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Brucellosis: An Investigation of the Knowledge, Attitudes and Behaviors Among a Selected Population in Majmaah Saudi Arabia

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ABSTRACT

Brucellosis is a zoonotic bacterial disease carried by animals such as sheep, cows, and camels. It is transmitted to humans through the consumption of affected animals or their by-products. Dairy products form a major part of the Arabic diet and are very widely consumed in Saudi Arabia, where brucellosis is endemic. This study has analyzed the current knowledge, attitudes, and behaviors toward brucellosis of adults aged 18 years and older among Majmaah University students and staff. A cross-sectional study with 181 participants was conducted using an online survey during March–April 2021. The results showed that the majority of people knew about brucellosis and its transmission, but only a fraction of them took the required precautionary measures. This study highlights that knowledge alone is insufficient to promote healthy behaviors. It is thus important to raise awareness in a way that can convert knowledge into action.

KEY WORDS: ATTITUDES, BEHAVIORS, BRUCELLOSIS, KNOWLEDGE, UNPASTEURIZED DAIRY PRODUCTS.

INTRODUCTION

Brucellosis is an infectious disease that spreads to humans through the consumption of unpasteurized dairy products and contact with livestock. It is most common in Middle Eastern countries among farm families who routinely handle livestock and dairy products. The results of a cross-sectional survey of Israeli respondents that sought to understand the purchase and consumption patterns of dairy products indicated a high-risk association of brucellosis with the consumption of unregulated dairy products (Baron-Epel et al. 2018; Nejad et al. 2020).

A survey in Jordan by Musallam et al. (2015) analyzed farmers' hygiene practices and found that 60% of livestock keepers were not boiling dairy products before use, which is a critical risk indicator of brucellosis. The lack of awareness of dairy product hygiene affects not only farmers directly, but also the people who consume such products in the supply chain (Nejad et al. 2020). Peck et al. (2018) conducted interviews with 51 small-scale goat farmers in Thailand to examine their knowledge, attitude, and practices (KAP) associated with brucellosis and found a low perceived risk. The researchers' analysis indicated a critical gap in knowledge and attitudes toward safe farm practices. Education and awareness training for farmers was thus considered a priority to contain the brucellosis endemic in Thailand. Kiffner et al.'s (2019) KAP analysis of Tanzanian residents revealed a demographic correlation between zoonotic diseases such as brucellosis and pathogenic transmissions, signifying that a careless attitude, limited knowledge, and the consumption of raw milk and meat are risky practices. Children who are highly exposed to livestock, dogs, and zoonotic pathogens may transmit such pathogens to their families as well as the people in those specific regions (Cavalerie et al. 2021).

Evaluation of the weak KAPs of Tajikistan farmers found a risk of brucellosis in about 30% of households (Nejad et al. 2020). In a survey by Cloete et al. (2019), only 60% of a cattle-keeping community in South Africa had heard of brucellosis, leaving the whole community highly vulnerable to the disease. The significant degree of risk provides essential insights into the alarmingly low awareness of brucellosis in urban and semi-urban areas (Cavalerie et al. 2021). Al Jindan (2021) argued that the diverse ethnicity of the workforce is a critical reason for the prevalence of *Brucella* or brucellosis in the Kingdom of Saudi Arabia (KSA), suggesting that people from various backgrounds and countries are potential carriers of zoonotic diseases. Alkahtani et al. (2020) conducted an epidemiological study

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in a KSA hospital and found demographic correlations between brucellosis and infected people. The results of the study showed that, during summer, 40.5% of young males were infected with *Brucella* (Alkahtani et al. 2020). The critical lack of standard KAP in the Saudi region was considered the primary factor in this high prevalence as the dearth of community awareness, practice of drinking raw milk, and unhygienic manufacturing in rural communities has resulted in a high rate of brucellosis in KSA (Alkahtani et al. 2020; Cavalerie et al. 2021).

Qasim et al. (2020) performed a specific medical analysis to understand the causes, complications, and clinical features of brucellosis in the Riyadh region. Their results indicated that nearly 15% required hospitalization from the samples that consumed large amounts of unpasteurized camel's milk (Qasim et al. 2020). A significant number of KSA livestock keepers engage in direct contact with the animals in their care, which carries a critical risk of spreading brucellosis to their families, communities, and the wider population. Al Hashan et al. (2017) conducted a study to determine the magnitude of brucellosis infection and the associated KAPs among the children of Najran City in southern KSA. They found that the children habitually ingested raw milk and dairy products, had contact with animals, and were constantly exposured to endemic areas and thus recommended that the rural areas of southern KSA implement more strategic plans to curb brucellosis. Aloufi et al. (2016) offered an analysis of the disease's trend. They showed that KSA had the highest rate of human brucellosis during the late 1990s and that, even though case numbers had plunged, it is still counted as an endemic disease in the country. This indicates that inadequate adherence to protective KAPs is responsible for this major health problem. Hosting diverse travelers, importing livestock, "supporting birth in infected livestock," unhygienic meat packaging, and the ingestion of raw milk products are the reasons for the existing cases of brucellosis in KSA (Al Anazi et al. 2019; Edathodu et al. 2021).

It has been suggested that KSA needs stricter policies and better awareness of hygiene and farm livestock maintenance (Al Anazi et al. 2019). Bakheet and Alnakhli (2019) reported that the infection rate in KSA is 70 per 100,000 people, which is significantly higher than that in other developed countries. KSA's socioeconomic mobility continues to be a strong cause of the existing endemic (Bakheet and Alnakhli 2019). According to the Ministry of Health Saudi Arabia, treatment policies to cure Malta fever, which is caused by brucellosis, include a clinical examination, laboratory tests, and a six-week program of antibiotics. The prevention guidelines include cooking meat at 63°C –74°C, avoiding unpasteurized dairy products, taking precautions in the workplaces, promoting handwashing, and wearing gloves when in contact with farm animals (Edathodu et al. 2021).

Because brucellosis is endemic in KSA and there are no specific health policies for brucellosis, it is crucial that public health officials, veterinary authorities, and governmental agencies disseminate information to support the essential KAPs and thus reduce the number of cases. This will not only strengthen the medical policies of the country, but also ensure a healthy population (Edathodu et al. 2021). In the current study, I assessed the knowledge and attitudes of Majmaah University staff and students regarding brucellosis as well as the amount of unregulated (homemade) dairy products purchased and consumed. I aimed to determine whether exposure to past cases of brucellosis in the individuals' communities had affected their behaviors. The study results may contribute to the planning of effective public health interventions.

Table 1. Showing Participants' Characteristics.

Participants Characteristics	Mean ± SD*/ percentage (frequency)
Age (in years)	30.88 ± 12.64
Gender	
Female	50.3 (91)
Male	49.2 (89)
Did not report	0.6 (1)
Marital Status	
Not married	40.9 (74)
Married	59.1 (107)
Job Group	
Academic	26.0 (47)
Administrative	6.6 (12)
Student	67.4 (122)
Income	
<5,000–10,000 SAR	42.0 (76)
10,001–20,000 SAR	34.8 (63)
20,001–30,000 SAR	5.0 (9)
>30,000 SAR	13.8 (25)
Did not report	4.4 (8)
Town	
With cases of brucellosis	54.7 (99)
Without cases of brucellosis	40.3 (73)
Did not report	5.0 (9)
History of brucellosis infection in the family	
No	95.0 (172)
Yes	5.0 (9)
Education	
School level	9.9 (18)
Diploma	0.6 (1)
Bachelor	49.2 (89)
Master	22.1 (40)
PhD	18.2 (33)

*SD: Standard deviation

MATERIAL AND METHODS

The cross-sectional study included a random online survey, which was distributed to multiple departments at Majmaah University during March and April 2021. The study was

approved by the Majmaah University Ethical Committee (no. MUREC-Feb/COM-2021/22-1). The study population included adults (18 years and older) who were either staff or students at Majmaah University. The survey garnered 181 responses (59 staff, 122 students). All the statistical analyses were conducted using SPSS 26.0 (IBM) and Factor 10.10.03 (Universitat Rovira I Virgili, Tarragona, Spain). I employed descriptive statistics, bivariate correlation tests (Pearson's test for continuous variables and Spearman's test for categorical variables), the Mann–Whitney *U* test, and binary logistic regression for the analyses. The Mann–Whitney *U* test was used because the knowledge and attitude scores were not normally distributed, as determined by both the Kolmogorov–Smirnov test and the Shapiro–Wilk tests. Multivariate binary logistic regression was applied after the necessary data assumptions had been verified. For all four models, there were no cases of multicollinearity (tolerance >0.1, variance inflation factors <10.0, inter-independent variable correlation coefficients <0.7) (Baron-Epel et al. 2018).

The linearity of the relationship between the continuous independent variables and the logit transformation of the dependent variable was met for three of the models. In one model with "Eating cheeses in unsealed packaging from unregulated sources" as the dependent variable, no linear relationship existed between attitude (the independent variable) and the dependent variable. For this model, the attitude score was therefore dichotomized. Attitude scores of 0–3 was coded as 0, indicating no or less agreement with the item, and a score of 3.1–5.0 was coded as implying agreement with the item. Hosmer and Lemeshow statistics were used to determine the model fit. Nagelkerke's R^2 statistics indicated that the variance was accounted for by the model (Baron-Epel et al. 2018).

RESULTS AND DISCUSSION

Participants' characteristics: The average age of the participants was 30.88 ± 12.64 years (Table 1). The participation proportion was nearly identical for men and women. Most (59.1%) of the study participants were married, and two-third (67.4%) were students. More than 75% of the participants recorded a monthly income in the range of 5,000–20,000 SAR. While the majority (54.7%) of the respondents indicated that their city had cases of brucellosis infection, most (95.0%) reported not having had a brucellosis infection in the family (Table 1).

Table 2. Distribution of correct responses to knowledge items across responses.

No.	Knowledge items	Correct responses % (n)		
		Responses with or without reported cases of brucellosis		
		With	Without	Total
1	*Brucella* can pass from a sick livestock animal to its milk.[#]	82.8 (82)	90.4 (66)	86.0 (148)
2	*Brucella* can cause serious illness and death.[#]	81.8 (81)	79.5 (58)	80.8 (139)
3	In humans, medications can be used to treat brucellosis.[#]	93.8 (91)	97.2 (70)	95.3 (161)
4	*Brucella* can be killed in dairy products if they are boiled or pasteurized to at least 63°C.[#]	73.7 (73)	69.9 (51)	72.1 (124)
	Mean[#] (0 = no correct answers, 5 = all correct answers; range: 0–5)	3.33	3.36	2.89

[#]Not significant. Tests employed: chi-square for items of the knowledge tool; Mann–Whitney *U* test for the mean knowledge score.

Distribution of knowledge about brucellosis: All four items used to assess the respondents' knowledge of brucellosis were loaded onto a single component that explained 52.8% of the variance. The knowledge subscale had good reliability, as indicated by a McDonald's ordinal omega value of 0.72 and a value of 0.88 for the greatest lower bound to reliability. Table 2 shows the distribution of the correct responses to the four knowledge items for the responses with and without reported cases of brucellosis. The percentage of correct responses (95.3%–72.1%) was high for all four items concerning knowledge of brucellosis. There were no significant differences in the percentage of correct responses for any of the four items in the knowledge subsection for towns with or without cases of brucellosis (Table 2). Younger respondents were associated with greater knowledge (the sum of all the knowledge item scores; $r = –0.41$, $p < 0.001$). In the entire survey, a total of four questions were posed to assess the participants' knowledge of brucellosis. The mean knowledge level for all the participants was 2.89, indicating that the subjects were aware of brucellosis, especially those who were younger. In KSA, the younger population tends to consume unpasteurized dairy products from livestock animals, especially in rural areas. Majmaah city is considered as a rural area with many farms. A population is more likely to be at risk of *Brucella* infection where poor hygiene is practiced in farming areas (Alaidarous 2018; Alqahtani et al. 2021).

Table 3. Attitudes toward the factors that increase *Brucella* transmission.[#]

Items	Mean	SD	Percentage agreeing (scores 4–5) with item
Homemade cheese is tastier than cheese purchased in sealed, certified packaging.	3.23	1.41	40.7
The milk from well-known dairies is not as fresh as milk prepared at home.	3.27	1.44	45.6
Homemade cheeses are free of bacteria because I get them from individuals who keep things clean.	2.69	1.28	26.1
I trust the people I buy cheese from.	2.89	1.30	30.9
Brucella bacteria will be killed if I heat the milk to at least 63°C.	3.39	1.24	45.6
Whether I get sick is a matter of luck; it does not relate to what I eat or drink.	1.67	1.12	8.6
Mean	2.86	0.72	

[#]On a scale of 1–5 (1 = do not agree at all; 5 = agree very much).

Table 4. Behavior associated distribution among responses.

No.	Behavior Items	Correct responses % (n)		
		Responses with or without reported cases of brucellosis		
		With	Without	Total
1	Drinking milk	91.9 (91)	93.2 (68)	92.4 (159)
2	Eating cheese	92.9 (92)	97.3 (71)	94.8 (163)
3	Preparing cheese from unpasteurized milk at home	12.4 (12)	5.5 (4)	9.4 (16)
4	Preparing cheese from pasteurized milk at home	27.3 (27)	26.0 (19)	26.7 (46)
5	Buying milk from unregulated sources[#]	16.2 (16)	11.3 (8)	14.1 (24)
6	Buying cheese from unregulated sources	6.2 (6)	9.6 (7)	7.6 (13)
7	Eating cheeses with unsealed packaging from unregulated sources	9.1 (9)	6.9 (5)	8.2 (14)
8	Eating white cheeses from unregulated sources	8.2 (8)	5.5 (4)	7.0 (12)
9	Drinking unpasteurized milk	15.3 (15)	13.9 (10)	14.7 (25)
10	Asking whether the milk you drink is from a pasteurized source	25.3 (25)	25.0 (18)	25.1 (43)
11	Drinking milk directly from a livestock animal, such as a goat, sheep, camel, or cow	50.5 (50)	38.4 (28)	45.3 (78)
12	Owning or visiting a farm with livestock animals, such as goats, sheep, camels, or cows	46.5 (46)	39.7 (29)	43.6 (75)
13	Experienced slaughtering a livestock animal, such as a goat, sheep, camel, or cow	58.6 (58)	69.4 (50)	63.2 (108)

[#]Not significant. Test employed: chi-square for items of the behavior tool.

Attitudes toward factors enhancing the transmission of brucellosis: All six items used to assess attitudes toward the factors that enhance the transmission of brucellosis loaded onto a single component and explained 39.9% of the cumulative variance. The attitude subscale had satisfactory reliability, as indicated by a McDonald's ordinal omega value of 0.68 and a value of 0.79 for the greatest lower bound to reliability. A small portion (8.6%) of the participating university students and staff showed a deterministic attitude (last item of Table 3). A large percentage of the study participants preferred the cheese and milk products made at home. This was reflected in 40.7% reporting that homemade cheese is tastier and 45.6% answering that home-produced milk products are fresher than those of major dairies (Table 3). A large percentage (45.6%) agreed that heating milk to at least 63°C will

kill *Brucella* bacteria. The unmarried respondents were associated with a higher score in their attitude toward the factors that promote the increased transmission of brucellosis (sum of all the attitudes item scores/no. of items; $r = –0.20$, $p < 0.05$) (Nejad et al., 2020).

The majority of the participants preferred their own cheeses made at home to the pasteurized ones sold in sealed, certified packaging, but many also demonstrated an awareness of the need to heat milk to 63°C to kill pathogens. A handful maintained that sickness and health are matters of fate or luck and that no additional precautionary measures were needed to prevent illness. It was also observed that the unmarried subjects were more likely to pursue activities that promote the transmission of brucellosis. These results are consistent with reports showing that the populations in multiple regions in KSA consume unpasteurized dairy products, especially those from camels, as part of their culture or to demonstrate the absence of fear of possible consequences. This may relate to low knowledge or awareness regarding infection caused by consuming dairy products in these regions (Alaidarous 2018; Alqahtani et al. 2021).

Table 5. Association between knowledge, attitudes, and behaviors regarding the practice of buying and consuming dairy products.

Type of Behavior		Knowledge[a]		Attitude[a]	
		Mean	SD	Mean	SD
Buying milk from unregulated sources	Yes	3.5	0.66	3.19	0.75
	No	3.3	0.87	2.81	0.71
	p	0.33		0.04	
Buying white cheese from unregulated sources	Yes	2.78	1.05	3.04	0.71
	No	3.37	0.82	2.84	0.73
	p	0.02		0.26	
Eating cheeses that come in unsealed packaging from unregulated sources	Yes	3.13	0.80	3.24	0.56
	No	3.33	0.85	2.83	0.73
	p	0.32		0.02	
Eating white cheese bought from unregulated sources	Yes	2.86	1.10	3.15	0.59
	No	3.36	0.82	2.82	0.73
	p	0.07		0.06	

[a] Mann-Whitney U test.

Table 6. Multivariate binary regression models: Predictors of the purchase and consumption of milk and milk products from unregulated sources.

Buying milk from unregulated sources

		Odds ratio	p	Confidence interval
Age (in years)		0.94	0.36	0.81, 1.08
Gender[a]		0.27	0.03	0.08, 0.87
Marital status[b]		1.52	0.68	0.21, 10.84
Job group	Academic	1	-	-
Job group	Administration	0.91	0.94	0.08, 10.48
Job group	Student	0.70	0.71	0.11, 4.63
Income	<5,000–10,000 SAR	1	-	-
Income	10,001–20,000 SAR	0.72	0.66	0.17, 3.09
Income	20,001–30,000 SAR	5.05	0.19	0.45, 56.21
Income	>30,000 SAR	0.88	0.89	0.14, 5.73
Town[c]		1.93	0.30	0.56, 6.60
History of brucellosis infection in the family[d]		0.35	0.50	0.02, 7.18
Knowledge		1.75	0.19	0.76, 4.01
Attitude		2.84	0.01	1.27, 6.37

Hosmer and Lemeshow statistics: $p = 0.27$; Nagelkerke's $R^2 = 0.23$

Buying white cheese from unregulated sources

		Odds ratio	p	Confidence interval
Age (in years)		0.97	0.64	0.83, 1.12
Gender[a]		0.33	0.17	0.07, 1.58
Marital status[b]		0.21	0.15	0.02, 1.78
Job group	Academic	1	-	-
Job group	Administration	0.00	1.00	0.00, 0.00
Job group	Student	1.44	0.74	0.16, 12.96
Income	<5,000–10,000 SAR	1	-	-
Income	10,001–20,000 SAR	0.30	0.25	0.04, 2.33
Income	20,001–30,000 SAR	1.20	0.90	0.08, 17.91
Income	>30,000 SAR	0.88	0.92	0.08, 9.76
Town[c]		0.87	0.84	0.23, 3.36
History of brucellosis infection in the family[d]		1.01	0.99	0.06, 16.52
Knowledge		0.61	0.26	0.26, 1.44
Attitude		1.96	0.19	0.72, 5.32

Hosmer and Lemeshow statistics: $p = 0.79$; Nagelkerke's $R^2 = 0.22$

Eating white cheese bought from unregulated sources

		Odds ratio	p	Confidence interval
Age (in years)		0.97	0.74	0.79, 1.18
Gender[a]		0.15	0.05	0.03, 0.96
Marital status[b]		0.28	0.40	0.02, 5.35
Job group	Academic	1	-	-
Job group	Administration	0.00	1.00	0.00, 0.00
Job group	Student	1.03	0.98	0.07, 15.14
Income	<5,000–10,000 SAR	1	-	-
Income	10,001–20,000 SAR	0.11	0.10	0.01, 1.57
Income	20,001–30,000 SAR	1.22	0.90	0.05, 28.85
Income	>30,000 SAR	0.20	0.35	0.01, 5.67
Town[c]		3.61	0.15	0.63, 20.50
History of brucellosis infection in the family[d]		0.31	0.52	0.01, 10.97
Knowledge		0.87	0.79	0.32, 2.41
Attitude		4.11	0.03	1.12, 15.03

Hosmer and Lemeshow statistics: $p = 0.12$; Nagelkerke's $R^2 = 0.30$

Eating cheeses that come in unsealed packaging from unregulated sources

		Odds ratio	p	Confidence interval
Age (in years)		0.62	0.05	0.39, 1.00
Gender[a]		0.03	0.01	0.00, 0.45
Marital status[b]		0.04	0.11	0.00, 2.03
Job group	Academic	1	-	-
Job group	Administration	0.00	1.00	0.00, 0.00
Job group	Student	0.01	0.03	0.00, 0.65
Income	<5,000–10,000 SAR	1	-	-
Income	10,001–20,000 SAR	0.04	0.09	0.00, 1.69
Income	20,001–30,000 SAR	32.89	0.10	0.53, 2051.03
Income	>30,000 SAR	0.03	0.13	0.00, 2.94
Town[c]		2.55	0.31	0.42, 15.46
History of brucellosis infection in the family[d]		0.16	0.36	0.00, 8.15
Knowledge		1.17	0.79	0.39, 3.53
Attitude dichotomized[e]	No/less agreement	41.42	0.00	4.45, 385.61

Hosmer and Lemeshow statistics: $p = 0.14$; Nagelkerke's $R^2 = 0.52$

[a]Reference group: men
[b]Reference group: not married
[c]Reference group: city with no reported cases
[d]Reference group: no brucellosis infection in the family
[e]Reference group: no/less agreement with the items of the subscale showing attitude toward the factors enhancing the transmission of brucellosis
SAR: Saudi Arabian riyal

Behavior associated with buying and consuming milk products: All 13 items used to assess the purchase and consumption behaviors associated with milk products loaded onto two components and explained 46.7% of the variance. The behavior subscale had excellent reliability, as indicated by a McDonald's ordinal omega value of 0.98 and a value of 0.83 for the greatest lower bound to reliability. Most of the participants or their family members used milk (92.4%) and cheese (94.8%) (Table 4). Of those preparing cheese at home, a small proportion (9.4%) used unpasteurized milk while a relatively higher percentage (26.7%) used pasteurized milk. The purchase of milk (14.1%) and cheese (7.6%) from unregulated sources was low (Table 4). The consumption of cheese from an unsealed package (8.2%) or unregulated sources (7.0%) was also low, while the consumption of unpasteurized milk (14.7%) was substantial. When consuming milk products, more than a quarter of the respondents inquired whether they were made from pasteurized milk. The drinking of milk drawn directly from a livestock animal was very common among the study participants (45.3%), and they commonly owned or visited a farm with livestock animals (43.6%) (Nejad et al. 2020).

The majority (63.2%) of the participants or their family members were experts in slaughtering livestock animals. The analysis of the participants' behaviors associated with the purchase and consumption of milk and milk products revealed that the majority of people consumed milk and milk products. While many of the participants took precautionary measures to prevent the transmission of brucellosis, others did not inquire about the source of their milk or milk products (Nejad et al. 2020).

Moreover, they also did not know whether the milk and cheese they were consuming had been pasteurized. They also purchased milk items from unregulated sources. As many of the participants were students, married, and earning 5,000–10,000 SAR per month, they likely purchased such products to reduce costs. Those who purchased milk from unregulated sources and cheese in unsealed packaging also demonstrated an attitude that promotes the transmission of brucellosis. Studies have shown that the young population in KSA constitute the higher percentage with this attitude. Young people are more outgoing and like to experience new things. Awareness of infectious diseases and how to prevent them therefore needs to be promoted widely (Al Anazi et al. 2019; Nejad et al. 2020).

Association between knowledge, attitudes, and behaviors regarding the purchase and consumption of dairy products: A significantly higher score in attitude toward the factors that promote the transmission of brucellosis (U = 1367.5, p = 0.04) was evident among those who purchased milk from unregulated sources (Table 5) (Alqahtani et al. 2021).

A significantly higher score in attitude toward the factors that promote brucellosis transmission (U = 729, p = 0.02) was also observed in those (or their family members) who consumed cheeses presented in unsealed packaging from unregulated sources (Table 5). Although the participants displayed impressive behaviors, attitudes, and knowledge regarding brucellosis and its transmission, a gap remains in translating that knowledge into practice. Knowledge, if not implemented, cannot reduce instances of brucellosis in KSA. Because milk and milk products form a major part of the Saudi diet, it is important that people know they must purchase dairy and meat items only from well-known, certified sources that properly pasteurize their milk and cheeses (Alaidarous 2018; Alqahtani et al. 2021).

Multivariate analysis: Predictors of the purchase and consumption of milk and milk products from unregulated sources: Four distinct binary logistic regression models were run to identify the predictors of four aspects of the purchase and consumption of milk and milk products from unregulated sources. The model with nine predictors, namely, age, job, gender, knowledge, income, town (with or without cases of brucellosis), history of brucellosis infection in the family, and attitude toward the factors enhancing brucellosis transmission, was significant in comparison to the model with intercepts only for classifying those who reported purchasing milk from unregulated sources: $\chi 2$ (12, N = 153) = 21.4, $p < 0.05$. Male gender and a higher score in attitude toward the factors enhancing the transmission of brucellosis were associated with purchasing milk from unregulated sources (Table 6). This is consistent with previous studies showing that men in KSA have higher cases of *Brucella* infection than women (Alaidarous 2018; Edathodu et al. 2021).

Furthermore, the model with nine predictors (i.e., age, job, gender, knowledge, income, town [with or without cases of brucellosis], history of brucellosis infection in the family, and attitude toward the factors enhancing brucellosis transmission [dichotomized score]) was significant in comparison to the model with intercepts only for classifying those who recorded purchasing and consuming cheeses in unsealed packaging from unregulated sources: $\chi 2$ (12, N = 154) = 39.8, $p < 0.001$. Male gender, younger age, and stronger agreement in attitude toward the factors enhancing the transmission of brucellosis were associated with purchasing milk from unregulated sources (Table 6). The consumption of livestock animals and their products is a cultural practice in the region, with people both drinking cow, sheep, and camel milk and consuming their meat (Alaidarous 2018). However, it seems that the majority of people involved in the supply chain are unaware of this infection and how it can be prevented. The disease has become so prevalent that it is deemed endemic in KSA (Nejad et al. 2020). The primary cause of brucellosis in the country is the significant consumption of milk, yogurt, cheese, and meat products. Many people are unaware of the concept of pasteurization, in which food items are heated to a specific temperature to halts all pathogenic activity, thus making it safe to consume meat and dairy products (Alaidarous 2018; Nejad et al. 2020).

CONCLUSION

Although there has been a reduction in brucellosis cases in KSA, the findings of the present study support the need to encourage people in KSA to cook their meat products

thoroughly, so that the chances of infection can be reduced even further. Furthermore, in closing the gap between knowledge and practice, it is important to include all those in the supply chain who deal with dairy and poultry products at various stages so that not only consumers but also manufacturers can play a role in preventing the transmission of brucellosis.

Data Availability Statement: The database generated and /or analysed during the current study are not publicly available due to privacy, but are available from the corresponding author on reasonable request.

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