



Knowledge, attitudes, and practices of rural and suburban areas about brucellosis in Central Bosnia

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ABSTRACT

Introduction: Brucellosis is a zoonosis classified as one of the most important neglected zoonoses in the world, especially in low- and middle-income countries with livestock farming represented. In recent years, an increased incidence of brucellosis has been reported in Bosnia and Herzegovina, particularly in the Central Bosnia Canton (CBC) region. In the CBC region, the first case of the disease was registered at the end of 2002 in the municipality of Novi Travnik. In the period 2003-2012, 539 cases in humans and 7508 infected animals were registered. The aim of this study is to assess the knowledge, attitudes, and practices regarding the risk of brucellosis in the population living in rural and suburban areas because human behavior plays a significant role in the spread of brucellosis.

Methods: It is a cross-sectional study conducted in selected rural and suburban areas of the CBC in the period from October 2023 to January 2024. In this study, 117 respondents participated with 60 respondents (51.3%) from rural areas and 57 (48.7%) from suburban areas.

Results: The respondents from rural areas showed better knowledge with an average score of $69.86 \pm 11.99\%$ than the respondents from suburban areas with an average score of 59.21 ± 11.86 ($p < 0.0001$). Looking at the average scores of the attitudes of the same regions, it can be seen that the respondents from the suburban region have a better attitude with $55.56 \pm 23.64\%$ ($p < 0.0001$) than the respondents from the rural region. In practice, the suburban region scored better with an average of $50.50 \pm 18.65\%$ than the rural region with $37.08 \pm 15.02\%$ ($p < 0.0001$).

Conclusion: The One Health approach, which involves collaboration between veterinary and public health professionals, is the key to successful brucellosis control.

Keywords: Brucellosis; Neglected zoonoses; Central Bosnia; Rural areas; Suburban areas

INTRODUCTION

Brucellosis is a zoonosis classified as one of the most important neglected zoonoses in the world, especially in low- and middle-income countries with livestock farming represented (1,2). The disease is caused by different types of bacteria of the genus *Brucella*. The source of infection is infected animals, either as sick individuals or as carriers, most commonly cattle, sheep, goats, pigs, dogs, but also horses, cats, and poultry (2).

Brucella is found in all parts of the body of an infected animal, with their concentration being highest in the gonads, the pregnant uterus, and the mammary glands. Infected animals excrete them through urine, milk, and after the

birth of young animals or after an abortion, through amniotic fluid, placenta, and vaginal secretions. Infected animals can be excreted from the body for months, sometimes even years. *Brucella* is a resistant bacterium that can survive for a long time in the external environment and particularly long in moist soil and water. They are also very resistant to desiccation, so they remain in the dust. The disease is transmitted directly between animals, sexually and through contact with placentas, aborted fetuses, and amniotic fluid, but also during grazing when infected and healthy herds are mixed or through contact with contaminated manure, pasture, or water (3).

Transmission of the infection from animals to humans occurs through the digestive tract, by contact, or aerogenically. Alimentary transmission occurs through the consumption of contaminated food of animal origin, usually raw, unpasteurized milk and dairy products made from it. Contact transmission occurs through direct contact of injured skin or conjunctiva with excretions, secretions, and

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tissues of an infected animal. This type of transmission is important for people involved in the slaughter of livestock. Aerogenic transmission occurs most frequently during the delivery of young animals, but also in laboratories. The symptoms of the disease appear after the *Brucella* has entered the body and a relatively long incubation period. The clinical manifestations are diverse, and the most common are chronic fatigue syndrome, recurrent fever, arthritis, and endocarditis (4,5).

The disease occurs occupationally and in the general population. Occupational diseases occur in people whose work brings them into direct contact with infected animals or samples, such as livestock breeders, veterinarians, slaughterhouse workers, and laboratory staff. Diseases in the general population are caused by the consumption of food of animal origin contaminated with *Brucella*. In a large number of patients with brucellosis, the clinical picture is non-specific, so the diagnosis is made late, which has a negative impact on the treatment. A major problem in diagnosing the disease in patients with suspected brucellosis is the inadequate resources of individual countries for monitoring this disease (2,5). Although the exact prevalence rate of brucellosis in humans worldwide is not known, there is a high prevalence in traditionally endemic areas such as the Mediterranean countries, along the Persian Gulf, in Central and South American countries, and in Africa, especially where sheep farming is developed. Brucellosis first appeared on the territory of the former Yugoslavia in 1947, but due to insufficient control measures, the disease spread to the surrounding countries (6).

After the introduction of measures, brucellosis was brought under control and appeared very rarely in the whole of Yugoslavia until the nineties of the past century. Bosnia and Herzegovina was free of brucellosis from 1980 to 2000, after which the disease recurred. The sudden increase in the number of patients, both human and animal, occurred after the war in Bosnia and Herzegovina, and the main reason was the importation of livestock to stimulate agriculture, unfortunately without adequate control measures at the border, where cattle positive for brucellosis were also imported. Although the preventive measure of mass vaccination of animals was introduced, which had a positive effect, the number of brucellosis patients has shown an increasing trend in recent years, especially on the territory of the Federation of Bosnia and Herzegovina, namely in three cantons, Central Bosnia Canton (CBC), Sarajevo Canton and Zenica-Doboj (7).

Brucellosis is endemic in these areas. In the area of CBC, the first case of the disease was registered at the end of 2002 in the municipality of Novi Travnik. In the 10-year period (2003-2012), 539 cases of the disease in humans and 7508 infected animals were counted. This area is characterized by livestock farming, which increases the risk of zoonotic diseases (8). Tackling the brucellosis problem has become a challenge, especially in developing countries, which further emphasizes the urgency of researching this disease and implementing the One Health approach (6). The importance of identifying and understanding risk factors requires the application of different approaches such as knowledge, attitudes, and practices (KAP) assessment. In many countries where there is a large population of small and large

ruminants as well as livestock farmers, KAP research is a widely accepted method for reviewing the state of knowledge (9,10).

The aim of this study is to assess the KAP related to the risk of brucellosis in the population living in rural and suburban areas, considered a particularly vulnerable population. To our knowledge, this is the 1st time this type of research has been conducted in Bosnia and Herzegovina. The collected data can be helpful in raising awareness to improve the existing approach to brucellosis, but also to other zoonoses in our country.

METHODS

The municipality of Travnik is located in central Bosnia and according to the administrative structure belongs to the CBC in the Federation of Bosnia and Herzegovina. According to the last census, 54.771 inhabitants live in the area of the town of Travnik and the surrounding 89 settlements. The municipality of Travnik covers an area of 563 km² at an altitude of 517 m above sea level and is mainly surrounded by forests and the mountainous terrain of the Vlašić Mountain and partly by flat terrain. The area is influenced by a temperate continental to mountain climate. The population is mainly engaged in agriculture and livestock farming. Agricultural production in the municipality of Travnik is characterized by natural production in family farms and to a lesser extent by commercial production, which is mostly not connected with the processing industry (11).

This cross-sectional study was conducted in selected rural and suburban areas of the CBC in the period from October 2023 to January 2024. Respondents were divided into two groups according to their place of residence. One group consisted of respondents with permanent residence in the villages around the town of Travnik and Mount Vlašić: Mudrike, Mehurić, Dub, Suhi Dol, Maline, Višnjevo, Gluha Bukovica, Sažići and Vitovlje. The second group consisted of respondents with permanent residence in the suburb of Turbe.

The criterion for participation was that the person had a permanent residence in one of the selected locations, that they were over 18 years of age, and that they voluntarily gave their consent to participate in the study.

The exclusion criteria are, in addition to another permanent residence, belonging to the same household, being under 18 years of age, not consenting to participate in the study, and an incorrectly or incompletely completed questionnaire.

The Ethics Committee of the University of Sarajevo - Faculty of Health Studies (number: 4-7-87/24) approved this study. Each respondent signed an informed consent to participate in the research and received an identification number to ensure complete anonymity. The statement in the introductory part of the questionnaire clearly emphasizes voluntary participation, anonymity, confidentiality, and the fact that the results will be used for research purposes only.

The questionnaire was prepared after reviewing the available literature by Baron-Epel et al., Mligo et al., Mburu et al., Aisha Urazaeva et al., with some modifications due to local specificities that are of importance, and with the advice and

approval of experts in the field. The questionnaires were in English and were translated into the local language. One person over the age of 18 from each household in rural and suburban areas took part in the survey.

The questionnaire contained 29 questions with suggested answers for rural areas and 24 questions for suburban areas (The questionnaire is attached). To compare knowledge, attitudes, and practice between suburban and rural areas, the scores were normalized on a scale of 0-100, with 0 being the worst possible score and 100 being the highest possible score, i.e. all answers are correct.

The analysis was carried out using the statistical package IBM Statistics SPSS v 23.0. The Chi-square test and the Mann-Whitney test with a statistical significance level of 95% were used to test for differences between the areas. Test results with $p < 0.05$ were considered statistically significant. The results are tabulated by the number of cases, percentage, arithmetic mean with standard deviation, and range of values.

RESULTS

The study included 117 participants who met the criteria for inclusion in the study. The structure of the sample

was uniform, with 60 respondents (51.3%) from rural and 57 (48.7%) from suburban areas.

In the suburban area, 32 (56.1%) of respondents belonged to the 21-30 age group, while in rural areas respondents over 50 dominated (36.7%). The analysis of respondents by gender shows that men predominate in the rural area (81.7% of respondents) and women (66.7%) in the suburbs ($p < 0.0001$). When analyzing the occupations of the respondents, we find that in the suburban areas, the majority of respondents, 36 (63.2%), are engaged in professional activities, while in the rural areas, a greater number of respondents, 40 (66.7%), are engaged in livestock and agriculture (Table 1). The level of education of respondents varied, but secondary education predominated in both areas. In the rural area, 26.7% of respondents completed only elementary school, while this number is significantly lower in the suburban area with 7% of respondents ($p < 0.0001$). Most households have four members, and there are no major differences in the number of household members between rural and suburban areas. In terms of animal ownership, 49 (85.9%) of respondents in suburban areas do not own animals, while in rural areas 47 (78.3%) households most commonly own cows, while goats and sheep are represented in a lower percentage. When asked if there were

TABLE 1. General characteristics of the population studied

Variables	Suburban		Rural		Total		X ²	p
	n	%	n	%	n	%		
Gender								
Man	19	33.3	49	81.7	68	58.1	28,054	0,0001
Woman	38	66.7	11	18.3	49	41.9		
Age								
21-30	32	56.1	11	18.3	43	36.8	18,191	0,0001
31-40	6	10.5	12	20	18	15.4		
41-50	9	15.8	15	25.0	24	20.5		
More than 50	10	17.5	22	36.7	32	27.4		
Occupations								
Professional	36	63.2	20	33.3	56	47.9	10,419	0,002
General	21	36.8	40	66.7	61	52.1		
Level of education								
No formal	0	0.00	1	1.17	1	0.9	25,152	0,0001
Elementary school	4	7.0	16	26.7	20	17.1		
High school	28	49.1	39	65.0	67	57.3		
University	25	43.9	4	6.7	29	24.8		
Number of household members								
Up to 2 members	5	8.8	8	13.3	13	11.1	5,583	0,061
Up to 4 members	38	66.7	27	45.0	65	55.6		
Up to 7 members	14	24.6	25	41.7	39	33.3		
Owning domestic animals								
Cows	6	10.5	47	78.3	53	45.3	9,702	0,008
Sheep	2	3.5	23	38.3	25	21.4		
Goats	4	7.0	4	6.7	8	6.8		
None of the above	49	85.9	6	10.0	55	47.0		
Do you know that there have been miscarriages in animals in your household or in your environment?								
Yes	3	5.3	15	25.0	18	15.4	8,747	0,003
No	54	94.7	45	75.0	99	84.6		
When you fertilize?								
Before planting	35	81.4	42	76.4	88	78.6	0,750	0,687
In the course of growth	2	4.7	5	9.1	7	6.3		
In all periods	6	14.0	8	14.5	17	15.2		

any abortions of domestic animals in the neighborhood or household, 5.3% in the suburban area and 25% in the rural area indicated that this was the case. Every household in the rural area and (50.9%) in the suburban area own farmland. When analyzing the results on fertilizer manipulation, it was found that 24.6% of rural respondents and 18.7% of suburban respondents fertilize at all stages of crop growth. Furthermore, the results show that (21.5%) respondents in both areas fertilize in all periods (Table 1).

Only a small number of respondents 8.8%, had never heard of brucellosis in humans, while 28.1% had never heard of this disease in animals, with most respondents coming from suburban areas. In both groups studied, the most common source of information about this disease was from friends 68 (58.1%), but a high percentage of 56 (47.9%) were also informed by other means. Respondents from suburban areas showed a better level of knowledge about the symptoms of brucellosis in humans than respondents from rural areas ($p < 0.0001$). All respondents from suburban areas and 78.3% of respondents from rural areas were aware of the symptoms of brucellosis in humans. According to the respondents from suburban and rural areas, the most common

symptoms of brucellosis in humans are fever 71 (60.7%), joint pain 64 (54.7%), and weakness 49 (41.9%). An almost equal number of responses are that domestic animals and humans can contract brucellosis, 88 (75.2%) were given by respondents from both areas ($p < 0.0001$), while both groups of respondents indicated that the most common route of transmission is from domestic animals per person 100 (85.5%). Regarding dairy transmission, most felt that the greatest risk for transmission of brucellosis is uncooked milk 88 (75.2), and rural respondents did not mention fresh cheese as a risk factor for transmission of brucellosis ($p < 0.0001$). The majority of respondents in suburban areas 50 (87.7%) believe that brucellosis can be transmitted using fresh/unpasteurized milk, while this number is slightly lower in rural areas 38 (63.3%). In rural areas, respondents also believe that fresh cheese is not a risk for brucellosis transmission, while this number is higher in suburban areas at 37 (64.9%) ($p < 0.0001$). In addition to dairy products, more than half of rural respondents 53 (88.7%) indicate that fresh, unwashed fruits and vegetables pose a risk for brucellosis transmission, while a lower level of knowledge was observed in suburban areas ($p < 0.0001$) (Table 2).

TABLE 2. Knowledge of the population in rural and suburban areas about brucellosis

Variables	Suburban		Rural		Total		χ^2	p
	n	%	n	%	n	%		
Have you heard of brucellosis in humans?								
Yes	52	91.2	59	98.3	111	94.9	3.033	0.092
No	5	8.8	1	1.7	6	5.1		
Symptoms in humans								
Back pain	21	36.8	13	21.7	34	29.1	28.906	0.0001
Fever	51	89.5	20	33.3	71	60.7		
Joint pains	39	68.4	25	41.7	64	54.7		
Headache	25	41.7	7	11.7	32	27.4		
Weakness	34	59.6	15	25.0	49	41.9		
I don't know	0	0.0	13	21.7	13	11.1		
Have you heard of brucellosis in animals?								
Yes	41	71.9	59	98.3	100	85.5	16.409	0.0001
No	16	28.1	1	1.7	17	14.5		
Who did you hear about brucellosis from?								
Friends	25	43.9	43	71.7	68	58.1	14.585	0.006
Education in school	21	36.8	7	11.7	28	23.9		
Other	33	57.9	23	38.3	56	47.9		
Who can get brucellosis?								
Only people	3	5.3	2	3.3	5	4.3	2.170	0.538
Only domestic animals	11	19.3	11	18.3	22	18.8		
Domestic animals and people	43	75.4	45	75.0	88	75.2		
Pets	0	0.0	2	3.3	2	1.7		
How can brucellosis be transmitted?								
Fresh unboiled milk	50	87.7	38	63.3	88	75.2	55.256	0.0001
Boiled milk	5	8.8	31	51.7	36	30.8		
Homemade fresh cheese	37	64.9	0	0.0	37	31.6		
Can brucellosis be transmitted through fruits and vegetables?								
Freshly washed fruits and vegetables	35	61.4	4	6.7	39	33.3	30.928	0.0001
Thermally processed fruits and vegetables	5	4.3	3	5.0	8	6.8		
Insufficiently washed fresh fruits and vegetables	30	52.6	53	88.3	83	70.9		
In which of the following ways can brucellosis be transmitted?								
From domestic animal to domestic animal	24	41.1	14	23.3	38	32.5	9.044	0.029
From domestic animals to humans	52	91.2	48	80.0	100	85.5		
From man to man	13	22.8	1	1.7	14	11.9		
From man to domestic animal	3	5.2	3	5.0	6	5.1		

Almost all respondents from rural areas 49 (81.7%) and 29 (50.9%) from suburban areas believe that fresh cheese and other dairy products made at home are healthier ($p < 0.0001$) (Table 3). The majority of rural respondents indicated that the dairy products they buy are safe 34 (56.7%). Suburban respondents have the opposite opinion. Almost half say they are not sure if the products they buy from acquaintances are safe (40.4%) ($p < 0.001$). The majority of rural respondents, 56.7%, and 45.6% of suburban respondents believe that brucellosis is a public health problem in Bosnia and Herzegovina ($p < 0.005$) (Table 3). Table 4 shows that more than half of the respondents (78.3%) come into direct contact with farm animals, including the birth of young animals, and that 36 (60.9%) of them are involved in the slaughter of farm animals. The devastating fact is that respondents predominantly bury material from abortions, placentas, and stillborn animals that may be infected with brucellosis in the manure they use to supplement fruits and vegetables. Considering that a larger proportion of the 36 respondents (65.4%) do not use protective equipment when in direct contact with animals, the potential risk of brucellosis transmission from infected domestic animals is unavoidable. According to the results of this study, 24.2% of the respondents in the rural region sell fresh milk over the counter. Most of the respondents, namely 61.76%, reported that they use fresh/unpasteurized milk for making homemade cheese, which is a risk factor for transmission of brucellosis.

It is worrisome that 56 (93.3%) of the respondents are supplied with water of unsafe quality, which is not regularly disinfected and hygienically tested. The majority of respondents from the rural region, 53 of them (88.3%), use fresh fertilizer for feeding fruits and vegetables in all stages of growth.

Table 5 shows that the majority of the respondents, namely 56 of them (98.2%) from the suburban region, regularly buy fresh milk and fresh cheese from the counter, which indeed indicates a high consumption of these products in the suburban region. The results show that as many as 51 (89.5%) of the respondents consume fresh cheese, which may pose a potential risk for transmission of brucellosis. In the suburban region, 50% of the respondents also

use fresh milk in the production of home milk. The results presented highlight that for 43 (74.7%) of the respondents in the suburban region, it is not important whether the dairy product they consume is made from pasteurized or unpasteurized milk. Furthermore, 8.8% of respondents stated that they do not wash fruits and vegetables regularly as they do not consider this a potential risk for the transmission of brucellosis.

Table 6 shows a comparison of the average values for KAP of inhabitants of suburban and rural areas. This shows that respondents from rural areas have better knowledge with an average of $69.86 \pm 11.99\%$ than respondents from suburban areas with an average knowledge of 59.21 ± 11.86 ($p < 0.0001$). Respondents from suburban areas have better attitudes $55.56 \pm 23.64\%$ compared to respondents from rural areas with an average of $36.94 \pm 19.67\%$ ($p < 0.0001$). Suburban residents have better practices with a mean score of $50.50 \pm 18.65\%$ compared to rural residents with $37.08 \pm 15.02\%$ ($p < 0.0001$).

DISCUSSION

This is the first study of its kind in Bosnia and Herzegovina, which investigated the KAP of the population in rural and suburban areas related to brucellosis as a re-emerging zoonosis. The importance of conducting this research in the CBC is due to the very high seroprevalence, which was reported at 35.71% in 2021, especially in rural areas (12). In addition, it is necessary to understand the cultural and traditional conditions that influence behaviors related to milk handling, as well as the daily practices and attitudes of the population of both regions that could pose a potential risk for brucellosis transmission. 117 individuals took part in our study, the majority of whom were from the rural region, 68 (58.1%), compared to 49 (41.9%) from the suburban region. The analysis of the demographic data shows that men dominated in the rural region with 81.7% of respondents, while female respondents predominated in the suburban region. The difference between the genders of respondents in the different regions, with a higher proportion of men in rural areas, suggests possible differences in activities related to agriculture, where men traditionally perform most of the labor tasks on farms or in animal

TABLE 3. Attitudes of respondents from suburban and rural areas toward brucellosis

Variables	Suburban		Rural		Total		X ²	p
	n	%	n	%	n	%		
Do you believe that fresh cheese and other dairy products made at home are healthier?								
Yes	29	50.9	49	81.7	78	66.7	16.348	0.0001
No	13	22.8	1	1.7	14	12.0		
I don't know	15	26.3	10	16.7	25	21.4		
Do you believe that the homemade dairy products you buy are not contaminated with bacteria because you buy them from people you know?								
Yes	14	24.6	34	56.7	48	41.0	13.831	0.001
No	23	40.4	10	16.7	33	28.2		
I don't know	20	35.1	16	26.7	36	30.8		
Does brucellosis a public health problem in Bosnia and Herzegovina?								
Yes	26	45.6	34	56.7	60	51.3	10.661	0.005
No	4	7.0	13	21.7	17	14.5		
I don't know	27	47.4	13	21.7	40	34.2		

TABLE 4. Practice of respondents from rural areas

Variables	Rural	
	n	%
Do you participate in the birth of young farm animals?		
Yes, regularly	33	55.0
Sometimes	14	23.3
No	13	21.7
Do you participate in the slaughter of domestic animals?		
Yes, regularly	26	44.1
Sometimes	10	16.9
No	23	39.0
Do I dispose of material from abortions, stillborn animals, and animal placenta?		
Burning	1	1.7
Burying in manure	31	51.7
Burial under the supervision of the veterinary service	3	5.0
Feeding dogs	11	18.3
Other	14	23.3
Do you use protective equipment (gloves, protective mask) when giving birth to young animals, helping, caring for livestock, and cleaning the area they are in?		
Yes, regularly	19	34.5
Sometimes	18	32.7
No	18	32.7
What type of milk do you use to make homemade fresh cheese?		
Boiled milk	10	29.42
Heated milk	3	8.82
Fresh milk	21	61.76
Where do you sell fresh milk?		
Buyers	25	75.8
At the market	1	3.0
Directly to customers	7	21.2
How are they supplied with water?		
Local water supply	56	93.3
Well	1	1.7
Local water supply and well	3	5.0
Do you use fresh manure to supplement fruit and vegetables?		
Yes, regularly	36	60.0
Sometimes	17	28.3
No	7	11.7

husbandry. In the rural region, a significant proportion of respondents were over 50 years old, compared to the suburban region where more than half of the respondents were between 21 and 30 years old. The results reported in our study regarding the general characteristics of the rural region are consistent with the results of the Greek study, in which the average age of respondents from the rural region was ± 49.36 years, with males dominating among the respondents (9). Considering that in our results on brucellosis symptoms in humans, 21.7% of respondents from the rural region did not know a single symptom, while respondents from the suburban region showed significantly good knowledge, the results obtained are consistent with the findings of a study from Uganda, in which all respondents knew the clinical signs of brucellosis in humans, mainly recurrent fever and joint and muscle pain (13). These results are also consistent with a study from Central Asia and

TABLE 5. Practices of the respondents in the suburban region

Variables	Suburban	
	n	%
Do you buy fresh milk and fresh cheese at the counter (street vending)?		
Yes, regularly	22	38.6
Sometimes	34	59.6
No	1	1.8
Do you or your family members eat fresh cheese?		
Yes, regularly	13	22.8
Sometimes	38	66.7
No	6	10.5
If you make cheese, what kind of milk do you use to make homemade fresh cheese?		
Boiled milk	3	37.5
Heated milk	1	12.5
Fresh milk	4	50
If you eat food that contains dairy products, do you ask whether it is made from pasteurized milk?		
Yes, regularly	14	24.6
Sometimes	14	24.6
No	29	50.9
Do you wash fresh fruits and vegetables with plenty of clean water before eating them?		
Yes, regularly	52	91.2
Sometimes	3	5.3
No	2	3.5

TABLE 6. Comparison of average scores for knowledge, attitudes and practices in suburban and rural areas

Variables	N	M \pm standard deviation	Range	Z	p
Knowledge					
Suburban	57	59.21 \pm 11.86	25.00-83.00	-4.349	0.0001
Rural	60	69.86 \pm 11.99	41.67-100.00		
Total	117	64.67 \pm 13.02	25.00-100.00		
Attitudes					
Suburban	57	55.56 \pm 23.64	0.00-100.00	-4.149	0.0001
Rural	60	36.94 \pm 19.67	0.00-83.33		
Total	117	46.01 \pm 23.53	0.00-100.00		
Practice					
Suburban	57	50.50 \pm 18.65	14.29-92.96	-3.793	0.0001
Rural	60	37.08 \pm 15.02	5.00-75.00		
Total	117	43.62 \pm 18.11	5.00-92.86		

South Africa (14,15). In contrast, a study in Ghana showed that only 4.5% of livestock owners were aware of at least one symptom of brucellosis, which shows us that our rural population has a basic knowledge of brucellosis (16). According to the results of the study by Moutus et al., all pastoralists surveyed (n = 204) knew about brucellosis (9). However, studies from Asia and Africa, which included a larger number of respondents, reported slightly lower levels of information about brucellosis (50%, 59.9%, 61.3%), although they had higher levels of education compared to the respondents in this study (16-18). The exception is the study by Deka et al. (2020), in which a 91.9% lack of information was reported (20). Slightly different results were reported in our study, where 94.9% of respondents were informed about brucellosis in humans compared to 98.3% in animals, with a higher percentage of those informed

coming from rural areas. One of the reasons for this is the higher frequency of reported cases of brucellosis in animals and humans in rural areas compared to suburban areas, although respondents from these areas had a higher level of education. In addition to the high level of information, 21.7% of respondents from rural areas do not know the symptoms that can occur in humans, while 28.1% of respondents from suburban areas do not know the symptoms in animals. Considering that knowledge of the route of transmission of brucellosis is important for the implementation of appropriate measures, the results of our survey showed that the usual route of transmission is from domestic animals to humans (75.4% vs. 75%). Similar results were reported by rural respondents from Portugal 74.7% (20). In addition, it is important to note that suburban respondents believe that human-to-human transmission is also possible. The literature reports that 68% of brucellosis cases are associated with human-to-human transmission of the *Brucella melitensis* pathogen. The main transmission routes are the placenta, transfusions and transplants of blood and bone marrow, the process of breastfeeding, and sexual contact (21). When analyzing the results to investigate the knowledge of the respondents, the values obtained showed significantly better results in the respondents of the rural region compared to the suburban region, which does not agree with the results of the study by Ghugay et al., who found low knowledge among rural respondents by analyzing that a small number of respondents had heard of brucellosis (4.71%) and that the source of information was medical personnel, which ultimately does not agree with the results of our study (22). Regarding close contact with animals, we can certainly point out that the majority of our rural population is in close contact with domestic animals, which includes lambing and slaughtering, which is not consistent with the results of the aforementioned Indian study that looked at similar practices of the rural population. In addition, the majority of rural people in our survey improperly dispose of placentas, stillborn animals, and animal placentas, with as many as 51.7% burying them in manure, which more than half of the respondents use fresh as a side dish with fruits and vegetables at all stages of growth, potentially increasing the risk of vegetarians and vegans contracting brucellosis. Our results are not consistent with the results of this Indian study, in which the livestock farmers used the mentioned materials exclusively for feed dogs, opening a new door for the possible spread of other zoonoses. The advantage of our study over the aforementioned one is that 34.5% of the rural population was vigilant in manipulating domestic animals and used protective equipment, while the population in the Indian region did not have any protective equipment. Slightly different results were obtained in Pakistan, where only a third of farmers reported removing placental intestines by burying them. Most disposed of them in manure or fed them to other animals. In addition, the majority of the rural population reported storing manure for more than 6 months and allowing their animal's access to this manure. As *Brucella* can survive in a moist environment (manure and soil) for several months, this can also pose a risk for disease transmission in animals (23). In Bosnia and Herzegovina, the traditional practice of preparing fresh cheese from unpasteurized milk is a widespread dietary

habit, which was confirmed in our study by research among the rural population. The results show that more than half of the respondents use unpasteurized milk. This data are consistent with data from Jordan, where the population also faces similar challenges in practice. Despite increased awareness of foodborne infection pathways, many farmers do not apply the important practice of boiling milk when preparing dairy products, increasing the risk of transmission of diseases such as brucellosis. In addition, when brucellosis is suspected, basic hygiene measures and placenta removal are often neglected, aborted material is also improperly buried in manure, and trade in suspect animals remains uncontrolled (24). While raw milk is frequently consumed in Egypt and Kenya, most households in Tajikistan are engaged in the processing and sale of unpasteurized dairy products, as is the case in Bosnia and Herzegovina. The commercialization of these products is often done without supervision, which can pose a risk to public health and food safety. In our study in Bosnia and Herzegovina, 60.6% of rural respondents use raw milk for cheese making and emphasize the role of raw goat milk in strengthening the immune system, especially in children and immunocompromised individuals (25-27). Unsatisfactory knowledge was reported from the rural areas of central Bosnia, which are mainly engaged in agriculture and livestock breeding. Rural respondents believe that fresh cheese does not pose a risk for brucellosis transmission, while suburban respondents indicated that the greatest risk comes from fresh, uncooked milk. In a study by Diez et al. (2013), 78.6 of respondents indicated that uncooked milk posed the greatest risk for disease transmission, while in our study 63.3% of rural respondents believed it was cooked milk. In our country, due to cultural beliefs, different types of dairy products are sold in both open street vending and household vending, which poses a great risk for transmission of brucellosis (20). Previous studies have shown that respondents have varying levels of knowledge about the transmission of brucellosis through dairy products. For example, a study from Pakistan reported that 62.7% of respondents from a rural area did not know that brucellosis can be transmitted through the consumption of unpasteurized milk, although the rural population surveyed was predominantly younger in age and had a high level of education compared to our study (18). An Indian and an Ethiopian study reported higher rates of fresh milk consumption among farmers, with the most commonly consumed type of fresh milk being goat and cow milk, which is an important consideration in the case of children due to the particular risk of brucellosis transmission (5,19). Given that the incidence of brucellosis in livestock and animals is higher in rural areas; rural respondents believe that their products are healthier and safer than those produced in markets. The attitude that their dairy products, such as cheese, are healthier than those offered on the market stems from their knowledge, as respondents pointed out that fresh cheese does not pose a risk for the transmission of brucellosis. Somewhat different results were obtained in a survey from Saudi Arabia, where 56.6% and 53.4% of parents, respectively, held the opposite opinion on this topic (28). As for the suburbs, respondents in this area tend to focus on buying dairy products due to the low level of breeding of domestic animals. However, due to the frequency of sales

from acquaintances and over the counter, respondents are not sure that the products they buy are not infected, unlike in rural areas. The results of the study by Baron-Epei et al. show a slightly different results in the urban region, where respondents had a more positive attitude toward this issue, indicating an increased risk of brucellosis transmission (29). A study by Abunna et al. (2024) showed similar results to our study in the rural population in terms of examining knowledge, attitude, and practice, with the results showing a good level of knowledge among the rural population, a negative attitude and rather poor practice regarding the potential risk of transmission of this zoonosis, as well as habitual risk behavior. It is disappointing that in this study, more than half of the respondents do not use protective equipment when working with domestic animals because gloves are not available, showing a much poorer practice in Ethiopia compared to our regio (30). The majority (95%) of milk produced in Ethiopia is sold through informal marketing systems and not through pasteurization plants, while in our study more than 70% of the rural population sells to buyers who carry out the pasteurization process, so we can safely say that the milk obtained is healthy. When analyzing the overall KAP in the suburban and rural regions, the scores obtained showed significantly better results in the attitudes and practices of respondents in the suburban region compared to the rural region, which is consistent with studies in Sudan and Tajikistan that have shown that farmers' and herders' practices regarding brucellosis and ways to prevent it are poor (27, 31, 32). Our study showed better knowledge among rural respondents, although our findings are not consistent with the research results from the Ardabil region of Iran, which has a very large livestock population but relatively low knowledge of zoonotic characteristics, transmission routes, and prevention measures of brucellosis (33).

CONCLUSION

Our study emphasizes the key role of knowledge, attitude, and practice in the control of human brucellosis. Therefore, assessing the general knowledge of high-risk populations about the disease, or attitudes and practices, is an important step in developing and implementing effective brucellosis control strategies and programs that meet the needs of the population. Although awareness of brucellosis is high in the study population, there is a significant gap in understanding the zoonotic nature of the disease, transmission routes, and preventive measures. This limited knowledge poses a major challenge to the effective control and elimination of the disease. The level of education as well as previous history of brucellosis showed a possible correlation with the outcome of knowledge about brucellosis.

In our research, the greatest risk for the transmission of brucellosis is associated with the use of thermally unprocessed milk and the consumption of cheese made from such milk, close contact with animals, and assisting with lambing and calving as well as inadequate handling of manure. The One Health approach, which involves collaboration between veterinary and public health experts, is key to successful disease control. It is recommended that similar KAP studies be conducted in other regions with intensive livestock and agricultural activity to gain a baseline understanding

of farmers' KAP that could serve as a foundation for future outreach programs.

Study limitation

The study was conducted in one part of Bosnia and Herzegovina, which may limit the generalizability of the results to other parts of the country. It is therefore recommended to conduct similar studies in other parts and regions of Bosnia and Herzegovina as well as in other neighboring countries to achieve better representativeness. In this study, a cross-sectional design was used, with data collected at one point in time. A longitudinal study could provide a better insight into changes in awareness, knowledge, and practices over time and help to identify trends or evaluate the effectiveness of awareness-raising measures. Considering that we used a questionnaire on KAP in the study without using diagnostic tools, we believe that this study would pave the way for investigating similar research using a combination of serological methods.

DECLARATION OF INTERESTS

Authors declare no conflict of interest.

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