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RESEARCH ARTICLE

Risk Factors for Bovine Tuberculosis Transmission in Burkina Faso's Cattle Herds

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Abstract: Bovine tuberculosis is a zoonotic disease, primarily caused by *Mycobacterium bovis*, that poses a serious threat to both human and animal health. Understanding the risk factors that contribute to its spread is critical for developing effective prevention and control strategies. This cross-sectional study investigated risk factors associated with bovine tuberculosis in cattle herds in Burkina Faso. A structured survey questionnaire was administered to 204 cattle breeders randomly selected across seven regions of Burkina Faso in local languages. Multivariable logistic regression was used to identify the risk factors associated with the occurrence of bTB. Of 204, 36.3% of survey respondents reported post-mortem bTB cases in their herds. Introduction of new animals (OR = 4.37; 95% CI [2.011; 9.534]; $p < 0.05$) and herd size (OR = 2.74; 95% CI [1.318; 5.689]; $p < 0.05$) emerged as the strongest predictors of bTB. However risk factors were statistically non-significant ($p > 0.05$) with an odds ratio (OR) >1 and 95% CI [0.817; 10.03], [0.341; 4.0421] and [0.776; 7.0281] respectively for water point sharing, pasture sharing and distance between farms and dwellings. Strengthening farm-level biosecurity and improving disease awareness among breeders could significantly reduce bovine tuberculosis transmission in Burkina Faso.

Keywords: Risk, Factors, Tuberculosis, Cattle, Burkina Faso

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Introduction

The livestock industry holds a significant place in the economies of most developing countries. In West Africa, the cattle population is estimated to exceed 60 million [1], serving as a major source of food and income for rural communities.

In Burkina Faso, cattle production accounted for 18% to 20% of the Gross Domestic Product (GDP) between 2012 and 2020, contributing approximately 26% of the country's livestock export revenues [2]. However, this sector is increasingly threatened by bacterial, viral, and parasitic diseases, resulting in significant economic losses. Concerns intensify when the causative agent has wildlife reservoirs [3-5]. Bovine tuberculosis (bTB) illustrates this dynamic, as wildlife populations serve as reservoirs for the *Mycobacterium tuberculosis* complex (MTBC) [6].

Bovine tuberculosis, primarily caused by *Mycobacterium bovis* (*M. bovis*) [7-8], remains one of the most devastating zoonotic infections of cattle in developing countries [9]. Bovine tuberculosis is one of the notifiable diseases of the World Organization for Animal Health (OIE) and was reported in approximately 50% of the 179 member countries between 2015 and 2016. Despite the implementation of bovine tuberculosis control programs, the disease prevalence remains high, especially in low- and middle-income countries (LMICs) in Africa, Asia, and America [10-11], and even in certain high-income countries where wildlife reservoirs persist [10].

Currently, control strategies rely heavily on testing and slaughter policies, movement restrictions, and post-mortem meat inspection [12,10], with the complete eradication of bTB remaining the ultimate goal. Previous research has suggested that the spread of bovine tuberculosis is influenced by environmental, herd-level, and individual factors [13-15]. Therefore, a comprehensive understanding of these risk factors, particularly those associated with *Mycobacterium tuberculosis* complex (MTBC) infection in cattle, is essential for effective disease prevention. Furthermore, various studies have reported that proximity to grazing areas, cattle movement and trade, management practices, contact with wildlife reservoirs, and direct animal-to-animal transmission are among the main factors influencing the spread of bovine tuberculosis [16-17,6,18-21].

In Burkina Faso, the prevalence of bTB has been rising, ranging from 1.75% to 27.7%, primarily due to the absence of a robust sanitation and biosecurity policy and the weak enforcement of existing regulations [6,22-24]. Despite this growing burden, information on the specific risk factors driving bTB transmission in cattle remains limited compared to northern countries, hindering the development of targeted prevention and control strategies. This study aimed to identify the risk factors associated with bovine tuberculosis in cattle in Burkina Faso.

Methods

Type, Period and Area of the Study

A cross-sectional study was conducted from December 2023 to January 2024 in 15 municipalities across seven (7) regions of Burkina Faso (Figure 1). These regions were selected for their accessibility and their relatively high level of livestock production, which may influence the transmission of contagious diseases such as bovine tuberculosis. In the Center-East Region, approximately 5% of livestock is raised using traditional methods [25]. This region also serves as a major transit corridor for livestock trade with neighboring countries (Togo, Benin, and Ghana), which may facilitate the spread of infectious diseases. Similarly, in the Central-West Region, livestock production is predominantly traditional and extensive, characterized by cyclical migrations in search of pasture and water sources. In the Center-South Region, farmers increasingly depend on transhumance and fodder purchases to sustain their herds. Transhumance remains a common practice in the Hauts-Bassins Region, although grazing areas have been officially demarcated [25-26]. This production system has led to a high density of animals within confined areas, thereby increasing the risk of disease transmission. Livestock farming in the Central Plateau Region is predominantly traditional, although during the dry season, large-scale farmers often engage in transhumance to access water and pasture. The Northern Region, characterized by drought conditions, relies on grassy and woody pastures for cattle feeding [27]. Overgrazing remains a major challenge, forcing breeders to move their animals frequently in search of better grazing areas. Extensive livestock farming predominates in the Central Region, where farmers face challenges related to land degradation and competition for pasture [28-29,26]. A prevalence of 27.7% was reported for the central region in 2019, compared to 1.75% for the central-west region.

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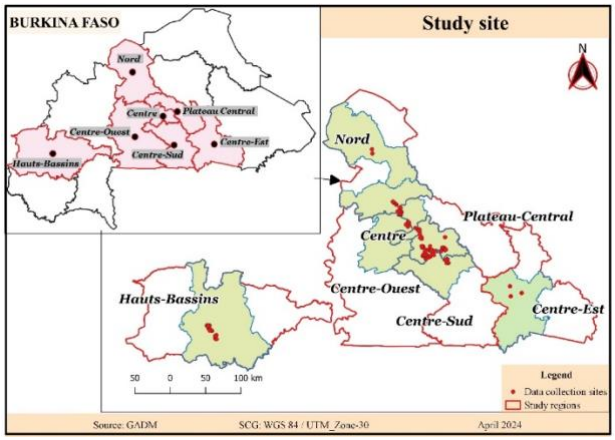

Fig. 1: Location of study area on Burkina Faso's map

Inclusion Criteria

Participants were eligible for inclusion if they were at least 18 years old, owned a minimum of five cattle, and provided consent to participate in the study.

Target Population

The sample size was estimated using the following formula: $n = Z2 \times P \times (1 - P)/d2$.

The required sample size is n, Z (1.96) is corresponding to level of confidence, P is the expected Btb prevalence of up to 1.75% according to Oumar et al. [22] and d (0.05) is precision. The calculation of n gave 26 respondents from each region. In practice, the number of respondents varied from one region to another depending on the accessibility of the sites. A total of 185 participants across the seven regions were included in the study, which was finally rounded to 204 to account for potential non-responses or unusable data. Respondents are people who owned a herd of cattle or shepherds, who monitored or guarded the herds. Participants were cattle owners or herders responsible for monitoring or guarding herds. They were selected randomly from farms or grazing areas without regard to gender, religion, or ethnicity.

Data Collection

Data were collected using a structured questionnaire (Appendix 1) that captured participants' socio-demographic and site characteristics, knowledge of bovine tuberculosis and susceptible species, livestock management practices, awareness of bTB symptoms, and control strategies. The questionnaire was composed primarily of closed-ended questions, supplemented by a few open-ended items, and was validated by animal health experts, including university researchers and livestock technicians. Interviews were conducted onsite in various local languages, including Mooré, Dioula, Fulfulde, and French, according to the participants' preferences and convenience. Interpreters were engaged when necessary to facilitate communication between the investigators and participants. Kobo Toolbox (https://KC.kobotoolbox.org) was used to facilitate data collection and management.

Ethical Considerations

This study did not involve any procedures affecting the physical integrity of humans or animals and therefore did not require formal ethical approval. However, verbally informed consent was obtained from all respondents after, they were provided with clear information about the study's purpose and procedures. Participants were assured that their responses would remain anonymous and confidential.

Data Analysis

Data analysis was conducted using Microsoft Excel (Microsoft Corporation, 2016) and R software (version 4.4.0; R Core Team, 2024).

Descriptive statistics were computed for several variables, including the characteristics of the study areas, the distribution of respondents by site, participants' socio-demographic profiles, the type of breeding system and herd size, knowledge of

bovine tuberculosis and susceptible species, and the reported symptoms and outcomes for infected animals. A multivariable logistic regression analysis was performed to identify the risk factors associated with bTB. Independent variables were selected based on a review of the literature, existing epidemiological evidence, and local livestock management conditions in Burkina Faso. The Hosmer-Lemeshow test (Appendix 2) was used for assessing model goodness-of-fit and that VIF (Appendix 3) was employed to check for multicollinearity. Statistical significance was established at $p < 0.05$.

Results

Characteristics of Study Sites

A total of 204 participants responded to the survey. The highest number of respondents was recorded in the Central Region (65), followed by the Hauts-Bassins Region (36) and the Center East Region (30). The review of the study sites with the number of respondents is presented in Table 1.

Table 1.Characteristics of study sites region

Regions	Number of municipalities	Number of sites	Number of respondents	Proportion (%)
Central	04	24	65	31.86
Center-East	01	8	30	14.71
Central-West	01	5	09	4.42
Center South	02	8	23	11.27
Northern	02	7	17	8.33
Plateau Central	03	8	24	11.76
Hauts-Bassins	02	8	36	17.65
07	15	76	204	100.0

Characteristics of Respondents

Among all participants, 96.08% were male, and 75% had not attended school, reflecting the demographic profile of cattle farmers in the surveyed areas. The distribution of respondents by gender and educational level is shown in Table 2.

Table 2. Socio-demographic characteristics of respondents

Variables	Modality	Number	Proportion (%)	p-value
Gender	Female	08	3.92	<0.01
	Male	196	96.08	
Total		204	100	
Level of education	No schooling	153	75.00	<0.01
	Elementary	23	11.27	
	Secondary and more	28	13.73	
Total		204	100	

Type of Breeding and Herd Size

Traditional livestock farming was the predominant system, practiced by 98.53% of respondents, compared to only 1.47% who practiced modern farming methods. Most respondents (43.63%) owned 11-30 cattle, while 9.80% had herds exceeding 50 animals. The results are presented in Table 3.

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Table 3. Type of breeding and herd size

Variables	Modality	Number	Proportion (%)	p-value
Livestock type	Modern	03	1.47	<0.010
	Traditional	201	98.53	
Total		204	100	-
Number of livestock	≤ 10 animals	45	22.06	<0.010
	11 - 30 animals	89	43.63	
	31 - 50 animals	50	24.51	
	≥ 50 animals	20	9.80	
Total		204	100	-

Animals Capable of Contracting Bovine Tuberculosis

Overall, 76.47% of respondents knew that cattle could contract or transmit bTB, while 73.04% identified sheep, 62.25% identified goats, and 38.24% cited donkeys as susceptible species. The results of their responses are presented in Figure 2.

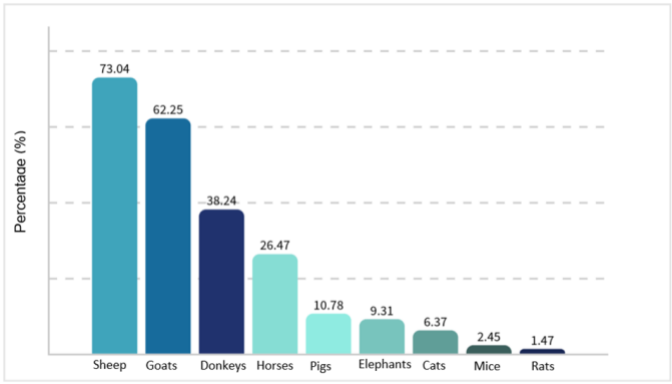

Fig. 2: Frequency of respondents' knowledge of animals capable of contracting bovine tuberculosis other than cattle

Knowledge of Tuberculosis Symptoms in Cattle

Participants demonstrated their levels of knowledge regarding disease symptoms. Of 204 respondents, 156 identified one or more signs of bTB, while 48 indicated that they were unaware of any. The most frequently cited symptoms were coughing (98.08%), loss of appetite (43.59%), and weight loss (39.74%), whereas salivation (1.92%) and mouth odor (0.64%) were mentioned less often. All of these results are shown in Figure 3.

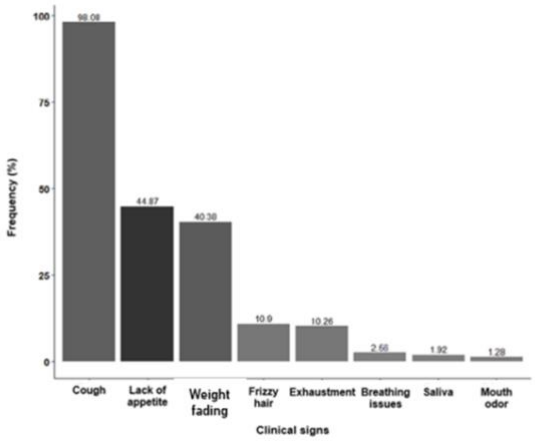

Fig. 3: Main symptoms associated with bovine tuberculosis according to respondents

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Outcomes of Animals Sick With Bovine Tuberculosis

Among study participants, 55.41% reported selling animals showing signs of tuberculosis, 27.03% indicated that they slaughtered them, and 17.57% kept them within their herds. These results are presented in Figure 4.

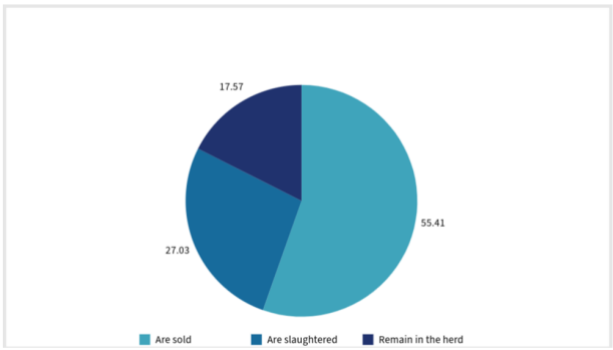

Fig. 4: Outcomes of animals sick with bovine tuberculosis

Extent of Bovine Tuberculosis

Regarding disease occurrence, 36.27% of respondents reported observing post-mortem tuberculosis lesions in their herds within the three years preceding the survey.

Risk Factors Associated With Bovine Tuberculosis

Finally, introduction a new animal and herd size was identified as two significant risk factors associated with bTB. Results are presented in Table 4.

Table 4. Identified risk factors associated with bovine tuberculosis

Variables	OR	p-value	CI (95%)	
Herd size				
< 30	1	…		
>30	2.73	0.007*	[1.318 ;	5.689]
Introduction of a new animal				
No	1	…		
Yes	4.37	0.001*	[2.010 ;	9.534]
Distance between the farm and human dwellings				
> 300 m	1	…		
< 300 m	6.82	0.083	[0.776 ;	7.028]
Animals share the same water point				
No	1	…		
Yes	2.86	0.100	[0.817 ;	10.03]
Animals use the same pasture				
No	1	…		
Yes	3.41	0.296	[0.341 ;	4.042]

Discussion

The Central Region registered the highest number of participants (65), followed by the Hauts-Bassins and Center-East Regions, with 36 and 30 participants, respectively. These figures exceeded the initial target of 26 participants per region. The

Central Plateau (24) and Center-South (23) Regions achieved near-target participation, while the Northern and Central-West Regions recorded 17 and 9 respondents, respectively both below the expected target. The high number of participants in the Central and Hauts-Bassins Regions was primarily attributed to their accessibility, which facilitated fieldwork and respondent recruitment. Beyond accessibility, the Central Region was also selected because of its relatively high prevalence of bTB, reported at 27.7% in previous studies [30]. The Hauts-Bassins Region, with a reported prevalence of 6.20% [23], was similarly prioritized to ensure regional representation and to compensate for areas that were difficult to access. In contrast, the Northern and Central-West Regions faced significant security challenges that restricted investigator mobility and reduced the number of respondents. At the time of the study, only seven of Burkina Faso's thirteen regions could be visited, as insecurity (terrorism) access to several areas.

Participants in this study were predominantly male (96.08%), while women accounted for only 3.92%, a difference that was statistically significant ($p < 0.05$). A similar trend was reported by [31] in Côte d'Ivoire, where 95% of cattle farmers were men. The association between respondents' sex and the level of knowledge of bovine tuberculosis suggests that gender-related differences may influence access to information, exposure to animal health education, or involvement in livestock management. In many settings, men and women assume different roles in animal husbandry, which can affect their opportunities to acquire knowledge about zoonotic diseases such as bovine tuberculosis. In literature, similar findings have been reported in previous studies, indicating that targeted awareness and training programs should consider gender-specific roles to improve overall knowledge and disease control. However, further research is needed to explore the underlying factors contributing to this association and to assess whether these differences persist across different socio-cultural contexts. This gender disparity reflects the prevailing socio-cultural and economic context of the study regions, where cattle farming remains largely a male-dominated activity. Typically, men manage livestock production and make major decisions related to cattle trade, while women tend to focus on small ruminants and poultry [32-34]. Men are more likely to be responsible for animal health management, marketing, and interactions with veterinary services, which increases their exposure to information on animal diseases. Women, although often involved in daily animal care, may have limited access to formal training, extension services, or decision-making processes related to livestock health.

Most respondents (75%) lacked formal education, whereas 11.27% had completed primary education and 13.73% had attained secondary or higher levels. These differences were statistically significant ($p < 0.05$). Similar results were reported by [23], who found that 71% of respondents had no formal education and 19% had only primary schooling. These findings may reflect the predominance of livestock farming as the main economic activity among rural populations, where formal education levels are generally low [35].

Education plays a crucial role in disease prevention and control. Indeed, education level is an important contextual factor, as it may affect awareness of zoonotic transmission pathways and engagement in practices that influence disease risk. As reported, lack of formal education is associated with risky livestock management practices and contributes to the persistence of animal diseases such as tuberculosis [36].

Traditional livestock farming was practiced by 98.53% of respondents, while only 1.47% practiced modern farming methods, indicating a statistically significant difference between farming practice types ($p < .05$). In Togo, a similar result (99.80%) was reported in 2012 [37]. Dominance of traditional farming systems among respondents, the bTB findings of this study should be interpreted within the context of management practices characterized by close animal contact and limited biosecurity. It is also due to the simplicity and low cost of traditional methods, which rely on locally available resources such as communal grazing lands [38-39]. However, seasonal movements inherent in this system may facilitate the spread of bTB. Despite its accessibility, traditional breeding faces challenges, including climatic variability, which reduces productivity and profitability. In contrast, modern livestock farming characterized by improved feeding, health monitoring, and biosecurity offers higher productivity [40]. However, it remains accessible only to a small minority of breeders due to its high cost.

Regarding herd size, 43.63% of respondents owned herds of 11-30 cattle, followed by 24.51% with 31-50 cattle, 22.06% with 5-10 cattle, and 9.80% with more than 50 cattle. Medium-sized herds (11-30) may reflect semi-commercial systems combining livestock farming with agriculture or trade. Larger herds (31-50) are typically owned by more affluent and experienced farmers, while smaller herds (5-10) indicate domestic or subsistence farming constrained by feed or financial limitations [41]. The low proportion of breeders with herds exceeding 50 cattle highlights the challenges of limited access to pasture, labor, and capital. Overall, the herd distribution observed in this study aligns with extensive and mixed breeding practices in Burkina Faso [42].

Respondents most frequently identified sheep and goats as animals capable of contracting or transmitting bovine tuberculosis, followed by donkeys, horses, pigs, elephants, cats, mice, and rats. These perceptions are consistent with previous studies, which indicate that many domestic and wild species are susceptible to *Mycobacterium bovis* infection [9,15,43-44]. Transmission among animals occurs primarily through the respiratory route via contaminated aerosols, but water or food contaminated by the secretions and excretions of infected animals also plays a significant role [45]. Wildlife species such as badgers, African buffalo, wild boars, and deer are recognized as reservoir hosts capable of maintaining and spreading the infection [46].

Knowledge of bTB symptoms is fundamental to effective disease surveillance. Among 156 respondents who provided information, the most frequently cited signs were coughing (98.08%), loss of appetite (43.59%), and weight loss (39.74%), followed by less commonly mentioned signs such as rough hair coat, fatigue, breathing difficulty, salivation, and mouth odor. These results are consistent with the clinical signs described in the literature, including coughing, fever, lymph node enlargement, respiratory distress, decreased milk production, poor coat condition, and anorexia [47-48]. Bovine tuberculosis symptoms depend on which organs are affected. When the lungs are involved, coughing may be observed, and when the mammary glands are affected, a decrease in milk production may be identified [49]. However, bTB symptoms are often subtle and non-specific, particularly in early stages, making clinical diagnosis difficult [50]. These results could show that the majority of respondents in the study are familiar with the main symptoms of bTB.

More than half of respondents (55.41%) reported selling animals showing signs of tuberculosis, 27.03% slaughtered them, and 17.57% kept them within their herds. Selling or retaining infected animals poses significant risks for disease transmission within herds and to humans. These practices contradict veterinary public health recommendations, which mandate the systematic slaughter of animals suspected of tuberculosis [51]. The trade of infected animals heightens the risk of spreading the disease to new herds and into the human food chain, especially in the absence of stringent veterinary inspection [52]. While slaughtering suspected animals helps limit transmission, it results in financial losses for farmers, which explains why some may conceal cases. Despite bTB being a notifiable disease in Burkina Faso, control efforts remain weak due to limited funding and unclear regulatory guidance [53] and this situation raises major risks of public health. The absence of financial compensation discourages breeders from complying with slaughter requirements. Effective disease control requires government support through compensation schemes, regular meat inspection, tuberculin testing, and promotion of milk pasteurization [24].

Based on respondents' reports over the previous three years, the observed prevalence of bTB in this study was 36.27%. This rate is higher than those reported in previous studies in Burkina Faso with 6.8% in 2014, 2% in 2021, and 1.75% in 2022 [54-55, 22] (Tarnagda et al., 2014; Tialla et al., 2021; Oumar et al., 2022). Similar trends have been observed in Côte d'Ivoire (22.10% in 2008) [56] (Cissé et al., 2008), Nigeria (25.70% in 2020) [57] (Agbalaya et al., 2020) and Ethiopia 43.3% in 2024) [58] (Hussein et al., 2024). However, since this prevalence is based on self-reported observations, potential recall or misclassification bias should be taken into account. The high proportion of respondents without formal education may also affect data reliability. In the absence of laboratory confirmation, these results should be interpreted cautiously. Nevertheless, in low-resource settings, such community-based data provide valuable insights into the epidemiological situation. Farmers' experience and knowledge of disease signs remain valuable assets for early detection.

The multivariable logistic regression model, which estimated the likelihood of bTB occurrence in herds over the past three years, was significant (Prob > χ^2 < 0.0001), with a Pseudo R^2 of 0.2472, indicating an acceptable model fit. Two variables were statistically significant at the 5% level ($p < 0.05$). Model validation was performed using post-estimation tests. Diagnostic analyses were conducted to assess the goodness of fit and verify the absence of multicollinearity among the explanatory variables. The Hosmer-Lemeshow test ($\chi^2 = 31.22$; df = 44; $p = 0.92$) demonstrated a good model fit, with the p-value exceeding 0.05, indicating no significant difference between predicted and observed probabilities. Furthermore, examination of the Variance Inflation Factors (VIF) revealed values ranging from 1.07 to 1.43, with an average VIF of 1.22. These values are well below the critical threshold of 5, indicating no evidence of multicollinearity among the independent variables. The estimated coefficients can therefore be considered stable and reliable for interpretation.

The introduction of new animals emerged as the strongest risk factor ($p < 0.001$). Farmers who introduced at-risk animals were 4.37 times more likely (95% CI [2.01-9.53]) to report cases than those who did not. This highlights the critical role of livestock movement in disease spread and underscores the need to strengthen health screening, origin certification, and quarantine measures during trade. Pre-introduction testing using serological or molecular methods could help prevent the spread of new infections. Herd size was also significantly associated with disease occurrence ($p = 0.007$). Farms with ≥30

animals had an odds ratio (OR) of 2.73 (95% CI [1.32-5.69]), nearly triple the risk compared with smaller herds (<30 cattle). This suggests that high animal density promotes close contact and facilitates the transmission of diseases. Herd size should therefore be adjusted to match available pasture and housing capacity, while rotational grazing and regular health monitoring can help mitigate risks. Several authors have identified risk factors such as contamination by introduction of an animal, contamination by neighborhood, recurrence [59], herd size [13,60], farm's history of tuberculosis and type of livestock [60], and contact with wildlife [61]. bTB risk factor identification in this study showed the need to take into account biosecurity in livestock farms in order to reduce risk of transmission.

Environmental factors such as shared water and grazing areas are risks that are generally associated with the transmission of tuberculosis in cattle [62-63], and similarly, the distance between farms and human dwellings. However, in this study, these factors were statistically non-significant ($p > 0.05$) with odds ratios (OR) >1 and 95% CI [0.817-10.03], [0.341-4.0421], and [0.776-7.0281] respectively for water point sharing, pasture sharing, and distance between farms and dwellings. This could mean that these variables are unreliable. As regards shared water, pasture sharing, and the distance between the farm and human dwellings, odds ratios greater than 1, although statistically non-significant ($p > 0.05$), suggest a trend toward increased risk. Despite non-significance, these factors may still contribute to disease transmission trends and warrant further investigation with larger samples.

Limits of the Study

This study had several limitations. Due to security concerns, some regions of Burkina Faso could not be surveyed. Furthermore, the study relied on self-reported data, which may introduce recall or reporting bias.

Conclusion

The present survey provided an overview of farmers' knowledge regarding zoonotic tuberculosis. Based on respondents' answers, bovine tuberculosis emerged as one of the most frequently detected infections in animals, particularly within cattle herds. The present analysis highlights the significant influence of animal introduction and herd size on the epidemiology of bovine tuberculosis. Introducing new animals without prior health screening or quarantine remains a major pathway for disease entry, while larger herds increase within-herd transmission due to higher animal density and complex management structures. Nevertheless, these risk factors can be mitigated through targeted biosecurity interventions. Implementing pre-introduction testing, establishing quarantine protocols, and adopting herd management strategies adapted to herd size such as group segregation and controlled animal movement can substantially reduce the risk of infection and spread. Understanding and adjusting these modifiable factors provide a foundation for effective, farm-level biosecurity systems. Strengthening such preventive measures is essential for the sustainable control of bovine tuberculosis and for enhancing the overall resilience of cattle production systems.

Implementing a comprehensive biosecurity national program is essential to prevent and control bovine tuberculosis (bTB) in cattle herds. A successful program should integrate risk assessment, controlled animal movements, wildlife management, and strict hygiene practices. Continuous surveillance, proper record-keeping, and farmer awareness are also key to minimizing disease transmission. Ultimately, the effectiveness of bTB control depends on consistent application of biosecurity measures and active collaboration between farmers, veterinarians, and regulatory authorities.

Future researches should focus on characterizing the strains of the *Mycobacterium tuberculosis* complex isolated from cattle and determining their susceptibility to first-line anti-tuberculosis drugs used in human medicine.

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All authors have read and approved the final version of the manuscript.

Ethics

All authors declare no conflicts of interest.

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