

## Seroepidemiological survey of brucellosis and Q fever among high-risk occupations in northeast of Iran for first time

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### ABSTRACT

**Background and Objectives:** Brucellosis and Q fever are considered as occupational hazards to people in contact with domestic animals or their carcasses. The present cross-sectional study was carried out to determine the seroprevalence of brucellosis and Q fever among professions at risk in the North Khorasan Province, northeastern Iran during 2020.

**Materials and Methods:** In this study, 185 sera samples were collected from butchers, slaughterhouse workers, farmers, and veterinarians in different counties of the province. The collected sera were tested by ELISA test for the detection of IgG antibodies against *Coxiella burnetii* and *Brucella* spp. A questionnaire was filled for each participant to investigate demographic characteristics information (i.e., age, gender, educational status, occupation, years of occupational experience, and location), and any exposure to risk factors (animals Keeping, consumption of unpasteurized dairy products, exposure to ill or dead animals, tick bite, splashing animal fluids, travel history, and use of personal protective equipment) that could be associated with these infections.

**Results:** The seroprevalence of antibodies against *C. burnetii* and *Brucella* spp. were 17.2% and 19.4%, respectively. Twelve participants also had Q fever and brucellosis co-infection, with a prevalence of 6.4%.

**Conclusion:** Based on the results, it is concluded that brucellosis and Q fever occur among the high-risk populations in this area and it needs more surveillance to control the diseases by public health and veterinary authorities.

**Keywords:** *Coxiella burnetii*; *Brucella* spp.; High-risk population; Seroprevalence; Enzyme-linked immunosorbent assay; Iran

### INTRODUCTION

Many zoonoses are occupational diseases which appear out of close contact between human and an-

imals or their carcasses (1, 2). Brucellosis and Q fever have been established as occupational zoonosis, globally. These diseases affect many groups, especially who mainly deal with infected livestock such as veterinarians, abattoir workers, and dairy farmer without the use of personal and environmental protection measures (3, 4).

Q fever, a worldwide-distributed zoonotic disease caused by *C. burnetii*, is considered a significant public health problem in many countries except for New Zealand and Antarctica (5, 6). Human Infections most commonly occur through contaminated

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aerosols generated by ruminants particularly during parturition (5, 7), however, the infection can also be acquired via the ingestion of raw milk and unpasteurized dairy products, bites of ticks, and person-to-person contact (5, 6). Q fever should be considered a disease of an occupational hazard for farmers, slaughterhouse workers, veterinarians, and butchers who have regular exposure to livestock or their products (3, 4, 8). In livestock and animals, Q fever is mostly asymptomatic (6) but in humans, *C. burnetii* infection can present as asymptomatic, acute, or chronic forms (5, 6). Approximately less than half (40%) of infected people will manifest clinical signs of acute Q fever. The most common clinical symptoms consisting of a flu-like illness, atypical pneumonia, and hepatitis (5, 6). In the patients with chronic Q fever form (with a rate of about 5%), endocarditis, vascular infection, nonspecific fatigue, fever, weight loss, night sweats, hepatosplenomegaly as well as premature birth and spontaneous abortion have been reported. Moreover, the majority of patients infected with Q fever (roughly 60%) remain asymptomatic (4-6, 9). High phases II antibody titer suggests acute infection whereas both phases I and II antibodies are identified in chronic Q fever (4, 5, 9). Endemic to the Middle East, Q fever has been reported from different parts of Iran (5, 6, 10).

Brucellosis is the most common zoonotic disease in humans around the world that is caused by Gram-negative bacteria, *Brucella* spp. (11, 12). Human brucellosis is endemic in many developing countries especially in the Mediterranean, Central and South America, Asia North and East Africa, and the Middle-East; especially in Syria, Iraq, Egypt, Turkey, and Iran (11, 13-15). More than 500 million new cases of brucellosis per year globally are introduced according to the World Health Organization (WHO) reports (13, 16). Transmission to humans occurs mainly via the consumption of unpasteurized dairy products from infected animals. Also, direct or indirect contact with infected animals or exposure to tissues such as the placenta and birth can contaminate human (4, 13, 15). Brucellosis is an occupational disease in veterinarians, slaughterhouse workers, butchers, and farmers through close contact with livestock or their products (3, 4, 17). In humans, brucellosis causes a wide range of symptoms including weakness, undulant fever, headaches, myalgia, night sweats, arthritis, splenomegaly, hepatomegaly, pulmonary, cutaneous, and ocular involvement (4, 13, 18).

The overall seroprevalence of IgG phase I and II antibodies of Q fever in Iran were 19.80% and 32.86% respectively, furthermore, seroprevalence of antibodies against brucellosis was 15.4% overall (6, 14).

Positive findings for Q fever and brucellosis are based on common serological tests including rapid tube agglutination, standard tube agglutination (STA), immunofluorescence assay (IFA), Rose Bengal, Coombs-Wright, 2-mercaptoethanol (2-ME), and ELISA for both immunoglobulin M (IgM) and immunoglobulin (IgG) antibodies (4, 9).

As mentioned before veterinarians, slaughterhouse workers, and butchers are at risk of contracting Q fever and brucellosis. Due to the endemicity of brucellosis and to a lesser extent Q fever in Iran and since the shortage of recent epidemiologic data regarding the distribution of them in North Khorasan Province, the current study thus intended to prepare a seroepidemiological survey for these two important zoonotic diseases in this province by ELISA method. The objective of this study was to determine the seroprevalence of brucellosis and Q fever among veterinarians, slaughterhouse workers, farmers, and butchers with exposure to work hazards. The most common hazards for these groups similar to previous studies that have been done in Iran (9, 11, 17) were considered (animals keeping, consumption of unpasteurized dairy products, exposure to ill or dead animals, tick bite, splashing animal fluids, travel history, and use of personal protective equipment). This, to our best knowledge, has never been investigated before.

## MATERIALS AND METHODS

**Study area.** This cross-sectional study was carried out in North Khorasan Province in the northeast of Iran in 2020. North Khorasan is one of the three provinces that were created after the division of Khorasan in 2004. This province has a total area of about 28434 km<sup>2</sup> and is located in northeastern Iran. The climate is mountainous and moderate with cold winters. North Khorasan shares a long border with Turkmenistan in the north. Bojnurd city is the capital of the province. The counties of North Khorasan Province are Shirvan County, Esfarayen County, Maneh and Samalqan County, Raz and Jargalan County, Jajarm County, Faruj County, and Garmeh County (Fig. 1).

**Samples collection.** The blood samples were col-

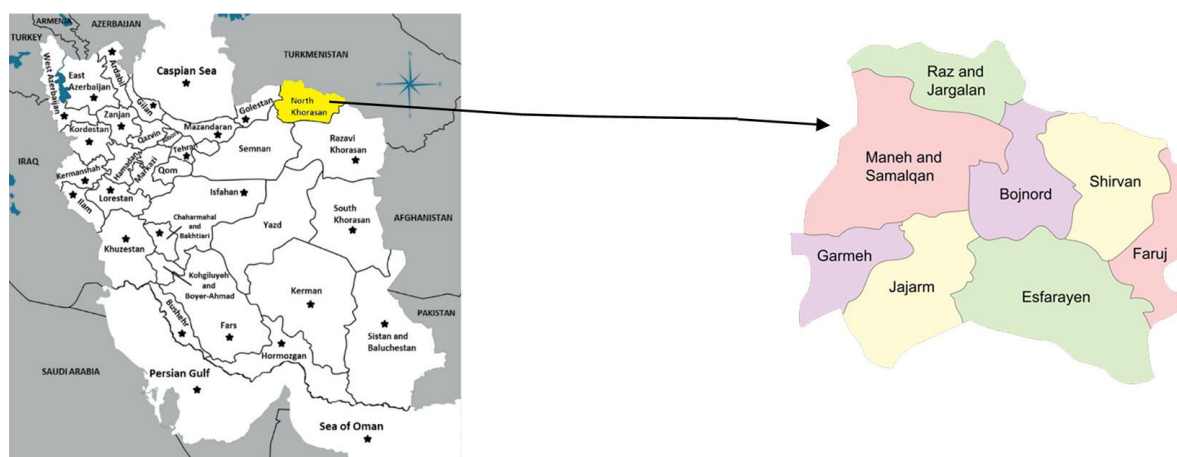


Fig. 1. Map of North Khorasan Province of Iran

lected from at-risk groups in all cities around the province. Four groups including butchers (33 subjects), slaughterhouse workers (30 subjects), farmers (70 subjects), and veterinarians (52 subjects) were tested in our study. A questionnaire including some demographic details was completed for each volunteer. 10 mL of blood samples in venouject tubes were taken from each individual. The blood tubes were transported to the laboratory under cool conditions. The blood clots were centrifuged for 5-10 min at  $800 \times g$  and the sera were stored at  $-20^{\circ}\text{C}$  prior to the serological examination.

**Serological tests.** In the present study, the enzyme-linked immunosorbent assay (ELISA) was used as a serodiagnostic tool. The IgG antibodies against *Brucella* and *C. burnetii* were detected using commercial ELISA kits (Vircell, Granada, Spain) according to the manufacturer's instructions. The following formula was applied to determine the upper and lower cut-offs: Lower Cut-off OD:  $0.9 \times \text{MW (STD)}$ , Upper Cut-off OD:  $1.1 \times \text{MW [STD and MW (STD)]}$ : mean standard OD.

**Statistical analysis.** The seroprevalence was calculated from the formula of the prevalence rate and dividing the number of positive cases by the population of each city. A logistic regression test was used to investigate the factors affecting the prevalence of the disease.

First, the relationship between each variable and the dependent variable was measured and variables with a P value less than 0.2 were selected for modeling and multiple regression and multiple logistic regression test was performed at a significant level of 0.05.

**Ethics approval and consent to participate.** The present study was approved by the Medical Ethics Committee of the North Khorasan University of Medical Sciences. (Ethic ID: IR.NKUMS.REC.1396.78). All participants' subjects submitted an informed written consent.

## RESULTS

In this study, 185 serum samples were obtained from employees in 4 occupational groups who were at risk for Q fever and brucellosis. The highest and lowest seroprevalence was found among farmers (54.8%,  $n=108$ ) vaccinator (4.9%,  $n=9$ ).

147 (79.5%) participants were male and 38 (20.5%) were female. The median age of the participants was 40 years and the median work experience was 12 years. Out of 185 participants, 36 ELISA test was positive and the prevalence of brucellosis was 19.4%. Also, 32 people were positive for Q fever and the prevalence of seropositive among these people was equal to 17.2%. Twelve participants also had Q fever and brucellosis co-infection, with a prevalence of 6.4%.

The results of univariate logistic regression showed that there is a significant relationship between the prevalence of brucellosis and the variables of age, sex, work experience, animal slaughter, education, occupation, and type of livestock at the level of 0.2, but according to the results of multiple regression test, age and sex has a significant relation with brucellosis. Women are 82% less likely to get brucellosis than men (OR = 0.82, P-Value = 0.02). Also, people over 40- years-old are 12% more than ones who are under 40-years-old (O=2.12, P-Value=0.04) (Table 1).

**Table 1.** Results from the bivariate logistic regression analysis of demographic predictors and Brucellosis using unadjusted odds ratios (ORs).

	No. Tested (% Seropositive)	Crude		Adjusted	
		OR	P-Value	OR	P-Value
Age (Median=40)					
≤40	14 (14)	-	-	-	-
>40	22 (25.8)	2.14	0.04	2.12	0.04
Sex					
Male	34 (23.1)	-	-	-	-
Female	2 (5.2)	0.185	0.02	0.18	0.02
Work History (median = 12)					
≤12	15 (15.7)	-	-	-	-
>12	21 (23.3)	1.62	0.19		
Slaughtering					
No	1 (4.3)	-	-	-	-
Yes	35 (21.6)	6.06	0.08		
Education					
Illiterate	11 (28.2)	-	-	-	-
Primary Education	11 (15.7)	0.47	0.12	0.25	0.03
Diploma	2 (8.3)	0.23	0.07	0.01	0.99
Associate degree,	5 (26.3)	0.9	0.88	0.16	0.25
Bachelor's degree, Master's degree,	7 (29.1)	1.04	0.93	0.07	0.12
Doctorate	0 (0)	0.001	0.99	0.01	0.99
Job					
veterinarian	2 (12.5)	-	-	-	-
Farmer	15 (13.8)	1.12	0.88	0.03	0.14
Stuff	5 (17.8)	1.52	0.64	0.11	0.34
Butchers	9 (37.5)	4.2	0.09	0.75	0.9
Vaccinator	5 (55.5)	8.75	0.03	0.33	0.64
Location					
Urban	19 (19.7)	-	-	-	-
Rural	17 (19.1)	0.95	0.9		
Family History					
No	26 (18.7)	-	-	-	-
Yes	10 (21.7)	1.2	0.65		
Consumption of unpasteurized dairy products					
No	12 (21.4)	-	-	-	-
Yes	24 (18.6)	0.83	0.65		
Animal Husbandry					
No	9 (20)	-	-	-	-
Yes	27 (19.1)	0.92	0.84		
Animal Type					
Sheep-Goat	16 (25)	-	-	-	-
Cow	1 (5.2)	0.16	0.09	0.28	0.3
Both	4 (12.9)	0.44	0.18	0.11	0.05
Abortion					
No	15 (18.2)	-	-	-	-
Yes	21 (20.3)	1.14	0.72		

**Table 1.** Continuing ...

Secretions					
No	8 (17)	-	-	-	-
Yes	28 (5.7)	1.24	0.62		
Travel History					
No	8 (18.6)	-	-	-	-
Yes	28 (19.7)	1.07	0.87		
Symptoms					
No	22 (19.1)	-	-	-	-
Yes	14 (20)	1.05	0.88		
Use of Personal Protective Equipment					
No	15 (17.2)	-	-	-	-
Yes	21 (21.4)	1.3	0.47		
Province					
Bojnurd	7 (23.3)	-	-	-	-
Shirvan	8 (22.8)	0.97	0.96		
Jajarm	0 (0)	0.001	0.99		
Garmeh	4 (30.7)	1.46	0.69		
Raz	1 (8.3)	0.29	0.28		
Faraj	3 (20)	0.82	0.8		
Mane Va Semelghan	10 (33.3)	1.64	0.39		
Esfarayen	3 (8.5)	0.3	0.11		
Tick bites					
No	20 (18.1)	-	-	-	-
Yes	16 (21.6)	1.25	0.54		

According to the results of the univariate regression test, there is a significant relationship between age, sex, work experience, occupation, family history, and history of animal husbandry and Q fever at a significant level of 0.2. However, according to the results of the multiple regression test, there is a significant relationship between sex and family history of the disease. Women are 68% less likely to have Q fever than men (OR = 0.32, P-Value = 0.04). Also, people with a family history of the disease are 200 percent more likely than people without a family history (OR = 3.05, P-Value = 0.007) (Table 2).

Some of the participants in the study had co-morbidities with brucellosis and Q fever. According to the results of a univariate regression test, age variables, and having a history of abortion at a level of 0.2 there was a significant relationship and according to the results of multiple regression tests, there was a significant relationship between the history of abortion and disease. People with a history of abortion were 33 percent more likely to get these two diseases at the same time than those whose cattle do not have a history of abortion (OR = 3.3, P-Value = 0.04) (Ta-

ble 3).

Results from the bivariate logistic regression analysis of demographic predictors and brucellosis, Q Fever, and both of them using unadjusted odds ratios (ORs) are summarized in Tables 1-3 respectively.

## DISCUSSION

In our research, we obtained the seroprevalence of two important occupational diseases among slaughterhouse workers, butchers, farmers, and veterinarians as high-risk populations to achieve their epidemiology in the North Khorasan province, northeastern Iran.

In 1973, the last human case of Q fever was reported in Iran, but recent reports show this infection in livestock, which so is widely distributed in different parts of the country (2, 4). Furthermore, due to difficulty in the clinical diagnosis of Q fever and long-term persistence of antibodies, the diagnosis is normally based on serological testing in most cases (2, 4, 19).

**Table 2.** Results from the bivariate logistic regression analysis of demographic predictors and Q Fever using unadjusted odds ratios (ORs).

	No. Tested (% Seropositive)	Crude		Adjusted	
		OR	P-Value	OR	P-Value
Age (Median=40)					
≤40	14 (14)	-	-	-	-
>40	18 (21.1)	1.65	0.2		
Sex					
Male	29 (19.7)	-	-	-	-
Female	3 (7.8)	0.34	0.09	0.32	0.04
Work History (median = 12)					
≤12	13 (13.6)	-	-	-	-
>12	19 (21.1)	1.68	0.18		
Slaughtering					
No	5 (21.7)	-	-	-	-
Yes	27 (16.6)	0.72	0.54		
Education					
Illiterate	9 (23)	-	-	-	-
Primary Education	13 (18.5)	1.05	0.95		
Diploma	4 (16.6)	0.79	0.79		
Associate degree,	3 (15.7)	0.7	0.71		
Bachelor's degree, Master's degree,	1 (4.1)	0.65	0.67		
Doctorate	2 (22.2)	0.15	0.14		
Job					
veterinarian	2 (12.5)	-	-	-	-
Farmer	17 (15.74)	1.3	0.73		
Stuff	4 (14.28)	1.16	0.86		
Butchers	8 (33.3)	3.5	0.15		
Vaccinator	1 (11.1)	87.0	0.91		
Location					
Urban	16 (16.6)	-	-	-	-
Rural	16 (17.9)	1.09	0.81		
Family History					
No	18 (12.9)	-	-	-	-
Yes	14 (30.4)	2.94	0.008	3.05	0.007
Consumption of unpasteurized dairy products					
No	9 (16)	-	-	-	-
Yes	23 (17.8)	1.13	0.77		
Animal Husbandry					
No	4 (9)	-	-	-	-
Yes	28 (19.8)	2.47	0.1		
Animal Type					
Sheep-Goat	12 (18.7)	-	-	-	-
Cow	3 (15.7)	1.2	0.75		
Both	5 (16.1)	0.97	0.97		
Abortion					
No	14 (17)	-	-	-	-
Yes	18 (17.4)	1.02	0.94		

**Table 2.** Continuing ...

Secretions					
No	9 (19.1)	-	-	-	-
Yes	23 (16.6)	0.84	0.69	-	-
Travel History					
No	10 (23.2)	-	-	-	-
Yes	22 (15.4)	0.6	0.24	-	-
Symptoms					
No	17 (14.7)	-	-	-	-
Yes	15 (21.4)	1.57	0.24	-	-
Use of Personal Protective Equipment					
No	15 (17.2)	-	-	-	-
Yes	17 (17.3)	1	0.98	-	-
Province					
Bojnurd	5 (16.6)	-	-	-	-
Shirvan	8 (22.8)	1.48	0.53	-	-
Jajarm	0 (0)	0.001	0.99	-	-
Garmeh	3 (23.1)	1.5	0.62	-	-
Raz	1 (8.3)	0.45	0.49	-	-
Faroj	0 (0)	0.001	0.99	-	-
Mane Va Semelghan	11 (36.6)	2.89	0.08	-	-
Esfarayen	4 (11.4)	0.64	0.54	-	-
Tick bites					
No	20 (18.1)	-	-	-	-
Yes	12 (16.2)	0.88	0.75	-	-

**Table 3.** Results from the bivariate logistic regression analysis of demographic predictors brucellosis and Q fever using unadjusted odds ratios (ORs).

	No. Tested (% Seropositive)	Crude		Adjusted	
		OR	P-Value	OR	P-Value
Age (Median=40)					
≤40	2 (2)	-	-	-	-
>40	10 (11.7)	6.53	0.01	-	-
Sex					
Male	12 (8.1)	-	-	-	-
Female	0 (0)	0.01	0.99	-	-
Work History (median = 12)					
≤12	5 (5.2)	-	-	-	-
>12	7 (7.7)	1.51	0.49	-	-
Slaughtering					
No	0 (0)	-	-	-	-
Yes	12 (7.4)	10.2	0.27	-	-
Education					
Illiterate	5 (12.8)	-	-	-	-
Primary Education	3 (4.2)	0.3	0.11	-	-
Diploma	2 (8.3)	0.61	0.58	-	-
Associate degree, Bachelor's degree, Master's degree, Doctorate	2 (10.5)	0.8	0.8	-	-
	0 (0)	0.01	0.99	-	-

**Table 3.** Continuing ...

Job					
Veterinarian	0 (0)	-	-	-	-
Farmer	6 (5.5)	1.2	0.3		
Stuff	1 (3.5)	1.1	0.34		
Butchers	4 (16.6)	2.2	0.23		
Vaccinator	1 (11.1)	2.1	0.4		
Location					
Urban	6 (6.25)	-	-	-	-
Rural	6 (6.7)	1.08	0.89		
Family History					
No	8 (5.7)	-	-	-	-
Yes	4 (8.6)	1.56	0.48		
Consumption of unpasteurized dairy products					
No	2 (3.5)	-	-	-	-
Yes	10 (7.7)	2.2	0.3		
Animal Husbandry					
No	1 (2.2)	-	-	-	-
Yes	11 (7.8)	3.63	0.22		
Animal Type					
Sheep-Goat	6 (9.3)	-	-	-	-
Cow	0 (0)	0.01	0.99		
Both	1 (3.2)	0.32	0.3		
Abortion					
No	2 (2.4)	-	-	-	-
Yes	10 (9.7)	4.3	0.06	4.3	0.04
Secretions					
No	2 (4.2)	-	-	-	-
Yes	10 (7.2)	1.75	0.47		
Travel History					
No	2 (4.6)	-	-	-	-
Yes	10 (7)	1.55	0.58		
Symptoms					
No	8 (6.9)	-	-	-	-
Yes	4 (5.7)	0.81	0.74		
Use of Personal Protective Equipment					
No	7 (8.1)	-	-	-	-
Yes	5 (5.1)	0.61	0.42		
Province					
Bojnurd	2 (6.6)	-	-	-	-
Shirvan	3 (8.5)	1.31	0.77		
Jajarm	0 (0)	0.01	0.99		
Garmeh	1 (7.6)	1.16	0.9		
Raz	1 (8.3)	1.27	0.85		
Faroj	0 (0)	0.01	0.99		
Mane Va Semelghan	5 (16.6)	2.8	0.24		
Esfarayan	0 (0)	0.01	0.99		
Tick bites					
No	20 (18.1)	-	-	-	-
Yes	12 (16.2)	1.07	0.9		



The findings of the current study, as the first in the province, revealed that the seroprevalence rate of Q fever IgG was 17.2% among high-risk populations. Several seroepidemiological studies related to Q fever carried out in Iran and reported different seroprevalence rates. For example, in a study in Ilam Province, the west of Iran, the overall seroprevalence (by ELISA) was 32.42% in high-risk populations (20). In another study in the Sistan va Baluchestan province in southeastern Iran, the overall seroprevalence (by ELISA) of *C. burnetii* was reported 22.5% among butchers and slaughterhouse workers in 2016 (4). Two separate serological surveys (by ELISA) were conducted by Khalili et al. on the high-risk populations including healthy slaughterhouse workers and veterinary students in Kerman (southeast of Iran) and the seroprevalence of Q fever was 68% and 34.7% respectively (19, 21). In Isfahan province, located in the center of Iran, a relatively high seroprevalence (by indirect immunofluorescence assay) of *C. burnetii* infection (43.1%) among the high-risk population was observed (9). Also, a comprehensive study was carried out on hunters and their family members, butchers, the staff of public health centers, and patients who were referred to laboratories; in Kurdistan province, and the seroprevalence of IgG antibody against Q fever was detected in 27.83% of participants (by ELISA) (2). In Fig. 2 we showed the prevalence of Q fever in each province. Moreover, several studies have been done among high-risk occupations in other countries with varying results; China (10%), Australia (5.2%), Denmark (11%), Spain (15.3%), and the USA (22%) (2, 22-26).



Fig. 2. Prevalence of Q fever in different provinces in Iran.

The results of the aforementioned studies are different from the results of this survey and the prevalence of Q fever in most regions of Iran and other countries were considerably higher. The difference may be due to the difference in the climate of sampling areas, geographical variations, laboratory tests, and different criteria were used. Considering the high rates of animal husbandry as one of the most important industries in North Khorasan, since longer exposure to infected livestock as the most important risk factor for the disease that already stated, we expected to have higher seropositivity compared to other areas but seropositivity was surprisingly much less than them. In the present study, probably, using personal protective equipment or type of hygiene precautions taken by individuals are the main reasons for the low seropositivity rate. Another hypothesis refers to the difference between the numbers of samples in similar studies. Besides, there was heterogeneity in the prevalence in different parts of the province; one possible justification for this finding is that the sample size was not the same in various regions. In our study, a positive significant association between seropositivity for *C. burnetii* and sex and family history of the disease have been identified. As expected, in the present study females had a lower rate compared to males with having longer exposure to occupational risks during work that these types of activities are more common in men. Furthermore, family history, as a risk factor associated with Q fever seropositivity, in high-risk occupations was identified which is directly engaged with keeping livestock and close contact with them (increased risk of exposure). Following our results, age, work experience, occupation, and history of animal husbandry were risk factors in the univariate regression test, but they were left out when the multiple regression test was used.

Brucellosis, as the most commonly neglected bacterial disease in the world, is an endemic disease in Iran and has been reported from different regions of our country (4, 27).

This survey reported that 19.4% of participants including slaughterhouse workers, butchers, farmers, and veterinarians had IgG antibodies to brucellosis. In Iran, few studies have been conducted among high-risk occupations and evaluated the presence of anti-*brucella* antibodies. In a cross-sectional study (by standard tube agglutination (STA)) in the west of Iran, Mamani et al. found that 13.3% of 218 participants including butchers, veterinarians, and

slaughterhouse workers were seropositive for *Brucella* which was lower than our finding (28). In other studies, were done among the mentioned high-risk occupational group in Sistan va Baluchestan and Guilan provinces, these rates were even less (7.9%, 9.8% respectively, using ELISA) (4, 29). In a systematic review by Ghajar et al. the seroprevalence range of brucellosis in high-risk populations has been determined from 12.3% to 13.7% in Iran (30). Various similar studies have been carried out in other countries and revealed different seropositivity rates among high-risk individuals around the world; in Pakistan 22%, 21.7%, and 6.9%, in Bangladesh 11.11%, in Saudi Arabia 35%, in India 25.5%, in Tanzania 19.5%, in Brazil 4.2%, and in South Korea 0.8% (31-38). The inconsistency between the results might be attributable to differences in the serological methods or the impact of climate change.

Based on the results of the multiple regression test in our study, there were associations between the age and sex of the investigated persons and the seroprevalence of brucellosis. Brucellosis was mainly found in 22 adult individuals aged over 40 years old (25.8%) which 23.1% of them were male. People with an age of >40 years are 12% more likely to be under 40 (OR = 2.12, P-Value = 0.04). The results of this study, which concur with those published from other studies (14), have also demonstrated that working-age male adults due to the increase in longer occupational exposure during their lifetime are more affected by brucellosis compared to females in different age groups. Given the above facts, male gender and older ages have been considered to be crucial risk factors associated with brucellosis seropositivity.

## CONCLUSION

This study is the first report on the seroprevalence of brucellosis and Q fever, as occupational hazards for certain professions, among high-risk populations in the North Khorasan Province in northeastern Iran. According to the results of the present study, a multitude of slaughterhouse workers, butchers, farmers, and veterinarians in the northeast of Iran was infected with *Brucella* spp. and *C. burnetii* which can be useful for health policy makers in their future planning to monitor and control these infections.

Moreover, the current study together with some other studies recently conducted in certain provinc-

es of Iran, indicate that many high-risk professions seem to be a risk factor for contracting brucellosis and Q fever, hence, it can be deduced that periodic occupational health monitoring programs in these groups are essential. Furthermore, acute Q fever may be manifested with influenza-like symptoms and, awareness of seroprevalence in a region will be helpful to its prevention.

Finally, it is highly recommended to carry out future complementary studies to more clearly define the epidemiological aspects of these diseases among high-risk populations in Iran which contribute to efficiently prevent and eradicate at due time.

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