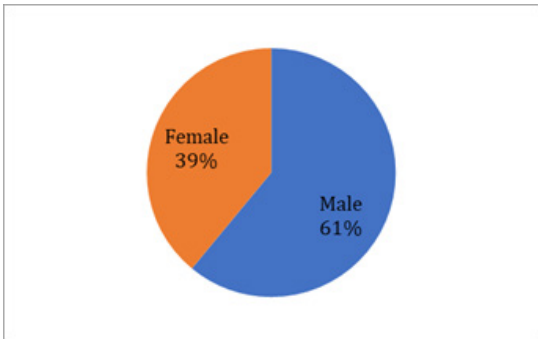

Figure 2: Distribution of samples between males and females.

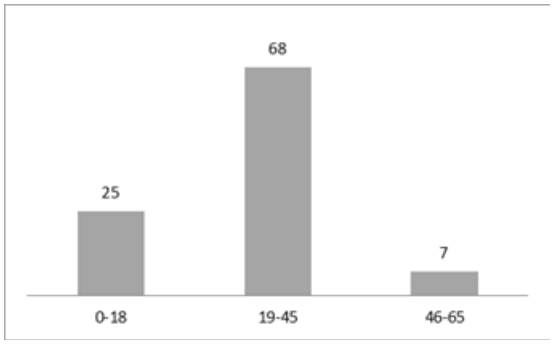

Figure 3: Distribution of samples according to age group.

Serological analysis using SAT revealed a range of antibody titers. The most frequently observed titer was 1/40, accounting for 49% of all positive cases (Figure 4). The monthly distribution of cases showed a distinct temporal pattern, with the incidence rate peaking in October 2023, when 16% of the total annual cases were recorded (Figure 5).

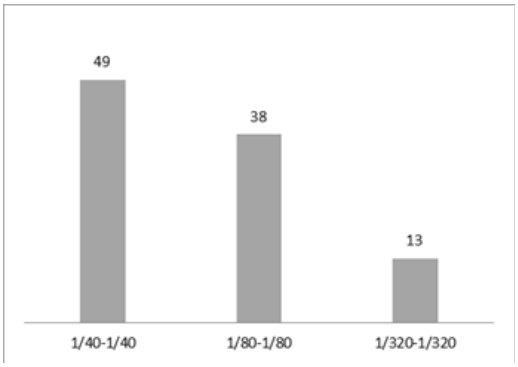

Figure 4: Distribution of samples according to the analysis results.

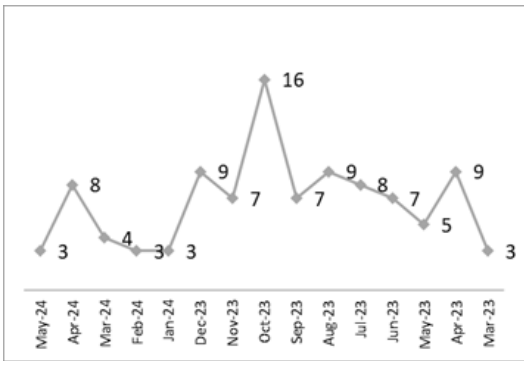

Figure 5: Shows the distribution of samples according to the date of analysis.

Discussion

The findings of this investigation, the first of its kind to systematically assess brucellosis seroprevalence in the Hajin region of northeastern Syria, confirm that the disease is hyper-endemic among the symptomatic population. The 100% positivity rate among patients with clinical suspicion underscores the critical public health challenge that brucellosis poses in this community, where intimate human-animal contact and traditional livestock-based livelihoods are ubiquitous.

The demographic patterns observed in this study align with established epidemiological trends for brucellosis in the Middle East. The higher prevalence in males (61%) is consistent with findings from neighbouring countries like Jordan and Iraq. This disparity is likely attributable to occupational and sociocultural roles, as men are traditionally more involved in high-risk activities such as herding, slaughtering, and assisting with animal births, which expose them to infectious animal tissues and fluids. Similarly, the concentration of cases within the 19-45 age group reflects the demographic most actively engaged in the agricultural workforce. This economic and social reality places the most productive segment of the population at the greatest risk, compounding the disease's so-

cioeconomic impact through loss of workdays and healthcare costs.

The overwhelming attribution of infection (80%) to the consumption of contaminated animal products, particularly unpasteurized milk and fresh dairy items like cheese, is a crucial finding. This directly implicates traditional dietary habits as the primary driver of human brucellosis in Hajin. Despite potential public health awareness efforts, these practices remain deeply ingrained, highlighting a significant gap between knowledge and behaviour that must be addressed. The reporting of other transmission routes, while less frequent, is also informative. While human-to-human transmission is exceedingly rare, its mention by participants may reflect local beliefs or a general uncertainty about the disease, pointing to the need for clearer, more targeted educational campaigns.

The temporal peak in incidence observed in October is a significant finding that warrants further investigation. This seasonality may correlate with specific agricultural cycles, such as the birthing season for sheep and goats, which typically occurs in late summer and autumn. This period is associated with a higher risk of exposure to aborted foetuses, placentas, and vaginal discharges, all of which contain extremely high concentrations of Brucella organisms. An increase in the production and consumption of fresh dairy products following these birthing seasons could also contribute to this peak.

From a diagnostic perspective, the prevalence of a low positive titer (1/40) in nearly half the cases is noteworthy. In highly endemic regions, a low titer in a symptomatic patient is often considered clinically significant. However, it can also represent a past, resolved infection or a chronic, low-grade disease state. This ambiguity highlights the limitations of relying solely on SAT for diagnosis and underscores the need for comprehensive clinical evaluation and, where possible, the implementation of more specific diagnostic tools like ELISA or confirmatory tests such as bacterial culture or PCR to improve diagnostic accuracy and guide appropriate treatment.

The persistence of high brucellosis rates, as demonstrated in this study, suggests that current control measures are either non-existent or inadequate. The findings are a stark reminder of reports from the World Organization for Animal Health, which have previously identified Syria as having one of the highest global incidences of human brucellosis. This study provides critical, contemporary evidence that the situation remains severe, at least in this region. The results strongly advocate for the urgent implementation of a multi-pronged "One Health" approach. Such a strategy must integrate veterinary and public health interventions, including systematic vaccination programs for livestock, surveillance with test-and-slaughter policies, and robust public health campaigns focused on the critical importance of milk pasteurization and safe food handling practices.

Conclusion

This study provides critical, contemporary evidence confirming that brucellosis is a hyper-endemic and severe public health problem in the Hajin region of northeastern Syria. The investigation, one of the few recent inquiries into the disease's prevalence in this area, reveals a 100% seropositivity rate among symptomatic individuals, underscoring the significant burden carried by this livestock-dependent community. The findings highlight that the primary route of transmission is the consumption of contaminated animal products, a practice deeply embedded in the local culture and economy. Furthermore, the demographic data clearly delineate the most vulnerable populations: economically active males between the ages of 19 and 45, who are disproportionately affected due to occupational and dietary exposures. The persistence of such high infection rates strongly suggests that current or past control strategies have been inadequate or are non-existent. This study, therefore, serves as an urgent call to action for the implementation of a comprehensive and integrated "One Health" framework. Such an approach is essential and must synergize efforts across veterinary and human health sectors. Key recommendations include the immediate rollout of systematic animal vaccination programs for sheep, goats, and cattle, coupled with robust surveillance and control measures within livestock populations. Concurrently, targeted public health interventions are imperative. These must include sustained educational campaigns focused on the critical importance of milk pasteurization and safe food-handling practices to interrupt the primary pathway of foodborne transmission. Additionally, promoting occupational safety through the use of personal protective equipment among farmers, veterinarians, and abattoir workers is crucial to mitigate the risk of direct contact transmission. Looking forward, this investigation lays the groundwork for essential future research. Broader, population-based epidemiological studies are required to ascertain the true prevalence of brucellosis beyond symptomatic cases, including asymptomatic carriers, to understand the full scope of the public health challenge. Molecular characterization of the circulating Brucella species and strains in both human and animal hosts is necessary to trace infection sources with greater precision and to inform more targeted control strategies. Brucellosis remains a neglected yet formidable zoonosis in northeastern Syria, inflicting a substantial toll on human health and economic stability. Without a concerted, multi-sectoral intervention grounded in the One Health philosophy, the disease will continue to thrive at the human-animal interface. This study provides the foundational data necessary to advocate for and guide the allocation of resources toward effective control and prevention programs, with the ultimate goal of alleviating the profound impact of brucellosis on this vulnerable population.

Acknowledgement

None.

Conflict of Interest

None.

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