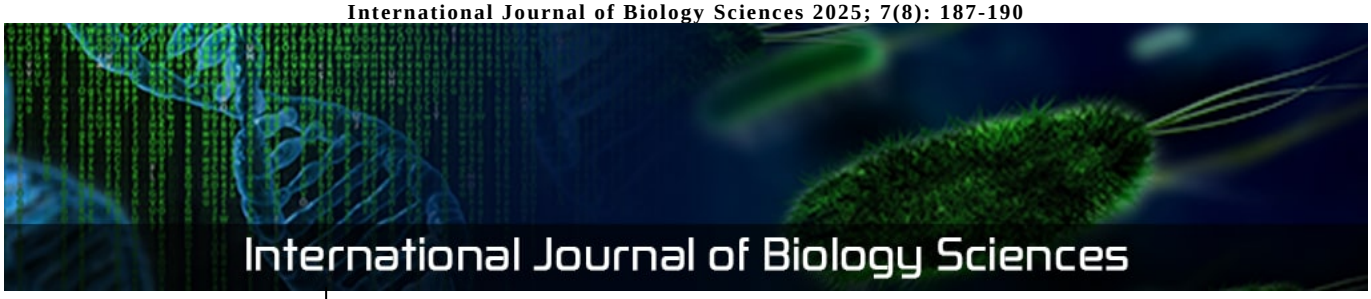

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Comparative analysis of risk factors associated with foot-and-mouth disease occurrence in hilly and plain regions

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Abstract
Foot-and-Mouth Disease (FMD) remains one of the most economically devastating livestock diseases worldwide, particularly in endemic regions where diverse ecological and management practices complicate control efforts. This study aimed to identify and compare the key risk factors associated with FMD occurrence in hilly and plain regions to inform geographically tailored intervention strategies. A cross-sectional study was conducted involving 707 cattle farms 250 located in hilly regions and 457 in plain regions. Structured questionnaires were used to collect data on farm demographics, animal husbandry practices, housing conditions, and herd health management. Multivariate logistic regression was applied to assess associations between potential risk factors and FMD occurrence, with results presented as odds ratios (OR) and 95% confidence intervals (CI). Significant risk factors for FMD occurrence included frequent interaction with other herds (OR = 2.07, 95% CI: 1.27-3.35, p = 0.001), recent FMD history in neighbouring farms (OR = 1.68, 95% CI: 0.73-3.12, p = 0.01), and the use of concrete housing (OR = 1.71, 95% CI: 1.08-2.74, p = 0.015). Farms in plain regions more frequently reported the use of intensive systems, commercial feed, and piped water factors that were positively associated with increased FMD risk. Male animals had significantly higher odds of FMD infection compared to females (OR = 1.67, 95% CI: 1.23-2.67, p = 0.031). Other factors such as deworming practices and cleaning frequency showed trends but were not statistically significant. FMD risk is influenced by both ecological and management-related factors. High herd interaction, farm clustering, and intensive housing conditions contribute to greater disease occurrence. These findings underscore the importance of developing region-specific biosecurity measures and control programs that consider local topography, resource use, and livestock movement dynamics.

Keywords: FMD, risk factors, hilly regions, plain regions, livestock management, epidemiology and biosecurity

Introduction
Foot-and-Mouth Disease (FMD) is a transboundary viral disease that affects cloven-hoofed animals and is known for its high contagiousness and economic consequences in livestock dependent communities (Donaldson *et al*., 2001; Knight-Jones & Rushton, 2013) [3, 10]. The disease leads to production losses, trade restrictions, and increased control costs, posing significant challenges in endemic regions, particularly in countries with varying agro-ecological settings. A variety of risk factors contribute to the occurrence and spread of FMD, including environmental conditions, herd management practices, and the level of interaction among herds. Communal grazing and watering practices have been consistently linked with higher FMD transmission, especially in areas where multiple herds converge at the same resources (Kebede *et al*., 2020; Balinda *et al*., 2009) [8, 1]. Similarly, extensive production systems and poor biosecurity are major contributors to outbreaks (Jemberu *et al*., 2023; Kitching *et al*., 2007) [6, 9]. Farm-level management practices also play a critical role in influencing FMD dynamics. Factors such as housing conditions, frequency of cleaning, and animal movement patterns impact exposure risk (Young *et al*., 2018; Sulayeman *et al*., 2023) [14, 11]. Studies have shown that inadequate cleaning of animal shelters and muddy housing environments provide conditions conducive to viral persistence (Wekesa *et al*., 2015) [13]. Breed susceptibility may also vary, with exotic and crossbreeds often reported to be more

vulnerable due to intensive management practices and higher contact rates (Kitching *et al*., 2007) [9].

Despite substantial research on FMD risk factors, there remains a gap in understanding how these factors vary between different topographical regions, such as hilly versus plain areas. Altitude and terrain can influence farm accessibility, herd interaction frequency, resource distribution, and overall exposure risk (Kebede *et al*., 2020) [8]. Recognizing these geographical differences is vital for developing targeted control strategies. The present study investigates the association of key epidemiological and management-related risk factors with FMD occurrence in hilly and plain regions.

Materials and Methods

Study Area and Design: This cross-sectional study was conducted between 2022 to 2025 across two ecologically distinct regions hilly and plain zones within Kashmir valley of India. These areas were selected based on differences in topography and livestock management systems. The classification into Hilly and Plain zones was based on altitude, with areas above 5,200 feet above sea level (ASL) categorized as Hilly, and those below 5,200 feet ASL as Plains (Mohiuddin, 2013) [15]. A multistage sampling technique was used to select districts, villages, and farms. Farms with cattle were included, and herds were sampled based on accessibility and consent from owners. The sample size was determined using standard prevalence estimation methods for cross-sectional studies (Thrusfield, 2018) [12].

Data Collection: Data were collected using structured questionnaires administered to livestock owners and farm managers. The questionnaire captured information on Recent history of FMD outbreaks in the farm or neighbouring farms, Production system (intensive vs. extensive). Sources of feed (commercial vs. local pasture) and water (piped vs. natural streams), Frequency of herd interaction with other animals, Periodic deworming practices, Housing type (concrete vs. muddy floors), Cleaning frequency of animal sheds, Breed types (local vs. exotic/crossbred), Gender distribution of the herd. Field investigators were trained prior to data collection to ensure consistency and minimize interviewer bias (Dohoo, Martin, & Stryhn, 2010) [2].

Data Analysis: Data were coded and analysed using SPSS (IBM Corp. 2010). Descriptive statistics were used to summarize the variables. Univariate analysis was conducted to identify potential associations between independent variables and FMD occurrence. Variables showing p-values ≤ 0.20 in the univariate analysis were included in the multivariable logistic regression model to estimate adjusted odds ratios (OR) and 95% confidence intervals (CI), Statistical significance was declared at $p<0.05$.

Results

A total of 707 respondents were surveyed, comprising 250 from hilly regions and 457 from plain regions. The mean altitude of farms in the hilly regions was significantly higher (7617±674 ft) compared to those in the plains (5167±612 ft), as expected based on geographic delineation. Risk Factor Analysis Table 1 presents the comparative analysis of selected risk factors associated with the occurrence of Foot-and-Mouth Disease (FMD) in hilly and plain regions. Several factors showed statistically significant associations with FMD presence.

Table 1: Analysis of Risk Factor Associations with FMD Occurrence in Plain and Hilly Regions

Independent Variables	Level	Hilly	Plain	P-Value	OR (95% CI)
Altitude		7617±674	5167±612	-	-
Have you observed any recent cases of Foot-and-Mouth Disease (FMD) in your or neighboring farms?	Yes	172	359	0.01	1.68 (0.73, 3.12)
	No	78	98		
What type of production system do you follow?	Intensive	52	305	0.1	1.91 (0.83, 4.95)
	Extensive	102	16		
What is the primary source of feed for the animals?	Commercial	27	252	0.03	1.34 (0.91, 2.23)
	Local pasture	127	69		
What is the primary source of water for animals?	Piped	07	186	0.11	0.68 (0.40, 1.14)
	Stream	156	135		
Whether periodic deworming was conducted	Yes	186	344	0.145	2.08 (0.61, 4.71)
	No	28	47		
How frequently do the animals interact with other herds	More	67	35	0.001	2.07 (1.27, 3.35)
	Less	87	286		
Breed type of cattle on the farm?	Local	54	22	0.136	1.6 (1.00, 2.55)
	Exotic/Cross	100	299		
What type of housing do you provide for your animals?	Concrete	22	314	0.015	1.71 (1.08, 2.74)
	Muddy	132	07		
How often do you clean the animal sheds?	Daily	82	160	0.065	1.47 (0.95, 2.31)
	Rarely	72	161		
Gender of the animal	Male	62	26	0.031	1.67 (1.23-2.67)
	Female	92	185		

Farms that reported recent FMD cases in their own or neighbouring farms had significantly higher odds of disease occurrence (OR = 1.68, 95% CI: 0.73-3.12; p=0.01), suggesting the importance of localized transmission dynamics and proximity-related exposure risks. Production system although not statistically significant (p=0.10), farms practicing intensive production systems exhibited nearly double the odds of FMD occurrence compared to those using extensive systems (OR = 1.91, 95% CI: 0.83-4.95), indicating a trend worth further investigation. Farms that relied primarily on commercial feed were at higher risk (OR = 1.34, 95% CI: 0.91-2.23; p=0.03), possibly due to increased animal density and interaction at distribution points. Similarly, access to piped water (OR = 0.68, 95% CI:

0.40-1.14; p=0.11) showed a protective trend, although not statistically significant. Farms that practiced periodic deworming had higher odds of FMD occurrence (OR = 2.08, 95% CI: 0.61-4.71; p = 0.145), though the association was not statistically significant. This could reflect reverse causality, where farms affected by disease are more likely to implement health interventions**.** High-frequency contact with other herds was significantly associated with increased FMD risk (OR = 2.07, 95% CI: 1.27-3.35; p=0.001), underscoring the role of direct and indirect animal-to-animal contact in FMD transmission.

Although not statistically significant (p=0.136), local breeds showed a higher odds ratio (OR = 1.6, 95% CI: 1.00-2.55) compared to exotic/crossbreeds, potentially reflecting regional distribution and management variations. Housing type was strongly associated with increased risk (OR = 1.71, 95% CI: 1.08-2.74; p=0.015), which may be attributed to higher stocking densities and limited ventilation, facilitating virus survival and spread. Farms that cleaned sheds daily had lower odds of FMD, though this association approached but did not reach statistical significance (OR = 1.47, 95% CI: 0.95-2.31; p=0.065), indicating a possible protective effect of improved sanitation. Male animals were significantly more likely to be associated with FMD cases compared to females (OR = 1.67, 95% CI: 1.23-2.67; p=0.031), possibly due to increased mobility or use in labour or trade, which may expose them to external herds.

Significant risk factors for FMD occurrence included recent history of FMD in nearby farms, high herd interaction frequency, housing type, and animal gender. These findings emphasize the need for region-specific control strategies that consider local geography, animal movement, and management practices.

Discussion

This study assessed risk factors associated with the occurrence of Foot-and-Mouth Disease (FMD) in two ecologically distinct settings hilly and plain regions. The findings highlight that both environmental and farm-level management practices significantly influence FMD epidemiology, emphasizing the need for region-specific control strategies. One of the most significant predictors identified was herd interaction frequency, where farms reporting frequent contact with other herds had more than twice the odds of FMD occurrence (OR = 2.07, p=0.001). This aligns with previous studies showing that communal grazing, livestock markets, and water points facilitate direct and indirect transmission of FMD (Kebede *et al*., 2020; Balinda *et al*., 2009) [8, 1]. In rural settings, unrestricted animal movement is often driven by resource availability and cultural practices, making control efforts challenging without coordinated community-level interventions (Jemberu *et al*., 2016) [6]. The presence of recent FMD cases in nearby farms was another significant factor, indicating strong spatial clustering of FMD outbreaks. This reflects the contagious nature of FMD and the importance of prompt outbreak reporting and quarantine measures. Similar spatial-temporal clustering has been observed in outbreaks in East Africa and South Asia, where proximity to infected farms significantly increased risk (Wekesa *et al*., 2015; Young *et al*., 2018) [15, 14].

Interestingly, concrete housing was associated with a higher risk of FMD (OR = 1.71, p=0.015), which may seem counterintuitive. However, concrete housing often reflects intensive farming systems where animals are kept in close proximity, creating conditions conducive to virus survival and transmission (Sulayeman *et al*., 2023) [11]. This finding is supported by Kitching *et al*. (2007) [9], who emphasized that intensive operations, without appropriate biosecurity, may elevate disease risk due to higher stocking densities and limited airflow. Male animals were found to have significantly higher odds of FMD occurrence (OR = 1.67, p=0.031), potentially due to increased mobility. Males are often moved for breeding, trade, or labor, increasing their exposure to external herds. Balinda *et al*. (2009) [1] similarly noted the role of animal movement in the spread of FMD, particularly in areas where males are frequently traded or loaned for draft purposes. While breed type did not reach statistical significance, local breeds showed higher odds of infection. This may reflect their predominance in extensive systems or in resource-poor farms where biosecurity is limited. On the contrary, exotic breeds are often reared in controlled environments with better management, although some studies have found exotic breeds to be more clinically susceptible (Knight-Jones & Rushton, 2013) [10]. Feed and water sources also played notable roles. Farms relying on commercial feed had higher odds of disease, possibly due to shared procurement and handling points, which may act as fomites. Similarly, piped water showed a protective trend, though not statistically significant. In contrast, natural streams often serve as communal watering sites, heightening exposure (Kebede *et al*., 2020) [8]. Though deworming appeared to correlate with increased odds, the association was not significant. This may reflect reverse causality, where farms experiencing disease become more proactive in health interventions. Likewise, shed cleaning showed a near-significant trend toward reduced risk, supporting the established role of hygiene in limiting environmental persistence of the virus (Wekesa *et al*., 2015) [13].

Conclusion

The results underscore the multifactorial nature of FMD risk and the importance of tailoring control measures to local contexts. Strategies focusing on limiting herd interaction, improving housing hygiene, and enhancing outbreak surveillance in clustered regions may help mitigate the spread of FMD. Future studies should explore longitudinal patterns and include molecular diagnostics to validate field-based observations.

Limitations

This study is limited by its cross-sectional nature, which restricts causal inference. Additionally, the reliance on farmer-reported data may introduce recall bias. Nevertheless, the findings offer valuable insights into how ecological and management differences shape FMD risk in diverse topographies.

Conflict of interest

Authors does not bear any conflict of interest

References

1. Balinda SN, Tjørnehøj K, Muwanika VB, Sangula AK, Mwiine FN, Ayebazibwe C, *et al*. Prevalence estimates of antibodies towards foot-and-mouth disease virus in small ruminants in Uganda. Transbound Emerg Dis. 2009;56(8):362-371. DOI:10.1111/j.1865-1682.2009.01091.x

2. Dohoo I, Martin W, Stryhn H. Veterinary epidemiologic research. 2nd ed. Charlottetown: VER Inc.; 2010. p.1-865.
3. Donaldson AI, Alexandersen S, Sørensen JH, Mikkelsen T. Relative risks of the uncontrollable (airborne) spread of foot-and-mouth disease by different species. Vet Rec. 2001;148(19):602-604. DOI:10.1136/vr.148.19.602
4. Hosmer DW, Lemeshow S. Applied logistic regression. 2nd ed. New York: Wiley-Interscience; 2000. p.1-373.
5. IBM Corp. IBM SPSS Statistics for Windows, Version 19.0. Armonk (NY): IBM Corp.; 2010.
6. Jemberu WT, Molla W, Almaw G. Epidemiological and economic significance of foot-and-mouth disease: a comprehensive review. Vet Med Sci. 2023;9(2):457-468. DOI:10.1002/vms3.974
7. Jemberu WT, Mourits MC, Woldehanna T, Hogeveen H. Estimation of the economic impact of foot-and-mouth disease outbreaks in Ethiopia. Prev Vet Med. 2016;132:49-58. DOI:10.1016/j.prevetmed.2016.08.008
8. Kebede AS, Mamo HH, Ayelet G, Gelaye E. Risk factors for foot-and-mouth disease in cattle in selected districts of Ethiopia. BMC Vet Res. 2020;16:94. DOI:10.1186/s12917-020-02610-1
9. Kitching RP, Hutber AM, Thrusfield MV. A review of foot-and-mouth disease with special consideration for the clinical and epidemiological factors relevant to predictive modelling of the disease. Vet J. 2007;173(2):293-309. DOI:10.1016/j.tvjl.2005.11.014
10. Knight-Jones TJD, Rushton J. The economic impacts of foot-and-mouth disease - what are they, how big are they and where do they occur? Prev Vet Med. 2013;112(3-4):161-173. DOI:10.1016/j.prevetmed.2013.07.013
11. Sulayeman M, Yimer M, Fekadu A. Prevalence and risk factors of foot-and-mouth disease in southern Ethiopia. Vet Med Int. 2023;2023:6690132. DOI:10.1155/2023/6690132
12. Thrusfield M. Veterinary epidemiology. 4th ed. Oxford: Wiley Blackwell; 2018. p.1-888.
13. Wekesa SN, Muwanika VB, Siegismund HR, Namatovu A, Balinda SN. Analysis of recent serotype O foot-and-mouth disease viruses from East Africa suggests evidence of four separate introductions of the virus into the region. Transbound Emerg Dis. 2015;62(5):479-493. DOI:10.1111/tbed.12178
14. Young JR, Suon S, Andrews CJ, Henry LA, Windsor PA. Assessment of financial impact of foot-and-mouth disease outbreaks on smallholder cattle farms in southern Cambodia. Transbound Emerg Dis. 2018;65(2):e250-e262. DOI:10.1111/tbed.12648
15. Mohiuddin M, Paulus R, Mitchell E, Hanna N, Yuen A, Nichols R, Yalavarthi S, Hayostek C, Willett C. Neoadjuvant chemoradiation for distal rectal cancer: 5-year updated results of a randomized phase 2 study of neoadjuvant combined modality chemoradiation for distal rectal cancer. International Journal of Radiation Oncology* Biology* Physics. 2013 Jul 1;86(3):523-8.