



# Knowledge, Attitudes and Practices of Physicians Regarding Brucellosis in Sana'a City, Yemen: Diagnostic Shortcomings Despite High Awareness

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## ABSTRACT

**Background:** Brucellosis is a widespread zoonotic infection that poses significant diagnostic and therapeutic challenges. However, it remains underdiagnosed due to nonspecific symptoms. Therefore, this study aimed to assess the knowledge, attitudes and practices (KAPs) of physicians regarding brucellosis in Sana'a City, Yemen.

**Methods:** A descriptive, cross-sectional study was conducted among 264 physicians of various specialties in Sana'a City, Yemen, from March to May 2025. Data on physician characteristics and brucellosis-related KAPs were collected using a structured electronic questionnaire. Responses were scored and categorized into good/poor knowledge, positive/negative attitudes, and acceptable/unacceptable practices, based on predefined thresholds. Data were summarized and presented using descriptive statistics.

**Results:** Among 264 surveyed physicians, 94% demonstrated good knowledge of brucellosis. Most identified animals (87.9%) as reservoirs and farmers (89%) as a high-risk group, though fewer recognized laboratory personnel (42.4%) as being at risk. Commonly known transmission routes included raw milk (89%), raw meat (69.3%), and direct contact with animals (66.3%), while awareness of occupational exposures—placentas (44.7%), aborted materials (42.4%), and aerosols (24.6%)—was limited. Clinical signs like fever (91.3%), gastrointestinal symptoms (85.2%), and neurological involvement (78.2%) were well recognized. Anemia (72.7%) was the most known hematological finding. While 72% correctly identified the doxycycline-rifampin regimen, only 51.1% knew the six-week treatment duration. A positive attitude prevailed among 92% of physicians, with strong support for increasing medical awareness (80.7%), recognizing frequent misdiagnosis (78.1%), and promoting continuing education (78%). About 71.3% trusted serological tests, and 69.7% supported referring cases to specialists, yet only 51.1% viewed





brucellosis as a major public health issue in Yemen. Diagnostic practices were acceptable among 68% of physicians, though few routinely asked about raw milk (40.2%), raw meat (23.1%), or animal contact (42.8%). Only 32.6% consistently tested chronic fever cases for brucellosis, and testing was rarely ordered for lab workers (8.7%) or animal-exposed individuals (25%).

**Conclusion:** Physicians in Sana'a City show good knowledge and attitudes toward brucellosis, but gaps remain in recognizing atypical exposures and applying consistent diagnostic practices. Limited perception of brucellosis as a major health issue hinders effective management, highlighting the need for standardized protocols and targeted continuing education to improve diagnosis and care.

**Keywords:** Brucellosis ▪ Knowledge ▪ Attitudes ▪ Practices ▪ Yemen

## 1. Introduction

Human brucellosis, commonly referred to as Malta fever or undulant fever, is a worldwide zoonotic bacterial disease caused by *Brucella* species, particularly *B. melitensis* and *B. abortus*, which primarily infect small ruminants and cattle, respectively.<sup>(1)</sup> The global incidence of human brucellosis has been recently estimated at approximately 2.1 million cases per year.<sup>(2)</sup> Africa and Asia bear the highest global burden and risk of brucellosis, though certain regions in the Americas and Europe also continue to pose significant concern.<sup>(2)</sup> The disease is endemic in several countries across different regions, including the Mediterranean, Africa, the Middle East, Central and South America, Western Europe, the Indian subcontinent, and Central Asia.<sup>(3)</sup>

Human brucellosis is primarily transmitted through direct contact with infected animals or their fluids, consumption of raw or unpasteurized dairy products, and, less frequently, via inhalation of airborne bacteria or accidental inoculation.<sup>(3)</sup> It exhibits a variety of clinical symptoms and can affect different organs, tissues, and systems. Moreover, brucellosis is difficult to differentiate from other febrile illnesses because of its non-specific manifestations, which include an undulating fever, night sweats, chills, arthralgia, myalgia, and fatigue.<sup>(4)</sup> If brucellosis is not properly diagnosed and treated during its acute phase, it can progress to a chronic form, leading to complications involving the musculoskeletal, hepatobiliary, neurological, and cardiovascular systems.<sup>(5)</sup>

Brucellosis remains a significant public health concern, particularly among individuals in high-risk occupations, such as farming, veterinary work, and food processing. Preventive strategies focus heavily on occupational hygiene and food safety, with a strong emphasis on avoiding unpasteurized dairy products. In the Middle East, brucellosis poses a significant burden to both animal and public health,<sup>(6-8)</sup> where traditional practices like consuming unpasteurized dairy products and widespread reliance on pastoralism facilitate disease transmission from animals to humans. Brucellosis is a major public health problem in Yemen, with seroprevalence ranging from 0.3% to 32.3% in humans.<sup>(9)</sup> In Sana'a city, 29% of patients with pyrexia of unknown origin were found to be seropositive for brucellosis, with handling animals being a risk factor.<sup>(10)</sup> In Yemen, several risk factors have been reported for brucellosis, including working in occupations like farming and herding, consuming unpasteurized dairy products, and residing in rural areas.<sup>(11,12)</sup> Moreover, control efforts are hindered by the lack of public awareness of brucellosis and the absence of effective animal vaccination programmes.

Physicians' knowledge, attitudes, and practices (KAPs) regarding brucellosis are crucial for its effective diagnosis and management. Although it poses a substantial public health challenge, brucellosis is often under-recognized in clinical settings. Several studies have highlighted inconsistent levels of awareness among healthcare providers, with gaps



in both knowledge and routine consideration of the disease during diagnosis. For instance, 73.4% of medical professionals in Namibia were aware of brucellosis, but 98.4% did not consider it in differential diagnoses for persistent febrile illnesses.<sup>(13)</sup> Moreover, 28% of these medical professionals engaged in risky behaviors, such as consuming raw milk.<sup>(13)</sup> In North India, only 25% of physicians considered brucellosis in differential diagnosis for acute fever and 50% in chronic fever, while 10% of orthopedists considered it in cases of arthralgia.<sup>(14)</sup> A Tanzanian study on frontline health workers' KAP regarding brucellosis found moderate awareness and positive attitudes but identified a key gap in diagnostic knowledge, especially among rural providers, hindering effective disease control.<sup>(15)</sup> A study in Karachi, Pakistan, found that while healthcare professionals showed good awareness of brucellosis and supported educational initiatives, gaps in clinical practice were evident due to limited consideration of the disease during patient evaluations.<sup>(16)</sup>

In Yemen, there is a lack of studies on KAPs regarding brucellosis among both the public and healthcare professionals. To address this gap, the present study aimed to assess the KAPs of physicians in Sana'a City regarding the disease to identify deficiencies and guide targeted interventions to improve brucellosis diagnosis and management.

## 2. Methods

### 2.1. Study design, population and setting

A descriptive, cross-sectional study assessing KAPs regarding brucellosis was conducted among physicians of various specialties in Sana'a City, Yemen, from March to May 2025. Physicians were included in the study if they were practicing in Sana'a City and consented to participate by agreeing to the informed consent statement provided at the beginning of an online form.

### 2.2. Sample size and sampling strategy

Based on an expected proportion of 50% of physicians with favorable KAP outcomes due to the absence of prior studies on physicians' KAPs regarding brucellosis in Yemen, a sample size of 384 was calculated using OpenEpi, version 3.01 ([www.openepi.com](http://www.openepi.com)), with a 95% confidence level and a 5% accepted margin of error. However, due to the limited number of physicians accessible online during the study period and logistical constraints, a final sample of 264 physicians was achieved.

Physicians were selected through convenience sampling, with invitations disseminated via emails, professional networks, and social media platforms. An electronic questionnaire developed using Google Forms was used to collect data on KAPs related to brucellosis. Once the required sample size was reached, the online questionnaire was discontinued.

### 2.3. Data collection

Data were collected using a structured, peer-reviewed electronic questionnaire comprising four sections. The first section included questions about physician characteristics, including age, gender, professional rank, education level, area of work, and years of experience. The second section consisted of 32 questions assessing physicians' knowledge of brucellosis. The third section included eight questions addressing their attitudes toward brucellosis, while the fourth section included 11 questions assessing their practices regarding disease diagnosis.

### 2.4. Data analysis

Data were analyzed using IBM SPSS Statistics for Windows (version 24.0; IBM Corp., Armonk, NY, USA). For continuous variables, means and standard deviations (SD) were used to describe normally distributed data, while categorical variables were presented as frequencies and percentages. Responses to knowledge items were scored as follows:



'2' for Yes, '1' for No, and '0' for Do not know, with an overall knowledge score for each participant ranging from 0 to 64. Physicians scoring 33 or above were classified as having good knowledge, whereas those scoring below 33 were classified as having poor knowledge. On the other hand, responses to attitude statements were scored as follows: '5' for "strongly agree", '4' for "agree", '3' for "neutral", '2' for "disagree", and '1' for "strongly disagree", with an overall attitude score for each participant ranging from 1 to 40. Physicians scoring 21 or above were classified as having a positive attitude, whereas those scoring below 21 were classified as having a negative attitude.

Regarding practices reported by the physicians, responses were scored as follows: '3' for "always", '2' for "often", '1' for "sometimes", and '0' for "no", with an overall practice score for each participant ranging from 0 to 33. Physicians scoring 16 or above were classified as having an acceptable practice, whereas those scoring below 16 were classified as having an unacceptable practice.

### 3. Results

#### 3.1. Characteristics of participating physicians

Among the 264 physicians surveyed, gender distribution was nearly equal, with 50.8% male and 49.2% female. The mean age was  $34.9 \pm 7.8$  years, ranging from 23 to 60 years, with the majority of the participants aged 30 years or older. Most participants were specialists (54.9%), followed by general practitioners (32.2%) and consultants (12.9%). The participants were distributed across different departments, with the highest proportion working in pediatrics (33.3%) and internal medicine (30%), and more than half of the participants had less than five years of experience (Table 1).

**Table 1:** Characteristics of physicians participating in the study\*

Characteristics	n (%)
<b>Gender</b>	
Male	134 (50.2)
Female	130 (49.8)
<b>Age (years)</b>	
Mean $\pm$ SD (range): $34.9 \pm 7.8$ (23–60)	
<30	76 (28.6)
$\geq 30$	188 (70.7)
<b>Professional degree</b>	
General practitioner	85 (32.2)
Specialist	145 (54.9)
Consultant	34 (12.9)
<b>Ward</b>	
Pediatrics	88 (33.3)
Internal medicine	80 (30.3)
Gynecology	31 (11.7)
Surgery	24 (9.1)
Other	41 (15.5)
<b>Years of experience</b>	
<5	138 (52.3)
$\geq 5$	126 (47.7)

\*The total number of physicians was 264. SD, standard deviation.

#### 3.2. Levels of physicians' KAPs regarding brucellosis

Overall, 94% (248/264) of the physicians demonstrated a good level of knowledge about brucellosis, with a mean knowledge score of  $47.4 \pm 8.9$ , and 92% (243/264) of the physicians exhibited a positive attitude toward brucellosis, with a mean attitude score of  $28.1 \pm 5.4$ . However, 68% (180/264) of the physicians showed an acceptable level of practice for diagnosing brucellosis, with a mean practice score of  $19.0 \pm 7.3$ .

#### 3.3. Physicians' knowledge of brucellosis

Table 2 shows that 87.9% of physicians recognized that animals could contract brucellosis, and 89% were aware that individuals involved in animal breeding or farming are at high risk. In contrast, only 42.4% knew that laboratory personnel are at high risk of infection. The majority of physicians (89%) identified drinking raw milk as a mode of transmission, followed by eating raw meat (69.3%) and contact with animals (66.3%). The least frequently



recognized modes of transmission were handling animal placentas (44.7%), handling abortion materials (42.4%), and inhalation of contaminated materials (24.6%). However, only 5.1% of physicians incorrectly cited mosquitoes as vectors of transmission.

Regarding clinical manifestations of brucellosis, fever was the most frequently recognized symptom (91.3%), followed by gastrointestinal symptoms (85.2%), neurological symptoms (78%), hepatomegaly (77.3%), splenomegaly (75.8%), and lymphadenopathy (73.5%).

Conversely, the least frequently recognized symptoms of brucellosis were respiratory (51.1%), cardiovascular (53%) and genitourinary (45.1%), besides gastrointestinal bleeding (20.5%). In terms of hematological abnormalities, 72.7% of physicians correctly identified anemia as associated with brucellosis, followed by 56.4% for leukopenia and 50.4% for thrombocytopenia. However, 52.3% of physicians incorrectly associated brucellosis with leukocytosis (Table 2).

**Table 2:** Knowledge of brucellosis among physicians in Sana'a City, Yemen (2025)\*

Knowledge item	Responses n (%)		
	Yes	No	Do not know
Animals could be infected with brucellosis.	232 (87.9)	21 (8.0)	11 (4.2)
People involved in animal breeding or farming are at high risk of contracting brucellosis.	235 (89.0)	19 (7.2)	10 (3.8)
Laboratory personnel are at high risk of contracting brucellosis.	112 (42.4)	97 (36.7)	55 (20.8)
<b>Brucellosis can be transmitted by:</b>			
Eating raw meat	183 (69.3)	48 (18.2)	33 (12.5)
Drinking raw milk	235 (89.0)	21 (8.0)	8 (3.0)
Contact with animals	175 (66.3)	68 (25.8)	21 (8.0)
Handling an animal placenta	118 (44.7)	69 (26.1)	77 (29.2)
Handling an animal abortion	112 (42.4)	70 (26.5)	82 (31.1)
Inhalation of contaminated aerosols	65 (24.6)	154 (58.3)	45 (17.0)
Mosquitoes	14 (5.3)	218 (82.6)	32 (12.1)
<b>Brucellosis could be manifested by:</b>			
Respiratory symptoms like cough and breathing difficulty	135 (51.1)	90 (34.1)	39 (14.8)
Cardiovascular symptoms	140 (53.0)	77 (29.2)	47 (17.8)
Gastrointestinal symptoms like vomiting and diarrhea	225 (85.2)	26 (9.8)	13 (4.9)
Hepatic symptoms like jaundice	184 (69.7)	46 (17.4)	34 (12.9)
Genitourinary symptoms	119 (45.1)	86 (32.6)	59 (22.3)
Neurological symptoms like headache	206 (78.0)	32 (12.1)	26 (9.8)
Fever	241 (91.3)	16 (6.1)	7 (2.7)
Hepatomegaly	204 (77.3)	36 (13.6)	24 (9.1)
Splenomegaly	200 (75.8)	39 (14.8)	25 (9.5)
Lymphadenopathy	194 (73.5)	32 (12.1)	38 (14.4)
Gastrointestinal bleeding	54 (20.5)	120 (45.5)	90 (34.1)
<b>Hematological findings in brucellosis include:</b>			
Anemia	192 (72.7)	43 (16.3)	29 (11.0)
Leukopenia	149 (56.4)	66 (25.0)	49 (18.6)
Leukocytosis	138 (52.3)	79 (29.9)	47 (17.8)
Thrombocytopenia	133 (50.4)	69 (26.1)	62 (23.5)

\*The total number of physicians was 264.

### 3.4. Physicians' knowledge of brucellosis treatment

Most physicians (72%) correctly identified the combination of doxycycline and rifampin as the recommended antibiotic regimen for treating brucellosis. However, 12.1% and 2.7% of physicians incorrectly cited monotherapy with doxycycline and rifampin, respectively. Meanwhile, 4.2% incorrectly

recommended the use of amoxicillin, and 9% recommended other antibiotics. Regarding treatment duration, one half of the physicians (51.1%) correctly identified a six-week course as the appropriate duration of treatment (Table 3).



**Table 3:** Knowledge of physicians about brucellosis treatment in Sana'a City, Yemen (2025)\*

Knowledge item	n (%)
<b>Antibiotics of choice for treating brucellosis</b>	
No treatment	25 (9.5)
Amoxicillin	11 (4.2)
Doxycycline alone	32 (12.1)
Rifampin alone	7 (2.7)
Doxycycline and rifampin	190 (72.0)
Other	24 (9.1)
<b>Duration for brucellosis treatment (weeks)</b>	
One	6 (2.3)
Two	31 (11.7)
Four	45 (17.0)
Six	135 (51.1)
Eight	22 (8.3)

\*The total number of physicians was 264.

**Table 4:** Physicians' attitudes toward brucellosis in Sana'a City, Yemen (2025) \*

Attitude statements	Responses n (%)				
	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Brucellosis is a major health problem in Yemen.	13 (4.9)	42 (15.9)	74 (28.0)	111 (42.0)	24 (9.1)
Brucellosis is being largely misdiagnosed.	8 (3.0)	18 (6.8)	32 (12.1)	143 (54.2)	63 (23.9)
Patients with brucellosis-like symptoms should be referred to a consultant.	8 (3.0)	35 (13.3)	37 (14.0)	151 (57.2)	33 (12.5)
There is a need to raise awareness among medical practitioners.	16 (6.1)	20 (7.6)	15 (5.7)	131 (49.6)	82 (31.1)
Brucellosis can be reliably diagnosed by blood culture.	12 (4.5)	40 (15.2)	47 (17.8)	125 (47.3)	40 (15.2)
Brucellosis can be reliably diagnosed by serology.	12 (4.5)	32 (12.1)	32 (12.1)	148 (56.1)	40 (15.2)
Brucellosis can be reliably diagnosed by imaging.	42 (15.9)	125 (47.3)	67 (25.4)	28 (10.6)	2 (0.8)
Attending continuing medical education seminars helps raise awareness.	20 (7.6)	15 (5.7)	23 (8.7)	135 (51.1)	71 (26.9)

\*The total number of physicians was 264.

### 3.6. Physicians' practices regarding brucellosis diagnosis

Table 5 shows that only 42.8% of physicians consistently inquired about recent contact with animals in suspected cases of brucellosis during history taking, while 2.7% reported never doing so. Likewise, 40.2% consistently inquired about the consumption of raw milk, while 7.6% did not inquire at all. In contrast, routine inquiry about raw meat consumption was reported by only 23.1% of physicians, with 17.8% never inquiring about it during history taking. Regarding diagnostic practices, 32.6%

### 3.5. Physicians' attitudes toward brucellosis

Table 4 shows that the majority of physicians (80.7%) agreed or strongly agreed on the need to raise awareness of brucellosis among medical practitioners, followed by the belief that brucellosis is largely misdiagnosed (78.1%) and that continuing medical education seminars could raise awareness (78.0%). However, only 51.1% of the physicians viewed brucellosis as a major health problem in Yemen. On the other hand, 69.7% supported referral of patients with brucellosis-like symptoms to a consultant, and 71.3% and 62.5% of physicians recognized serology and blood culturing, respectively, as reliable diagnostic methods, but 11.4% believed in the reliability of imaging.

of the physicians consistently requested brucellosis testing for patients presenting with chronic fever. Testing was also consistently requested for patients with recurrent fever accompanied by hepatosplenomegaly (26.9%), arthritis (25.8%), anemia (25.0%), and headache (21.6%). A quarter of physicians reported requesting brucellosis testing for patients in contact with cattle, while only 8.7% of physicians requested testing for laboratory personnel. On the other hand, differential diagnosis of other febrile illnesses was reported to be considered by 45.8% of physicians.



**Table 5:** Physicians' attitudes toward brucellosis in Sana'a City, Yemen (2025) \*

Practice items	Responses n (%)			
	Always	Often	Sometimes	Never
Inquiry about recent animal contact during history taking in suspected cases	113 (42.8)	89 (33.7)	55 (20.8)	7 (2.7)
Inquiry about recent raw milk consumption during history taking in suspected cases	106 (40.2)	87 (33.0)	51 (19.3)	20 (7.6)
Inquiry about recent raw meat consumption during history taking in suspected cases	61 (23.1)	82 (31.1)	74 (28.0)	47 (17.8)
Requesting brucellosis testing for patients with chronic fever	86 (32.6)	76 (28.8)	61 (23.1)	41 (15.5)
Requesting brucellosis testing for patients with recurrent fever and hepatosplenomegaly	71 (26.9)	93 (35.2)	68 (25.8)	32 (12.1)
Requesting brucellosis testing for patients with recurrent fever and anemia	66 (25.0)	83 (31.4)	64 (24.2)	51 (19.3)
Requesting brucellosis testing for patients with recurrent fever and arthritis	68 (25.8)	88 (33.3)	58 (22.0)	50 (18.9)
Requesting brucellosis testing for patients with recurrent fever and headache	57 (21.6)	89 (33.7)	55 (20.8)	63 (23.9)
Requesting brucellosis testing for patients in contact with cattle	66 (25.0)	98 (37.1)	53 (20.1)	47 (17.8)
Requesting brucellosis testing for patients working in laboratories	23 (8.7)	59 (22.3)	54 (20.5)	128 (48.5)
Investigating other differential diagnoses like malaria	121 (45.8)	96 (36.4)	37 (14.0)	10 (3.8)

\*The total number of physicians was 264.

## 4. Discussion

To the best of our knowledge, this is the first study assessing the KAPs of Yemeni physicians regarding brucellosis, which is a neglected zoonosis with substantial public health implications. The findings revealed a high level of good knowledge, with 94% of surveyed physicians exhibiting good knowledge about brucellosis, indicating a high general awareness of the disease within the healthcare sector in Sana'a City. This finding aligns closely with a finding from Turkey,<sup>(17)</sup> where 93.1% of healthcare workers were reported to be aware of brucellosis but contrasts markedly with lower awareness levels reported for primary healthcare physicians in Saudi Arabia (55%),<sup>(18)</sup> medical practitioners in Pakistan (48.4%),<sup>(16)</sup> medical professionals in Namibia (73.4%),<sup>(13)</sup> and health workers in Tanzania (28.1%).<sup>(15)</sup>

Despite the high level of good knowledge among physicians in the present study, several important gaps have been identified, particularly in relation to occupational risks, transmission routes, and atypical clinical manifestations. In the present study, approximately 88% of physicians accurately identified animals as the primary source of infection with

brucellosis, and 89% recognized individuals engaged in animal breeding and farming as high-risk groups for infection. These findings indicate high awareness of the zoonotic nature of brucellosis among physicians in Sana'a. In contrast, 27.6% of Pakistani medical practitioners in Karachi identified brucellosis as one of the most common zoonoses.<sup>(16)</sup>

The low proportion of physicians in the present study (42.2%) who recognized laboratory personnel as being at high risk is concerning despite documented laboratory-acquired brucellosis through aerosol exposure, accidental inoculation, or mishandling of cultures.<sup>(19)</sup> This gap in awareness underscores the need for targeted training in laboratory biosafety and brucellosis risk communication. In terms of transmission modes, the majority of physicians correctly identified the consumption of raw milk (89%) and raw meat (69.3%) as significant routes of infection. Nevertheless, fewer high-risk exposures were recognized, such as handling animal placentas (44.7%), abortion materials (42.4%), and inhalation of contaminated aerosols (24.6%).

In the present study, physicians demonstrated a high level of knowledge about the common clinical manifestations of brucellosis. Fever was the most frequently recognized symptom (91.3%), which is in



line with its status as the hallmark feature of the disease. The majority of physicians also correctly identified several manifestations that are commonly observed in acute and subacute forms of the disease, including gastrointestinal symptoms (85.2%), neurological involvement (78%), hepatomegaly (77.3%), splenomegaly (75.8%), and lymphadenopathy (73.5%). These findings reflect the knowledge of physicians about the systemic nature of the disease and its effects on multiple organ systems. Recognition of these signs is crucial for the timely diagnosis and management of brucellosis, particularly in endemic regions, where patients may present with nonspecific or overlapping symptoms.

Physicians' knowledge of hematological abnormalities associated with brucellosis was variable. While most respondents correctly identified anemia (72.7%) as a common finding, just over half of physicians were aware of leukopenia and thrombocytopenia as associated hematological abnormalities. Conversely, more than half of the physicians (52.3%) incorrectly cited leukocytosis as associated with brucellosis. However, leukocytosis is generally atypical and, when present, often suggests a secondary bacterial infection rather than primary brucellosis. This misconception may lead to diagnostic confusion, as leukocytosis often directs clinicians toward bacterial infections other than brucellosis, particularly in febrile patients. Enhancing physicians' understanding of the typical hematological profile of brucellosis is crucial for accurate clinical assessment and appropriate diagnostic workups in endemic areas.

Regarding the treatment of brucellosis, the majority of physicians in the present study (72%) correctly identified the combination of doxycycline and rifampin as the recommended first-line regimen. This finding is consistent with that reported in Saudi Arabia, where 88.7% of primary healthcare physicians

had good knowledge about brucellosis treatment.<sup>(20)</sup> Likewise, in western Iran, most physicians (60.4%) prescribed the standard dual therapy of doxycycline and rifampin for patients with brucellosis.<sup>(21)</sup> Our finding is encouraging, as it aligns with the World Health Organization (WHO) guidelines,<sup>(22)</sup> which recommend a dual therapy consisting of doxycycline and rifampin for six weeks as the standard approach for brucellosis. The relatively high level of awareness among physicians regarding the WHO-recommended regimen is encouraging, as adherence to it is critical for effective disease management and relapse risk reduction, particularly in endemic settings such as Yemen. However, a minority of physicians had suboptimal knowledge regarding antibiotic regimens, with 12.1% and 2.7% incorrectly selecting monotherapy with doxycycline or rifampin, respectively. Monotherapy is generally discouraged due to a higher likelihood of treatment failure and relapse, as *Brucella* species are intracellular pathogens that require prolonged and combination therapy to ensure effective eradication.<sup>(23,24)</sup>

Physicians' attitudes toward brucellosis play a pivotal role in the early detection, appropriate diagnosis, and timely management of the disease. In this context, physicians' attitudes were overwhelmingly positive, with 92% expressing favorable views regarding the importance of the disease and its management. This high level of positive attitude is encouraging and may serve as a strong foundation for improving clinical practice and brucellosis control efforts in Yemen. In contrast, 72% of health workers in Tanzania had a positive attitude toward preventing and controlling brucellosis.<sup>(15)</sup>

A substantial majority of physicians in the present study (80.7%) emphasized the need to raise awareness of brucellosis among medical practitioners, reflecting a widespread recognition of the current gaps in knowledge and diagnostic practices.





Similarly, the majority of medical practitioners in Pakistan agreed or strongly agreed that continuing medical education seminars are valuable for raising awareness of brucellosis among medical practitioners.<sup>(16)</sup> Furthermore, in the present study, 78% of physicians agreed that brucellosis is frequently misdiagnosed, which is strongly supported by existing literature.<sup>(25-27)</sup> Similarly, 72% of medical practitioners in Pakistan agreed that brucellosis is often misdiagnosed.<sup>(16)</sup> Brucellosis is known for diverse and nonspecific clinical manifestations, often mimicking other febrile illnesses such as malaria and typhoid fever, which contributes to frequent diagnostic delays or errors, especially in endemic and resource-limited settings.<sup>(28)</sup> Misdiagnosis can lead to delayed treatment and inadequate management. In this study, 69.7% of physicians supported referring suspected cases to consultants, which further reflects a cautious and collaborative clinical approach that can improve patient outcomes in complex cases.

Physicians' attitudes toward tools for brucellosis diagnosis in the present study were supportive of serological testing, with 71.3% recognizing serological tests as reliable, compared to 62.5% considering blood culture to be dependable. This difference may reflect real-world concerns regarding the sensitivity of blood cultures, laboratory capacity, and time delays associated with culture-based diagnostics, particularly in low-resource settings. While blood culture is considered the gold standard, it has low sensitivity and is time-consuming.<sup>(29-32)</sup> On the other hand, serological tests are widely used, with the Rose Bengal test showing high sensitivity for screening.<sup>(32-34)</sup> In the present study, only 11.4% of physicians regarded imaging as a reliable diagnostic method for brucellosis, which aligns with the current clinical understanding that radiological findings in brucellosis are typically nonspecific. Although brucellosis

frequently affects the musculoskeletal system, with osteoarticular involvement ranging from 10% to 85%,<sup>(35)</sup> radiological imaging cannot confirm the diagnosis independently. Therefore, imaging is considered an adjunctive tool rather than a primary diagnostic modality to support the identification of complications such as spondylitis, osteomyelitis, or hepatosplenomegaly, lacking the specificity required to distinguish brucellosis from other infectious or inflammatory conditions.<sup>(23)</sup>

Notably, half of the physicians in the present study perceived that brucellosis constitutes a major public health problem in Yemen, which may stem from limited national surveillance data or a lack of institutional emphasis on brucellosis compared to other infectious diseases. This finding is concerning because brucellosis remains a significant zoonotic concern in the country due to the heavy reliance on livestock, widespread consumption of unpasteurized dairy products, and limited access to veterinary and medical services.<sup>(9)</sup> In agreement with the present study, 57% of medical practitioners in Pakistan believed that brucellosis represents a serious health issue.<sup>(16)</sup> Efforts to improve disease recognition and control must therefore be reinforced through public health initiatives, intersectoral collaboration, and sustained educational campaigns.

Effective diagnosis relies heavily on clinical suspicion and thorough patient history taking, making physicians' diagnostic practices crucial for identifying cases early and preventing complications. In the present study, 68% of physicians demonstrated an acceptable level of practice regarding brucellosis diagnosis, indicating a disconnect between knowledge and clinical practice. In contrast, 25% of primary healthcare physicians in Saudi Arabia and 46.9% of health workers in rural Tanzania showed good practices regarding brucellosis diagnosis.<sup>(15,20)</sup> In the present study, the majority of physicians did



not consistently inquire about contact with animals, or the consumption of raw milk or raw meat, with only 42.8%, 40.2% and 31.1% consistently inquiring about these risk factors, respectively. Similarly, 35.9% of medical practitioners in Pakistan reported inquiry about recent animal contact, and raw meat and milk consumption.<sup>(16)</sup> The failure to regularly investigate these exposures during history taking can lead to missed opportunities for early diagnosis.

Underdiagnosis of brucellosis, particularly in patients presenting with chronic fever, is a significant concern in clinical practice. Although chronic fever is a hallmark symptom of brucellosis, only 32.6% of the physicians in the present study ordered brucellosis testing. Brucellosis often presents with undulant or intermittent fever, which can persist for weeks or months if undiagnosed or untreated. This oversight can lead to prolonged morbidity and complications, emphasizing the need for increased awareness among physicians. Likewise, an increasing proportion of physicians requested brucellosis testing for cases presenting with recurrent fever and hepatosplenomegaly, anemia, arthritis, or headache. On the other hand, only 25% of physicians in the present study reported routinely requesting brucellosis testing for patients with a history of contact with cattle, and 8.7% reported requesting such testing for laboratory personnel. These findings indicate under-recognition of key epidemiological risk factors among the occupationally exposed population groups. Farmers, herders, veterinarians, and others involved in animal husbandry are at an increased risk due to regular exposure to infected animal secretions, placentas, and aborted fetuses. Meanwhile, laboratory-acquired brucellosis is a significant occupational hazard for healthcare workers, particularly in microbiology laboratories. Studies have shown that aerosolization during routine identification activities is the primary cause of exposure, accounting for 88%

of cases.<sup>(19)</sup> Therefore, medical education and continuous professional development should place greater emphasis on the importance of thorough occupational history taking and routine serological testing for high-risk groups exposed to occupational hazards of brucellosis, particularly in endemic areas.

Although the clinical features of brucellosis overlap with those of other febrile illnesses, only 45.8% of physicians reported considering malaria as a differential diagnosis in febrile patients. In contrast, most medical professionals (98.4%) in Namibia were found not to consider brucellosis as a differential diagnosis in cases of prolonged febrile conditions.<sup>(13)</sup> This finding suggests a possible diagnostic bias toward more common or familiar conditions, which can delay the identification and treatment of brucellosis.

This study provides initial insights into physicians' KAPs in Yemen regarding brucellosis as a neglected zoonotic disease. Nonetheless, a number of limitations should be acknowledged. First, the descriptive, cross-sectional design limits the ability to establish associations between physicians' knowledge or attitudes and their diagnostic and therapeutic practices, highlighting the need for future analytical research. Second, the relatively small sample size may limit the generalizability of the findings. Nonetheless, it is considered sufficient for estimating proportions with reasonable precision in this descriptive study and aligns with sample sizes used in similar KAP studies conducted in resource-limited settings. Importantly, the study was not designed to achieve statistical power for inferential analysis but rather to generate baseline data to guide future research and inform targeted interventions related to physicians' KAPs regarding brucellosis in the country. Third, self-reported data may have introduced social desirability bias, with participants potentially overstating their knowledge or adherence to recommended prac-



tices. Additionally, convenience sampling via online questionnaires may have introduced selection bias and limited the generalizability by excluding physicians with infrequent Internet access. However, this method was chosen because of its cost-effectiveness and feasibility in a resource-limited context to allow rapid data collection with minimal logistical barriers. To address these limitations, future research should consider longitudinal designs, incorporate qualitative methods, ensure broader geographic representation, and include a wider range and larger sample size of healthcare professionals.

## 5. Conclusion

Physicians in Sana'a City have good knowledge of brucellosis, particularly in relation to its animal reservoirs, primary transmission routes, and high-risk occupational exposures. However, gaps remain in their awareness of less common transmission methods and at-risk groups such as laboratory personnel. While typical symptoms like fever are widely recognized, more atypical or systemic manifestations receive less attention. Most physicians hold favorable attitudes toward the disease, acknowledging the role of continuing education, likelihood of misdiagnosis, value of consultant referral, and reliability of serological testing. Nevertheless, brucellosis is not widely perceived as a significant public health concern in Yemen. In practice, diagnostic approaches and history taking are inconsistently applied, with insufficient attention paid to key exposure risks and limited inclusion of brucellosis in differential diagnoses. Diagnostic testing also does not align with the broad clinical spectrum or occupational risks associated with this disease. To address these shortcomings, continuing medical education, targeted training, and adoption of standardized diagnostic protocols are essential to

improve physicians' practices related to the diagnosis and management of brucellosis.

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## Ethical approval and consent

Ethical approval for this study was obtained from the Research Ethics Committee of the Faculty of Medicine and Health Sciences at the University of Science and Technology, Sana'a, Yemen (Ethical Approval No.: 1446/0055/UREC/UST). In addition, informed consent was obtained electronically from all participating physicians through an online form, following a clear explanation of the study's objectives. All participant information was treated with strict confidentiality and was securely managed by the research team.

## Conflict of Interest

The authors declare no conflict of interest associated with this article.

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