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ORIGINAL ARTICLE

Bovine Foot-and-Mouth-Disease risk factors in Mymensingh district of Bangladesh

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Abstract

Background: A hospital-based case-control study was undertaken to identify the risk factors for bovine Foot-and-Mouth-Disease (FMD) in the Mymensingh district of Bangladesh.

Methods: Two hundred and eighteen FMD cases diagnosed between 2009 and 2018 at the Bangladesh Agricultural University Veterinary Teaching Hospital (BAUVTH) were selected and three controls per case were then selected from BAUVTH (n=872). Data on age, breed, gender, location, and time of presentation wereUsed for the analysis. A multivariable mixed-effect logistic regression model was used to identify risk factors. Location was considered random intercept, demographic variables, and season as fixed effects.

Results: The lowest (10) and highest (43) cases were recorded in 2014 and 2015, respectively. There was a decreasing trend (τ = -0.07) in FMD occurrence but was inconsistent and statistically insignificant (P=0.85). The odds FMD was significantly higher in cattle aged >1–3 years (odds ratio (OR) 2.3; 95% confidence interval (CI): 1.5; 3.6) and >3–8 years (OR 1.9; 95% CI: 1.3; 3.0) compared to those aged ≤ 1years. Indigenous cattle (OR 1.7; 95% CI: 1.1; 2.8) were at higher risk of being an FMD case than Shahiwal cross. In addition FMD cases were significantly higher in pre-monsoon (OR 1.9; 95% CI: 1.3; 2.9) and winter (OR 2.2; 95% CI: 1.3; 3.7) than post-monsoon season.

Conclusion: Indigenous cattle aged between >1 year to 8 years should be prioritized for FMD vaccination, especially before pre-monsoon and winter seasons to prevent future FMD outbreaks and control FMD in Bangladesh.

Keywords: Case-control study, Mixed-effect, Age, Breed, Season

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Introduction

Foot-and-Mouth-Disease (FMD) is transboundary viral disease of domestic and wild cloven-hoofed animals which is highly endemic in Bangladesh (Brito *et al.*, 2017; Rahman *et al.*, 2020). High fever, salivation, vesicle formation in the tongue, feet and teats are the most common clinical signs of FMD. Outbreaks occur almost every year causing serious economic loss. The most important manifestations of FMD are fever, lameness, drooling, and vesicular lesions of the tongue, feet, and teats (Alexandersen and Mowat, 2005). Mortality, reduced production, treatment cost are the main causes of economic losses due to FMD (Giasuddin *et al.*, 2021). The projected financial loss due to the FMD outbreak in Bangladesh was estimated to be US$ 2.22 billion per year (Giasuddin *et al.*, 2021).

FMD serotype O, A are predominant but Asia 1 is also reported to be emerging in Bangladesh (Nandi *et al.*, 2015; Ali *et al.*, 2020). FMD vaccines containing the prevalent serotypes are recommended to prevent future outbreaks as the serotypes are immunologically distinct. The total doses of trivalent FMD vaccines available in Bangladesh are insufficient for the cattle and buffalo populations. In such a resource limited setting, the FMD hotspots should be prioritized for the FMD vaccination in Bangladesh (Rahman *et al.*, 2020). In addition, the animals and time at high risk should also be prioritized for vaccination in such scenario. However, there is limited study on the demographic and seasonal risk factors for FMD especially using appropriate study design (Sarker *et al.*, 2011; Chowdhury *et al.*, 2020). Hence, the objective of this study was to identify the demographic and seasonal risk factors for FMD in Mymensingh district of Bangladesh based on case-control study design.

Materials and methods

FMD case and control data

We used the case records of Bangladesh Agricultural University Veterinary Teaching Hospital (BAUVTH) to collect the Foot-and-Mouth-Disease (FMD) case and control data. All bovine FMD cases attended at BAUVTH between January 2009 and December 2018 were collected. For each FMD case, three control records of cattle were randomly selected from the sampling frame containing all cattle records during the 10-year study period. The data on FMD cases and controls included the date of examination, farm location name, demographic data, clinical signs, presumptive diagnosis and treatment given.

Case and control definitions

If one cattle had fever, salivation and lameness simultaneously we considered it as an FMD case. Controls were defined as those records of cattle attended to the BAUVTH for other diseases than FMD. We selected randomly, irrespective of time or location, because we were interested in exploring spatial and temporal risk factors. Three controls per case were chosen as a ratio of more than three controls per case adds little to the precision of a study (Rony *et al.*, 2017).

Data analysis

The case and control data were entered in Microsoft Excel sheet (Microsoft Excel 2010) and transferred to R version 4.1.3 (The R Foundation for Statistical Computing, 2022) for analysis. Age was converted to a categorical variable. Months of presentation were converted to season. We used the 'tabpct' function of the R package 'epiDisplay' (Chongsuvivatwong, 2018) to summarize the FMD case–control data. To identify the trend of FMD cases over the period of 2009 to 2018 we used Mann–Kendall trend test using the 'MannKendall' function of the R package 'Kendall' (McLeod, 2011).

Univariable and multivariable mixed-effect logistic regression analyses

Initially, a univariable mixed-effect logistic regression analysis was performed to assess the association between FMD status and explanatory variable considering location of cases and controls as random intercept (R package 'glmmTMB' (Magnusson *et al.*, 2017). Any explanatory variable associated with rabies case status with a P-value of □0.20 was selected for multiple mixed-effect logistic regression analysis.

Stepwise multivariable mixed-effect logistic regression model was used to identify risk factors for FMD. The final multivariable model was automatically selected based on the lowest Akaike's information criterion value. The performance of the model was evaluated by the "simulateResiduals" function of the R package "DHARMa" (Hartig et *al*., 2017). The methods to detect multicollinearity and confounding was described earlier (Noman *et al*., 2021)

Results and discussion

The lowest (10) and highest (43) cases were recorded in 2014 and 2015, respectively (Figure 1). An inconsistent decreasing trend (τ = -0.07) in FMD cases was observed over the period 2009–2018 (P = 0.85). The monthly distribution of FMD cases and control attended at Bangladesh Agricultural University Veterinary Teaching Hospital between 2009 and 2018 were presented in Table 1. The lowest (11) and highest (29) number of FMD cases were recorded in February and April, respectively. In the univariable screening, age, breed and season were associated with FMD case status at $P<0.20$ and were included in the multivariable model (Table 2). Age, breed and season were identified as risk factors for FMD (Table 3). The odds FMD was significantly higher in cattle aged >1–3 years (odds ratio (OR) 2.3; 95% confidence interval (CI): 1.5; 3.6) and >3–8 years (OR 1.9; 95% CI: 1.3; 3.0) compared to those aged ≤ 1years. Indigenous cattle (OR 1.7; 95% CI: 1.1; 2.8) were at higher risk of being an FMD case than Shahiwal cross. In addition FMD cases were significantly higher in pre-monsoon (OR 1.9; 95% CI: 1.3; 2.9) and winter (OR 2.2; 95% CI: 1.3; 3.7) than post-monsoon season.

Using 10 years of hospital based passive surveillance date we identified three risk factors for FMD. We proposed an evidence based vaccination strategy to prevent future outbreaks and control FMD in resource limited settings like Bangladesh. Relatively older cattle were found to be at higher risk for FMD than younger cattle. Similar findings have also been described by other authors (Chowdhury *et al*., 2020; Hasan and Mia, 2021). Indigenous cattle were found to be significantly more affected by FMD than Sahiwal cattle. Similar result has also been reported by other study (Chowdhury *et al*., 2020; Hasan and Mia, 2021). The occurrence of FMD was more frequent in dry (winter and pre-monsoon) than wet seasons (monsoon and post-monsoon). The results of a meta-analysis also revealed that the prevalence of FMD is higher in dry season than wet season (Hasan and Mia, 2021).

Conclusion

Indigenous **c**attle aged between >1 to 8 years should be prioritized for FMD vaccination especially before pre-monsoon and winter seasons to prevent future FMD outbreaks and control FMD in Bangladesh.

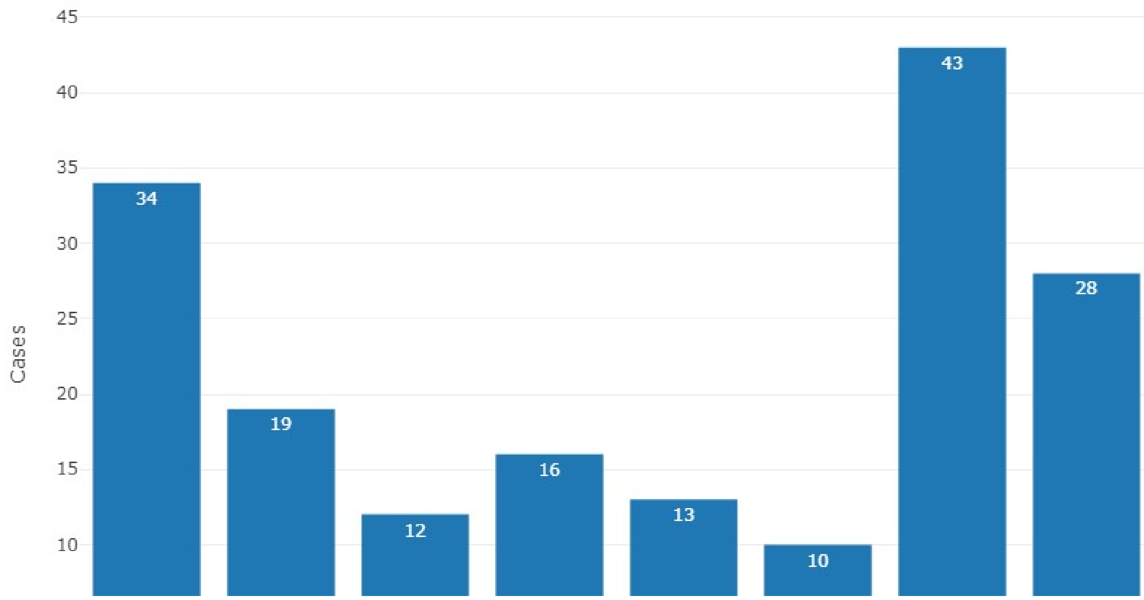

Figure 1. Yearly distribution of FMD cases attended at BAU veterinary Teaching hospital between 2009 and 2018

Table 1. Monthly distribution of FMD cases and control attended at Bangladesh Agricultural University Veterinary Teaching Hospital between 2009 and 2018

Month	Cases	Control	% Cases
January	13	19	40.6
February	**11**	47	19.0
March	18	55	24.7
April	**29**	55	34.5
May	20	36	35.7
June	21	71	22.8
July	19	60	24.1
August	16	64	20.0
September	15	90	14.3
October	23	75	23.5
November	17	69	19.8
December	16	13	55.2
Total	218	654	33.3

Table 2. Univariable association between independent variables and FMD case/control status based on the passive surveillance data from BAUVTH between 2009 and 2018

Risk factors	Categories	Case	Control	% Cases	Odds ratio (95% CI)	P-value
Season						0.001
	Pre-monsoon (March-May)	67	146	31.5	1.9 (1.3; 3.0)	
	Monsoon (June - August)	56	195	22.3	1.2 (0.8; 1.9)	
	Post-monsoon (September - November)	55	234	19.0	Reference	
	Winter (December-February)	40	79	33.6	2.2 (1.3; 3.6)	
Age (years)						0.005
	≤ 1	42	205	17.0	Reference	
	>1 to 3	81	189	30.0	2.2 (1.4; 3.3)	
	> 3 to 8	80	217	26.9	1.8 (1.2; 2.7)	
	> 8	15	43	25.9	1.8 (0.9; 3.5)	
Breed						0.009
	Indigenous	148	366	28.8	1.7 (1.1; 2.8)	
	Holstein Friesian Cross	44	179	19.7	1.0 (0.6; 1.8)	
	Shahiwal Cross	26	109	19.3	Reference	
Sex						0.72
	Male	74	214	25.7	1.1 (0.8; 1.5)	
	Female	144	440	24.7	Reference	
Total		218	654	33.3		

Table 3. Risk factors for bovine FMD identified in a final mixed-effect multivariable logistic regression model in Bangladesh, 2009–2018

Risk factors	Categories	Estimate	SE	Odds ratio (95% CI)
Age (years)				
	≤ 1	-	-	Reference
	>1 to 3	0.84	0.22	2.3 (1.5; 3.6)
	> 3 to 8	0.67	0.22	1.9 (1.3; 3.0)
	> 8	0.62	0.35	1.9 (0.9; 3.8)
Breed				
	Indigenous	0.55	0.25	1.7 (1.1; 2.8)
	Holstein Friesian Cross	-0.02	0.28	0.9 (0.6; 1.7)
	Shahiwal Cross	-	-	Reference
Season				
	Pre-monsoon	0.65	0.21	1.9 (1.3; 2.9)
	Monsoon	0.16	0.22	1.2 (0.8; 1.8)
	Post-monsoon	-	-	Reference
	Winter	0.80	0.25	2.2 (1.3; 3.7)

Competing Interest

The authors declare that they have no competing interests.

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