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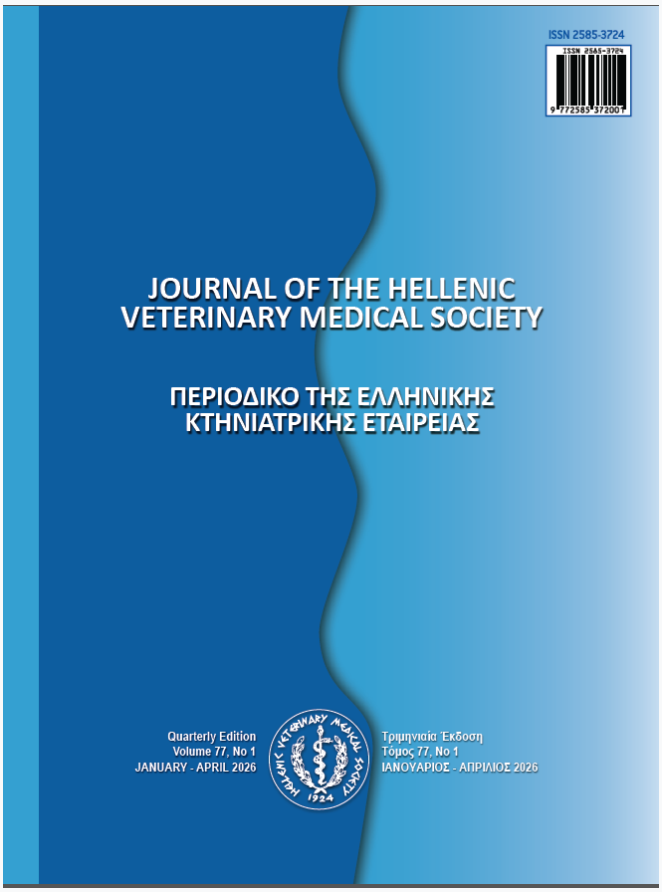

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Research article
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Expert perspectives on brucellosis control: challenges, risk factors, and management strategies in Iranian livestock

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ABSTRACT: Brucellosis, one of the most common zoonotic diseases, affects the livestock sector and poses a significant threat to human health. The WHO and WOAH have advised efforts to manage or eradicate brucellosis, although only a few developed countries have achieved this. In this study, a qualitative study employing a questionnaire tool under a snowball sampling technique at the national level helped to assess the expert viewpoints on animal brucellosis in Iran. This survey research was conducted from September 2022 to February 2023 by a questionnaire using the approach of expert opinion, which consisted of three main fields concerning the status and management of brucellosis in Iran, demographic data of experts, and risk factors connected with brucellosis on dairy farms. A total of 481 experts, primarily veterinarians, participated, and the response rate was 68%. An expert review of the questionnaire ensured validity, while reliability was measured using Cronbach's alpha coefficient. The responses show essential insights into the management challenges of brucellosis control, such as improving vaccination strategies, testing new cattle for brucellosis, and educating farmers. Most experts supported regular vaccination, but farmer cooperation, insurance policies, and compensation for testing and culling were noted as concerns. Expert assessments of various risk factors highlighted the introduction of untested cows and poor farm hygiene as significant threats to brucellosis control in Iran. Therefore, it highlights the need for an effective strategy in brucellosis prevention, farmers' engagement, and systemic support because of the increasing incidence rate among veterinary professionals and farm workers.

Keyword: Brucellosis; livestock health; expert opinion; disease management; vaccination strategies; dairy farm risk factors

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INTRODUCTION

Brucellosis is a prevalent zoonotic disease on a global scale (McDermott et al. 2013). Although several industrialized countries have eradicated brucellosis, it is still a significant public health concern in Asia, the Mediterranean, Latin America, Africa, and the Middle East (Dadar et al., 2025). Substantial financial losses result from the impact of brucellosis on the cow industry and worldwide livestock trade. Direct contact with infected animals or consuming contaminated dairy products also directly risks human health (Godfroid et al. 2013). Different national conditions affect the efforts at eradication in different ways (Rubach et al. 2013). Although several countries have made great strides toward eradicating animal brucellosis, most underdeveloped countries, like Iran, still have difficulties reaching total eradication. The main goals of controlling brucellosis are health safety, economic loss prevention, and better trade possibilities. Efforts to control brucellosis in Iran began in 1967 and included mass immunization, test-and-slaughter programs, farmer education, and quarantine policies (Esmaeili 2014). Iranian Veterinary Organization (IVO) has supported the required control programs in livestock farms. Effective control of neglected zoonotic diseases depends on the benefits of inter-sectoral cooperation guided by the "One Health" concept (Organization, 2015). Strong worldwide leadership, active national engagement, and concrete local results are essential to further the application of cross-sectoral approaches. In recent years, 0.3% of industrial and semi-industrial dairy cows in Iran had brucellosis. Improving public health, lowering economic losses, and increasing trade prospects in Iran's cattle industry depend on efforts at brucellosis control aligned with the "One Health" idea. However, this estimate does not account for other traditionally kept animals that may increase occurrence (Esmaeili 2014). A study evaluated 3322 Iranian industrial and semi-industrial dairy farms for brucellosis, and 131 were positive (Bahreinipour et al. 2023). *Brucella abortus* biovar 3 and *Brucella melitensis* biovar 1 were the most common strains in dairy cattle farms. In addition, *B. melitensis* biovar 2, 3, *B. abortus* biovar 1, and RB51 vaccination were limited to certain regions (Alamian et al. 2024; Dadar et al. 2019). Different studies reported that brucellosis is a considerable problem in managing dairy cattle farms in Iran (Alamian et al. 2023; Dadar et al. 2021; Zowghi and Ebadi 1982). Therefore, this study aims to assess the current situation, risk factors, and management techniques for controlling brucellosis in dairy cattle farms in Iran. It seeks to evaluate professional views on disease frequency, pinpoint essential risk factors, and assess the efficacy of current control strategies, such as vaccination, education, and quarantine rules.

MATERIAL AND METHODS

Questionnaire preparation

This qualitative study used the expert opinion method from September to February 2023. The initial questionnaire was prepared by referring to the studies conducted and the research team's experiences. The questionnaire questions included three aspects: The first part included experts' views on the status of brucellosis in Iran and its management, where the statements were presented, and respondents expressed their opinions from completely disagree to agree (Likert scale) completely. The second part addressed the main risk factors of brucellosis in dairy farms separately, each presented as a question, and respondents were asked to rate the risk of each from one to ten. The final section of the questionnaire included the personal details of the expert, which comprised age, gender, educational qualification, place of activity, work experience, and province of activity (The questionnaire is included as a supplementary file).

Validity of the questionnaire

The initial questionnaire was sent to 6 specialists in brucellosis (from government organizations, Razi Institute, and universities). The final questionnaire was prepared after their review and revision of the questions. Therefore, the questionnaire's validity was of the content validity type.

Reliability of the questionnaire

This index also considered the calculation of Cronbach's alpha coefficient (for evaluating the internal consistency of the questionnaire) following the formula below:

$$\alpha = \frac{N}{N-1}\left(1 - \frac{\sum_{i=1}^{N}\sigma_{Y_i}^2}{\sigma_X^2}\right)$$

N = number of items (or questions) in the scale.
$\sigma_{Y_i}^2$ = variance of the i-th item.
σ_X^2 = variance of the total score (i.e., the sum of the item scores for each respondent).

The Cronbach's alpha coefficient in the study is 0.71.

Selection of experts

The authors identified the interviewed specialists through established networks because of their expertise in prioritizing animal health. For this purpose, in coordination with the Animal Health Management Office, a letter was sent to the provincial veterinary offices requesting they introduce active experts in brucellosis (employed in organizational and private sectors). After about a month, the names and mobile numbers of 696 individuals from the provinces of Iran were received.

Sending the questionnaire

The questionnaire prepared in the " Porsa " system, which belongs to the Iranian Research Institute for Information Science and Technology, was implemented. Its link was sent to the selected community through SMS to experts and a letter from the Animal Health Management Office to the provinces. Additionally, during the days of the Large Animal Clinicians Congress (ECLAP 2023), after in-person discussions with several clinicians and experts, the questionnaire link was sent to them, and 8 of them completed the questionnaire.

Data analysis

The completed questionnaires' output was extracted and analyzed as an Excel file from the Porsa system. Information was extracted through a standardized template derived from the question guide, and summaries of the interviews were generated. The data output from the Pars system was prepared in Excel format, and the data analysis was performed using SPSS software (version 25).

RESULTS

In total, 481 experts on brucellosis completed the questionnaire by visiting the provided link. If we subtract 8 university professors from this number (473 people), the response rate to the questionnaire was 68 percent.

Of 481 respondents, 449 (93.3%) were men, and the rest were women. The average age of the participants in the study was 42.7 (±8.4) years. The minimum and maximum ages of the respondents were 27 and 73 years, respectively. The mean work experience of the individuals was 15.9 (±2.8) years, with minimum and maximum values of 1 and 38 years, respectively. In terms of educational level, approximately 79 percent of the participants held a Doctor of Veterinary Medicine degree, and 12 percent had a specialized doctorate (Table 1).

Table 1. Profile of informants (experts) involved in the study (qualitative interview).

Profile	Categories	Number (%)
Gender	Women	32 (6.4)
	Men	449(93.3)
Expertise area	Veterinary Organization	394(81.9)
	Private sector	79(16.4)
	University	8(1.7)
Education Level	Associate's Degree	12 (2.5)
	Bachelor's Degree	26 (5.4)
	Doctor of General Practice	379 (78.8)
	Specialist Doctorate	64 (13.3)
Province of the major activities	West Azerbaijan	40 (8.3)
	Khorasan Razavi	34(7.1)
	Kermanshah	33(6.9)
	Kerman	32(6.7)
	South Khorasan	27(5.6)
	Sistan and Baluchestan	27(5.6)
	Yazd	25(5.2)
	East Azerbaijan	24(5)
	Tehran	23(4.8)
	Kurdistan	23(4.8)
	Ilam	18(3.7)
	Khuzestan	16(3.3)
	Markazi	16(3.3)
	Gilan	15(3.1)
	Isfahan	14(2.9)
	Hamadan	13(2.7)
	Lorestan	12(2.5)
	North Khorasan	11(2.3)
	Zanjan	11(2.3)
	Semnan	11(2.3)
	Kohgiluyeh and Boyer-Ahmad	11(2.3)
	Fars	10(2.1)
	Qazvin	8(1.7)
	Qom	7(1.5)
	Alborz	5(1)
	Ardabil	3(0.6)
	Bushehr	3(0.6)
	Chaharmahal and Bakhtiari	3(0.6)
	South Kerman	1(0.2)
	Fars - Alborz – Tehran*	1(0.2)
	Qazvin and Semnan**	1(0.2)
	Golestan	1(0.2)
	Mazandaran	1(0.2)
	Hormozgan	1(0.2)

*and **, These categories refer to experts whose professional activities span multiple provinces. These individuals are involved in brucellosis control and related work across two or three provinces rather than being based in a single location.

The workplace of 82% of the participants was from the IVO, while the others were from the private sector (16.4%) and universities (Table 1). The highest number of participants was from the provinces of West Azerbaijan, Khorasan Razavi, Kermanshah, and Kerman (each with over 30 people). In contrast, only one person from each of the provinces of Golestan and Mazandaran completed the questionnaire (Table 1).

The results of Table 2 indicate the differing opinions of brucellosis experts regarding vaccination and control of brucellosis in cattle herds. According to the data, most individuals (83%) supported regular vaccination with a full dose in dairy farms, and 74% of experts also supported vaccination with a reduced dose. However, there are different opinions regarding the cooperation of farmers with vaccination teams. 65.3% of the expert persons have reported appropriate cooperation of farmers in vaccinating calves, which comes down to 50.5% in vaccinating adult cows. Regarding foreign vaccines, 25.6% of farmers like to use them, 29.3% agree, 23.3% are undecided, and 21.8% oppose it. Regarding other issues, such as mandatory insurance against brucellosis, the majority (65.9%) consider it a suitable plan. Still, farmers' satisfaction with the insurance compensation conditions has been low, with 72.4% dissatisfied. Furthermore, the responses also indicate that farmers' cooperation with the testing and culling teams has decreased over the past years. 83.8 % of the respondents feel that the failure to pay compensation by the concerned organizations has resulted in a decline in the willingness of the livestock farmers to cooperate with the teams. Again, 87.8% of the farmers in semi-industrial units have agreed to a deterioration in their cooperation with these teams due to a lack of compensation. On vaccination and brucellosis testing in farms, 78.8% of the respondents said that IVO laboratories have sufficient accuracy and reliability for the tested samples. In comparison, 41.8% of farmers believe granting licenses to private laboratories could effectively reduce brucellosis. Regarding the use of the S19 vaccine compared to the RB51 vaccines, 42% of respondents had no opinion, and 29.7% believed that the use of the S19 vaccine should be prioritized. Additionally, regarding the impact of the RB51 vaccine on pregnant cows, 22.4% of individuals agree with it, while 34.1% oppose its use due to the potential risk of abortion in pregnant cows. A significant number of people (43.5%) hold no opinion on this matter. The results indicate that the incidence of brucellosis among veterinary medical staff has increased in recent years. 53.1% of the respondents agree with this, while 16% disagree and 31% have no opinion. Regarding the prevalence of brucellosis among farm workers, 37.7% of respondents believe this disease has increased, while 13.5% disagree and 48.9% disagree.

Based on the data in table 3, most experts have evaluated the risk of introducing new cows without testing for brucellosis as high as most responses fall into the higher ranges of the risk scale. This table shows the experts' evaluations from 1 to 10 regarding various risks associated with brucellosis in cattle farms. Among all the risks, introducing a new cow without conducting a brucellosis test has the highest level of risk, with an average of 8.86 and a standard deviation of 1.75. This result indicates the high importance of testing new cows before their entry into the dairy farm. Additionally, the average score of 8.74 for the lack of awareness among farmers about the control and prevention of brucellosis is an indication of a critical problem in the management of livestock health that needs further training. However, the subsequent sec risks have been evaluated with lower averages. For example, the inadequate design of calf pens and feeding troughs, with an average of 7.74 and a standard deviation of 2.17, and the lack of washing and disinfecting milking machines, with an average of 7.1 and a standard deviation of 2.56, are considered significant hazards that can indirectly lead to the spread of brucellosis in dairy farms. Furthermore, risk factors such as the high density of cows per unit area, with an average of 6.92, and the presence of other animals in the dairy farm (like stray dogs, cats, and rodents), with an average of 6.07, are evaluated as management issues that contribute to reduced hygiene in the farms and increased the brucellosis transmission risk. Moreover, the intermediate risks include poor wastewater management from infected animals and fodder from dubious infected suppliers. Other elements, such as low vaccination coverage with an average of 8.35, and economic challenges coupled with a focus on herd needs rather than health management, must be addressed for improved disease control in cattle farms.

DISCUSSION

The professional and demographic profiles of the study participants provide an insightful analysis of the representativeness and variety of the answers obtained for the control of brucellosis in Iranian

Table 2. Opinions of veterinarians and brucellosis specialists on various issues related to vaccination and control of brucellosis disease in Iranian cattle farms

Question	Opinion				
	Completely agree (%)	Agree (%)	I don't have an opinion (%)	Opposed (%)	Completely opposed (%)
Regular vaccination with a full dose in dairy farms	187(38.9)	212(44.1)	19(4)	57(11.9)	6(1.2)
Regular vaccination with a reduced dose in dairy farms	139(28.9)	217(45.1)	41(8.5)	71(14.8)	13(2.7)
Proper cooperation of farmers for the vaccination in calves	76(15.8)	238(49.5)	40(8.3)	114(23.7)	13(2.7)
Proper cooperation of farmers for the vaccination of adult cows	49(10.2)	194(40.3)	58(12.1)	160(33.3)	20(4.2)
The preference of farmers for foreign vaccines compared to local vaccines	123(25.6)	141(29.3)	112(23.3)	82(17)	23(4.8)
Farmers are interested in foreign vaccines since they can use one vaccine for cows and calves	119(24.7)	134(27.9)	94(19.5)	23(4.8)	111(23.1)
Farmers believe that foreign vaccines provide better immunity compared to Iranian vaccines	137(28.5)	141(29.3)	73(15.2)	25(5.2)	105(21.8)
Insufficient vaccination coverage of small livestock against brucellosis has led to an increase in brucellosis in cattle farms	101(21)	161(33.5)	81(16.8)	108(22.5)	30(6.2)
The use of private sector services in conducting brucellosis vaccinations leads to better disease control in cattle farms	105(21.8)	192(39.9)	56(11.6)	88(18.3)	40(8.3)
The use of the S19 vaccine currently takes precedence over RB51	43(8.9)	100(20.8)	202(42)	106(22)	30(6.2)
The use of the RB51 vaccine in pregnant cows causes abortion	28(5.8)	136(28.3)	2.9(43.5)	91(18.9)	17(3.5)
Mandatory insurance for cattle farms against brucellosis is a suitable plan	159(33.1)	158(32.8)	39(8.1)	82(17)	43(8.9)
Farmers are satisfied with the compensation payment conditions in mandatory insurance	10(2.1)	46(9.6)	77(16)	186(38.7)	162(33.7)
The cooperation of farmers with the brucellosis testing and slaughter teams has decreased in recent years	123(25.6)	233(48.4)	52(10.8)	67(13.9)	6(1.2)
The failure to pay compensation by IVO has reduced the willingness of farmers in large industrial units to cooperate with testing and slaughter teams	219(45.5)	184(38.3)	46(9.6)	29(6)	3(0.6)
The failure to pay compensation by IVO has reduced the willingness of farmers in semi-industrial units to cooperate with testing and slaughter teams.	238(49.5)	184(38.3)	32(6.7)	25(5.2)	2(0.4)

Table 2. Opinions of veterinarians and brucellosis specialists on various issues related to vaccination and control of brucellosis disease in Iranian cattle farms

Question	Opinion				
	Completely agree (%)	Agree (%)	I don't have an opinion (%)	Opposed (%)	Completely opposed (%)
In recent years, the cooperation of cattle ranchers in sending brucellosis reactor cows to the slaughterhouse has decreased.	121(25.2)	206(42.8)	69(14.3)	75(15.6)	10(2.1)
Some farmers have taken action to test and remove positive reactor cows before the scheduled active brucellosis care by IVO.	30(6.2)	110(22.9)	176(36.6)	119(24.7)	46(9.6)
In recent years, the incidence of brucellosis among veterinary staff has increased.	96 (20)	159 (33.1)	149(31)	67(13.9)	10(2.1)
In recent years, the incidence of brucellosis among workers in dairy farms has increased.	48(10)	133(27.7)	235(48.9)	61(12.7)	4(0.8)
The personnel of IVO have sufficient motivation for the vaccination of cattle farms.	67(13.9)	156(32.4)	74(15.4)	130(27)	54(11.2)
Private vaccination centers have sufficient motivation for vaccination of cattle farms	59(12.3)	167(34.7)	65(13.5)	134(27.9)	56 (11.6)
The personnel of IVO have sufficient motivation for testing and culling in the active brucellosis surveillance program	70(14.6)	165(34.3)	84(17.5)	122(25.4)	40(8.3)
The brucellosis diagnostic laboratories of IVO have the necessary accuracy and reliability for the exanimated samples	133(27.7)	246(51.1)	71(14.8)	24(5)	7(1.5)
Granting licenses to private sector laboratories can help reduce the incidence of brucellosis	70(14.6)	131(27.2)	69(14.3)	108(22.5)	103(21.4)

cattle farms. The high response rate of 68% indicates a high degree of involvement among the target population, suggesting the importance of the study's topic to the responders. The average age of the respondents (42.7 years) and their notable work experience (mean of 15.9 years) suggest a mature group of experts, which undoubtedly enhances the dependability of their observations. Remarkably, the range of work experience (1 to 38 years) reveals the presence of both early-career professionals and seasoned experts, providing a realistic picture of both current and classic approaches to brucellosis control in Iran. On the other hand, the considerable degree of expertise among the responders corresponds with the aim of the study, which is to aggregate informed opinions on managing and controlling brucellosis. Conversely, the underrepresentation of private sector and university professionals (16.4% and a few university professors) and the concentration of replies from IVO (82%) suggest a bias toward points of view from government entities. Geographical representation also highlights disparities; provinces like West Azerbaijan, Khorasan Razavi, Kermanshah, and Kerman had significant contributions, while others, including Golestan and Mazandaran, had very little. This inequality highlights the need for targeted

Table 3. Distribution of experts' responses to the risk level of brucellosis in dairy cattle farms (Risk level 1-10)

Risk item	Quantitative Distribution		Distribution Based on Quartiles		
	Mean	Standard Deviation	First Quartile (25%)	Median Quartile (50%)	Third Quartile (75%)
Introduction of a new cow without performing a brucellosis test	8.86	1.75	8	10	10
Lack of awareness, insight, and knowledge among cattle farmers regarding the control and prevention of brucellosis	8.74	1.73	8	10	10
Lack of a properly designed maternity and calf barn	7.74	2.17	6	8	10
Failure to wash and disinfect water troughs	6.02	2.57	5	6	8
High density of cows per unit area	6.92	2.31	5	7	9
Failure to wash and disinfect milking machines	7.1	2.56	5	8	10
The presence of other animals in the livestock farm (stray dog, cat, rodents)	6.07	2.75	4	6	8
Being close to a flock of sheep and goats	7.56	2.38	6	8	10
Improper management of wastewater from infected herds	6.89	2.4	5	7	9
Inadequate vaccination coverage in the dairy farm	8.35	2	8	9	10
Use of forage from unreliable sources suspected of brucellosis contamination	6.68	2.7	5	7	9
Economic challenges and focus on meeting herd needs instead of management and hygiene	7.83	2.15	6.5	8	10

efforts to engage underrepresented areas in the subsequent study and may limit the generalizability of the results nationwide.

Our findings highlight the diverse expert perspectives and challenges in vaccination and brucellosis control within cow herds. Considered the best method of disease control in endemic areas, frequent full-dose immunization is supported by most experts (83%). Vaccinating cattle is highly advised in places like Iran, which is an endemic country for brucellosis. Vaccination increases herd immunity and protects individual animals, lowering the disease's prevalence. Vaccination is the most successful control tool since stamping_out could cause significant financial challenges (Deka et al. 2018; Makita et al. 2011). RB51 has been recommended for usage in Iran. It has been effectively employed in the United States since 1996 (Ragan et al. 2013). Although RB51 has shown good protection against modest challenges in controlled circumstances, field infections in animals vaccinated with RB51 have been reported several times. Due to the uncertain duration of immunity provided by this vaccine, field infections have been reported even in revaccinated animals (Moriyón et al. 2004; Olsen 2000).

In contrast, support for reduced-dose vaccination was slightly lower, with 74% in favor. The results indicate that, although a significant majority supports reduced-dose vaccination, it faces more doubt relative to the full-dose approach. This may reflect concerns about the efficacy, safety, or long-term protection associated with reduced doses. The higher rate of opposition also highlights a need for further communication, evidence, or field trials to build trust in reduced-dose strategies.

A higher willingness to vaccinate calves (65.3%) compared to adult cows (50.5%) suggests practical difficulties and possibly different opinions on risk or

economic consequences among farmers, reflecting varying levels of farmer cooperation. Thus, mass immunization, especially in endemic regions, is the first step towards brucellosis control. Furthermore, assessing the success of the vaccination once animals have been injected is essential.

Although free brucellosis immunization is available in all parts of Iran, several obstacles have hindered the efficient implementation of immunization. Among these obstacles are improper timing of vaccinations, insufficient knowledge among cattle breeders, problems with vaccine viability and quality, inadequate storage conditions for vaccines, inadequate quarantine procedures, and a lack of awareness regarding the risks of brucellosis-related abortions among vaccinated animals (Behzadifar et al. 2021; Yazdi et al. 2009). A combined 54.9% of respondents indicated a preference for foreign vaccines, suggesting that more than half of the farmers perceive foreign vaccines as more reliable or effective than local alternatives. Experts may prefer foreign vaccines over local ones for several reasons. One of the main factors is the perception that foreign vaccines are produced under higher manufacturing standards and stricter regulatory oversight, which can lead to greater confidence in their safety and effectiveness. They have been approved or certified by international health authorities such as the World Health Organization (WHO) or the U.S. Food and Drug Administration (FDA), which also carries more credibility, reinforcing expert preference. Many foreign vaccines also have a proven track record, having been used extensively in different countries with consistent results. Additionally, foreign manufacturers often use more advanced technology in vaccine development, which may appeal to experts seeking the most up-to-date and effective solutions.

The conflicting opinions on the use of foreign vaccines indicate underlying issues, including cost, confidence in efficacy, and accessibility. Twenty-three percent of respondents who are unsure (23.3%) or opposed (21.8%) to farmers' preference for foreign vaccines highlight that increased education and communication would help address these issues among experts. The survey results reveal a divided perception among farmers regarding the effectiveness of foreign vaccines compared to Iranian vaccines. A total of 57.8% of respondents believe that foreign vaccines offer better immunity. This suggests that a majority of farmers perceive foreign vaccines as more effective than those produced domestically. This indicates the need for further education, transparency, and possibly comparative studies to build farmer confidence in vaccine quality, whether foreign or domestic.

Furthermore, a majority of respondents, with 61.7% agree that involving the private sector could improve the effectiveness of brucellosis vaccination programs and disease control in cattle farms. This support may reflect perceived advantages such as better logistics, greater reach, or increased efficiency in service delivery. However, the notable proportion of opposition suggests that careful planning, transparent regulation, and stakeholder engagement are essential for successful implementation.

On the other hand, a majority of respondents, with over 54% believe there is a link between inadequate vaccination in small livestock in Iran and increased brucellosis in cattle. This reflects a general concern or recognition of the potential role small ruminants may play in the transmission dynamics of the disease.

In points of view on the vaccination decision, particularly between the S19 and RB51, while there is some support for the use of S19 in our result, the high percentage of neutral and opposing responses highlights the need for further discussion, education, or data to clarify the advantages and limitations of both vaccines for control program of cattle farms in Iran. Both S19 and RB51 are widely used live attenuated vaccines, and meta-analyses indicate that, at their optimal doses (S19 at 10^9 CFU and RB51 at 10^{10} CFU), they offer comparable efficacy in preventing abortion and infection in cattle, though S19 may have a slight edge in some studies (de Oliveira et al., 2022). Given these differences, the optimal vaccine strategy in Iran should be informed by detailed epidemiological data on the prevalent *Brucella* strains, the diagnostic infrastructure available, and the specific goals of the national brucellosis control program. Since *B. melitensis* is prevalent in dairy cattle farms (Alamian et al., 2024), the use of the S19 vaccine is recommended.

RB51 vaccination is widely used in Iran; however, its efficacy against *B. melitensis* in dairy cattle has been questioned (Alamian et al. 2024). RB51 is designed to target *B. abortus*, which affects cattle, not *B. melitensis*, so this restriction presents a difficulty in controlling the disease (Blasco et al. 2023). Research on the efficiency of RB51 in dairy cattle farms afflicted with *B. melitensis* has not yet been conducted in Iran. The high percentage of answers suggests a knowledge gap that needs to be addressed by intentional education and communication.

Furthermore, this study's high average score of 8.35 for inadequate vaccination coverage as risk factor that underscores the need to maintain sufficient immunization levels across herds. Coupled with economic difficulties and a primary emphasis on herd productivity over health management, this issue reveals systematic inadequacies that must be filled. Brucellosis management can be improved by supporting vaccination through subsidies, farmer education, and more robust enforcement policies.

Although mandatory insurance against brucellosis seems generally accepted (65.9%), farmer cooperation is seriously limited by widespread dissatisfaction (72.4%) about compensation terms. This dissatisfaction appears to be directly linked to reduced farmer cooperation in brucellosis control efforts. Addressing delays or inadequacies in compensation, especially by IVO, could be critical for restoring trust and improving compliance with disease control measures across both industrial and semi-industrial cattle farms.

Overcoming these economic barriers will help to improve cooperation and compliance. One of the difficulties facing a cattle producer's insurance program is the need for sufficient interest to support payments. Even with knowledge of risk management strategies, livestock producers sometimes neglect them, reducing the efficacy of insurance programs (Grannis et al. 2004; Zhichkin et al. 2021).

This study showed that 78.8% of IVO labs support their accuracy, and these facilities have a positive reputation for dependability. However, the advice (supported by 41.8%) that private labs may enhance control efforts suggests a likely route for increasing capacity and accessibility in diagnostics. The RBPT is the first brucellosis screening test utilized in Iran; positive samples undergo confirmatory testing, including Wright's seroagglutination and 2-Mercaptoethanol (2-ME) tests. Indirect-enzyme linked immunosorbent assay (i-ELISA), complement-enzyme linked immunosorbent assay (C-ELISA), complement fixation test (CFT), Fluorescence Polarization Assay (FPA), Polymerase chain reaction (PCR), and bacterial culture are other final detection techniques. Wright's and 2-ME tests are helpful for screening, however, given their limited specificity and cross-reactivity, they might not be best for confirmation (Di Bonaventura et al. 2021). Therefore, the private labs could focus on alternative routes to confirm *Brucella* spp. On the other hand, the "One Health" strategy for brucellosis control relies increasingly on modern diagnostic methods, such as PCR. Due to the nonspecific symptoms and prolonged infection of brucellosis, serological assays and blood cultures can be challenging to diagnose. Even when serological data are unclear or cultures are negative, PCR and other molecular diagnostics can detect *Brucella* species in humans and animals earlier (Godfroid et al., 2013).

Regarding and underscoring the occupational hazards related to the disease, the increasing incidence of brucellosis among veterinary professionals (53.1%) and farm laborers (37.7%) is remarkable. Although a large percentage of respondents (48.9%) did not have an opinion on the frequency among farm workers, this suggests a lack of sufficient information on this subject. To protect human well-being, efforts should focus on improving surveillance and increasing awareness of zoonotic transmission risks. Significant risk factors for occupational brucellosis are close contact with animal feces, veterinary services, labs, handling, trading, or processing of animal products. However, one health strategy has proven challenging to implement in poorer countries due to a limited understanding and lack of practical advice on boosting cross-sector cooperation (Dadar et al. 2023). These challenges demand a comprehensive strategy that stresses worker education and practical safety measures. All animal or potentially contaminated material activities should require PPE such as gloves, masks, and protective clothing. Workers must receive regular training to understand how brucellosis is spread and recognize its early symptoms for prompt medical treatment. Disease transmission is further reduced by strict adherence to hygiene practices, including hand washing and cleaning of equipment (Lounes et al., 2022). Routine livestock vaccination and early isolation or culling of infected animals help reduce the reservoir of infections. Laboratory workers and *Brucella* culture handlers must adhere to biosafety requirements and employ proper containment measures. Early identification and post-exposure treatment also protect high-risk groups. A coordinated plan of education, protective measures, animal health management, and continuous monitoring is needed to reduce the risk of brucellosis in veterinarians and farm workers (Traxler et al., 2013).

Evaluating the risks of brucellosis associated with cattle farms in this study highlights significant weaknesses that require prompt attention to improve disease control. Among the assessed haz-

ards, introducing new cows without a brucellosis test was the most important, with an average score of 8.86 and a very low standard deviation (1.75). This outcome highlights a fundamental disparity in agricultural biosecurity strategies. The strict application of this practice should be given top priority, as new cows should be examined before they are introduced to herds, thereby reducing the potential for disease transmission. Cattle brucellosis has a complex epidemiology related to individual transmission and risk factors associated with herd management and environmental conditions. Important management aspects include biosecurity, population density, herd size, and safety level; climate also affects these elements (Alhaji et al. 2016; Dadar et al. 2024). Although a history of abortion, introducing new animals, and replacing cattle increases the infection risk, research in Iranian herds shows that maintaining hygiene and sanitizing water can reduce the risk of brucellosis (Bahreinipour et al. 2023). Another main risk factor is the average score of 8.74, indicating farmers' limited understanding of brucellosis control and prevention. This result highlights a significant need for improved training and education for farmers. Efforts in education that stress the consequences of brucellosis on herd productivity, health, and economy should help increase the acceptability of control measures and cooperation.

Other significant hazards include the poor construction of calf cages and feeding troughs (average score of 7.74), as well as the neglect of routinely washing and sterilizing milking machines (average score of 7.1). These problems reflect critical hygienic flaws that can help the disease spread. Although these hazards were relatively minor compared to others, their indirect contribution to disease spread warrants consideration. Farm biosecurity would be significantly enhanced by addressing these issues through improved infrastructure design and regular sanitation practices. Intermediate risks include poor wastewater management and the use of fodder from potentially contaminated sources, highlighting the most common environmental and operational factors that influence brucellosis control. Different studies also reported that cow abortion produces a large amount of the pathogen, and *Brucella* survives rather well in the surroundings and contaminates pastures, stables, and fodder. Improper disposal of these materials might help the bacteria to spread. Like wells, open water supplies can also become contaminated, especially with farm waste (Salman and Steneroden 2022; Smits and Kadri 2005). *B. melitensis* has a somewhat low infectious dosage; thus, appropriate disinfection is essential. These findings suggest that farms must tighten their control over waste and feed sources to reduce contamination problems.

Based on our results, a comprehensive approach to brucellosis control and research must include immunization, diagnostics, and human health impacts in clear topic parts and include the opinions of a variety of participants outside government agencies. The vaccine, coverage, and techniques for livestock immunization are crucial to minimizing animal and human disease prevalence. Diagnostic problems exist, especially in resource-limited countries where infrastructure is lacking and brucellosis symptoms overlap with other febrile infections, leading to underdiagnosis and underreporting. These diagnostic constraints require practical, locally relevant solutions, such as epidemiologically customized field diagnostics and surveillance systems. Brucellosis causes acute devastating illness and persistent sequelae, which have significant socioeconomic repercussions, especially in endemic areas with limited health resources.

Effective brucellosis control requires a 'One Health' approach that connects animal and human health sectors with livestock holders and local communities to gather input from those most affected. Veterinarians, farm workers, researchers, and community members can help politicians create more sustainable and approved solutions. This inclusive technique makes control measures more relevant and applicable, increasing involvement and compliance at all levels. Thematic content organization and stakeholder participation are vital for developing brucellosis prevention and control science and practice.

One limitation of this study is the potential sampling bias resulting from the overrepresentation of government veterinarians compared to those from the private sector. This imbalance may influence the perspectives captured, as government veterinarians may have different experiences, priorities, and exposure to brucellosis control strategies. Additionally, geographical disparities in participant distribution may limit the generalizability of the findings across all regions of Iran. Future studies should aim for more representative sampling across various professional sectors and geographic areas to enhance the applicability of the results.

CONCLUSION

This study reveals that the effective control of brucellosis in Iranian cattle farms is hindered by a combination of inadequate vaccination coverage, low farmer cooperation driven by dissatisfaction with compensation systems, and significant gaps in biosecurity and education. While there is general support for full-dose vaccination and mandatory insurance, trust in vaccine efficacy (especially regarding local vs. foreign options) and institutional reliability remains mixed. Poor herd management practices, lack of awareness, and inconsistent regional participation further complicate control efforts. Notably, the introduction of untested animals into herds and farmers' limited knowledge were identified as the highest-risk factors. Addressing these challenges through improved compensation mechanisms, farmer education, enhanced vaccine strategies, and stronger biosecurity protocols, while involving both public and private sectors, will be critical for improving disease control outcomes in Iran. Dealing with these problems, utilizing dependable diagnostic tools, and exploring private sector engagement can help enhance control strategies and significantly reduce the brucellosis load. The results of this study encompass various approaches for preventing and controlling bovine brucellosis. The primary focus of efforts must be on biosecurity policies, farmer education, improved infrastructure, and higher hygiene standards. Together, tackling these risks would help reduce the frequency of brucellosis and improve overall cattle health and productivity in Iran. The findings of the study aim to inform policies that enhance biosecurity, education, and compensation mechanisms, aligning with the "One Health" framework to mitigate this zoonotic threat.

Data availability

The manuscript presents all the data included in this study as tables.

Abbreviations

IVO: Iranian Veterinary Organization
Brucella abortus: B. abortus
Brucella melitensis: B. melitensis
ECLAP 2023: Large Animal Clinicians Congress
2-ME: 2-Mercaptoethanol test
i-ELISA: Indirect-enzyme linked immuno sorbent assay
C-ELISA: complement-enzyme linked immuno sorbent assay
CFT: Complement fixation test
FPA: Fluorescence Polarization Assay
PCR: Polymerase chain reaction

Declarations

Ethics approval and consent to participate This study was approved by the Research Ethics Committee of the College of Veterinary Medicine, Tehran University. All participants provided written informed consent to collect the data used in the study. The clinical investigation was performed under the Declaration of Helsinki, and all participants provided informed consent.

Competing Interests The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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