Economic impact of Foot-and-Mouth Disease (FMD) on dairy farmers of the highlands

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Abstract

The present study evaluates the economic impact of Foot and Mouth Disease (FMD) in cattle during an outbreak in the Union Territory (UT) of Jammu and Kashmir, from 2021 to 2022. The samples collected from animals suspected of FMD were systematically screened by using molecular-based Polymerase Chain Reaction (PCR). The tested animals were confirmed positive for the FMD virus, with the outbreak attributed to serotype O. The economic losses associated with the outbreak were categorised into two major components: (a) productivity loss, as a result of a short-term reduction in milk yield and (b) the treatment costs, which include expenses incurred for veterinary care and medications. A significant decrease in milk yield was observed in FMD-affected animals, with an average post-FMD milk yield (2.01 ± 0.21 L) being substantially lower ($P \leq 0.05$) compared to the pre-FMD milk yield (10.57 ± 0.29 L). The average per-treatment cost incurred per infected animal was Rs. 1,235.83. Considering the above parameters, the financial loss per infected animal during the disease episode was estimated at approximately Rs. 10,149.64, excluding other concurrent expenses. These findings highlight the significant economic burden imposed by FMD outbreaks, which directly impacts the livelihoods of dairy farmers. The study emphasises the urgent need for timely disease control measures and financial assistance programs to mitigate the adverse economic consequences of frequent FMD outbreaks in the highlands.

Keywords: Economic losses; FMD; Highlands; Milk yield; Serotype O

Introduction

The livestock industry holds significant importance in Indian agriculture and the overall economy, contributing notably to 4.11% of the nation's GDP and 25.6% of agriculture GDP (20th Livestock Census) (DADH, 2022). India is one of the world's top milk producers, with significant growth over the past decade, increasing from 187.30 million tons in 2018-19 to 230.58 million tons in 2022-23 (GoI, 2024). However, the prevalence of the highly infectious Foot and Mouth Disease (FMD) poses a significant threat to this sector, as it is regarded as an economically devastating disease (Aslam and Alkheraije, 2023). Foot and Mouth Disease (FMD) is a highly contagious and detrimental disease that affects domestic ruminants, primarily cattle, buffaloes, sheep and goats (Alexandersen et al., 2003). The disease is caused by the Foot and Mouth Disease Virus (FMDV), belonging to the Aphthovirus genus of the Picornaviridae family (Jiang *et al.*, 2014). The virus exists in seven distinct serotypes; O, A, C, Asia 1, SAT 1, SAT 2, and SAT 3, each demonstrating unique antigenic properties. The antigenic variability and genetic diversity of the FMDV and the lack of cross-protection between these serotypes pose significant challenges to its eradication, even with vaccinations (Singh et al., 2019). The FMDV typically causes fever, salivation, mouth and foot lesions, anorexia and decreased milk production, typically with low mortality rates (Fakhrul-Islam et al., 2016; Poorkhalily et al., 2018). The FMD significantly affects the economy, causing substantial losses in livestock production and trade causing weight loss and decreased productivity (Thompson et al., 2002). Recurrent outbreaks in India have raised concerns about its potential spread to other regions, posing a threat to global livestock trade. Govindaraj et al. (2021) estimated FMD-related farm losses in India at USD 2,768 million for severe, USD 237 million for moderate, and USD 133 million for mild outbreaks. The losses associated with FMD are multifaceted, including direct impacts such as reduced milk yields and meat production and indirect consequences like decreased draught ability and reproductive disorders (Govindaraj et al., 2015). Indirect losses also stem from trade restrictions on animals and animal products (Howlader et al., 2004). Adult animals may suffer weight loss and production losses for a longer period (Brito et al., 2018). Efforts to control and mitigate the spread of FMD are crucial to safeguard the livelihoods of those dependent on the livestock industry. Recognizing the substantial impact of Foot and Mouth Disease (FMD), particularly in the Kashmir region where livestock plays a critical role in the livelihoods of rural communities. This study was conducted to provide a comprehensive and updated analysis of its economic implications on the affected cattle owners during the latest outbreak period.

Materials and Methods

Sample collection: A study included cross-bred cattle affected with FMD across outbreak sites from 2021 to 2022 in Kashmir Valley. The valley is located between 32° and 36° N latitude and 74° and 80° E longitude, with an average elevation of 1,850 meters (6,070 feet) above sea level. The study included 89 FMD-infected cattle of all age groups from four districts of Jammu and Kashmir: Baramulla, Bandipora, Ganderbal and Srinagar (Fig. 1). The study districts were selected based on their significant cattle (Holstein cross and Jersey cross) population and active FMD cases during the summer and autumn seasons. Additionally, the vaccination status of the animals was documented.

After thorough clinical examinations, epithelium samples (1–2 cm^2) were collected from ruptured vesicles on the oral mucosa, tongue, hard palate, udder and feet/hooves from the affected animals. These samples were preserved in Trizol reagent and stored at -80°C to facilitate molecular confirmation of the disease.

Molecular identification: The RNA was extracted from tissue samples using TRIzol reagent following the protocol by (QIAGEN RNAeasy Clean-up Kit). PCR was performed with 5UTR universal primers 1F/1R targeting the FMD virus genome's 5 untranslated regions (UTR), generating a 328 bp product (Madi et al., 2015). Serotype identification for FMDV-positive samples was conducted using serotype-specific primers for serotypes O, A, and Asia-1 with expected size of 1301 bp, 863-866 bp and 911bp (Knowles et al., 2016).

Economic estimations: The estimated losses were assessed based on the responses of FMD-affected farm families, considering selected qualitative and quantitative parameters (Govindaraj et al., 2015).

The economic losses attributed to FMD were evaluated in terms of:

(a) **Productivity loss** – a reduction in milk yield and (b) **Treatment costs** – expenses incurred for veterinary care and medications, excluding other concurrent losses.

Average short-term loss due to milk yield reduction per animal was calculated as per the formula: (S_Y=1/n $\sum$ (E-A) x D x P)

(Where S_Y = average short-term loss due to milk yield reduction per animal; E=expected milk yield (L/day); A=actual milk yield till recovery from FMD (L/day); D=duration of infection in lactating animals (days); P=litre of milk; n=number of lactating animals recovered from FMD)

Average treatment costs per animal were calculated as per the given formula: (L_T = 1/n $\sum$ (F+M+1))

(Where L_T=average treatment costs per animal; F=fees for veterinarians/animal/farm family; M =cost of medicines/animal/farm family; I=cost of drugs/treatment during the infected period; n=total number of animals infected by FMD).

Total losses: (Total loss per animal =SY + LT)
The total losses were calculated as the sum of the average short-term loss due to reduced milk yield (SY) and the average treatment cost per animal (LT).
Statistical analysis: The qualitative data were presented as percentages, while the quantitative data were analysed using One-way ANOVA. Post-hoc analysis was conducted with Duncan's Multiple Range Test (DMRT) using SPSS-20.

Results and Discussion

A total of 89 cattle exhibited clinical signs of FMD with altered vital parameters and lesions on the mouth, muzzle, hooves and udder/teats followed by acute painful stomatitis and profuse salivation (Fig. 2 (a) (b) (c)). The affected cattle had mouth lesions (98.87%), foot/hoof lesions (85.39%) and udder/teat lesions (6.74%). All the samples collected from FMD-suspected animals tested positive for the FMDV using PCR targeting the 5-UTR gene. Further PCR amplification identified serotype O (Fig. 3). According to the findings, only 3.3% of cattle affected by Foot-and-Mouth Disease (FMD) had been vaccinated. The disruption of the FMD vaccine supply chain in Kashmir during the COVID-19 pandemic may have been a contributing factor.

Foot and Mouth Disease remains one of the most devastating livestock diseases due to its severe economic repercussions. FMD outbreaks are associated with significant economic losses, primarily due to the severity of clinical signs and mortality among affected cattle, especially in newborn calves (Ranjan et al., 2016). In lactating dairy cattle, milk yield (in litres) was recorded both in healthy animals and after they got infected with FMD. The mean pre-FMD milk yield (10.57 ± 0.290 L) was significantly ($P \leq 0.05$) higher than the post-FMD milk yield (2.01 ± 0.21 L) in affected animals. The mean pre-FMD milk yields in affected cattle from the four representative districts; Baramulla, Bandipora, Ganderbal and Srinagar were significantly ($P \leq 0.05$) higher than the post-FMD yields. The pre-FMD milk yield and post-FMD milk yields are provided in Table 1.

The average short-term losses resulting from reduced milk yield in FMD-infected cattle were calculated and the average short-term milk loss per FMD-infected animal was estimated at approximately 8913.29 Indian rupees including associated costs (Table 2). The average treatment cost was calculated and the estimated cost for a single treatment regimen was approximately Rs. 1,235.83 per FMD-infected animal (Table 3).

The average losses per infected animal were calculated by adding the average short-term milk loss (SY = Rs. 8913.29) and average treatment expenses (LT = Rs. 1,235.83). The total loss per FMD-affected animal was calculated as Rs. 10,149.64 during the disease episode in this outbreak period.

This study estimated an average economic loss per infected animal as Rs. 10,149.64 primarily due to reduced milk production and treatment costs. Consistent with previous reports, milk loss (both direct and indirect) accounted for the largest proportion of total losses (49.83%), followed by opportunity costs (16.15%) and reduced growth (12.20%) (Mulei et al., 2001). A similar study, conducted over 95 days reported milk production losses as the largest share of economic losses due to FMD (42.0%), followed by additional feed costs (13.6%) (Sobhy et al., 2018).

Table 1: The Pre-FMD and Post-FMD mean milk yield of suspected cattle from different districts (Mean ± S.E.)

Districts	Pre-FMD milk yield (L)	Post-FMD milk yield (L)
Baramulla	10.57 ± 0.32^{a}	2.01 ± 0.24^{b}
Bandipora	10.50 ± 1.50^{a}	1.00 ± 0.00^{b}
Ganderbal	11.00 ± 0.930^{a}	2.50 ± 0.65^{b}
Srinagar	9.33 ± 1.20^{a}	1.00 ± 0.50^{b}
Average	10.57 ± 0.290^{a}	2.01 ± 0.21^{b}

The different superscripts (row-wise) indicate a significant difference ($P \leq 0.05$)

Table 2: Average short-term milk loss (SY) per animal

Parameters	Notations	Average Estimates
Expected milk yield (litres/day)	E	6
Actual milk yield (litres/day)	A	0.5
Duration of infection (days)	D	30
Price of milk in litres	P	40

Table 3: Average treatment costs per animal

Parameters	Notations	Average Estimates
Fees for veterinarians	F	200
Cost of medicines	M	447.5

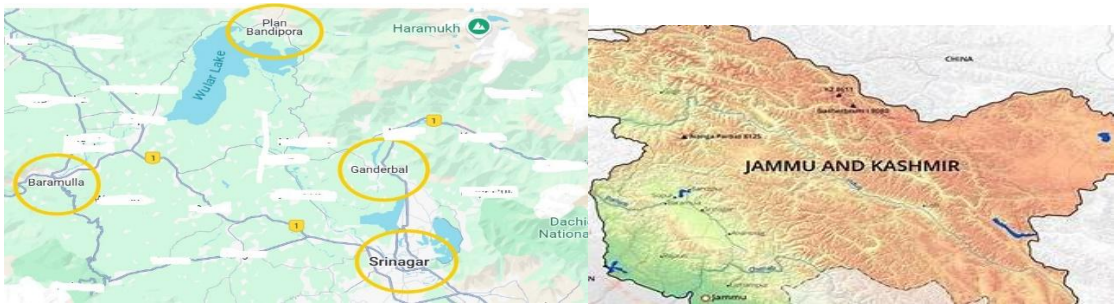

Fig 1: Sampling districts of UT of Jammu and Kashmir: Baramulla, Bandipora, Ganderbal and Srinagar

(a) Profuse salivation and nasal discharge **(b)** Oral lesions and ruptured vesicles **(c)** Foot-lesion in the interdigital skin

Fig 2: Clinical presentations in FMD-affected Cattle

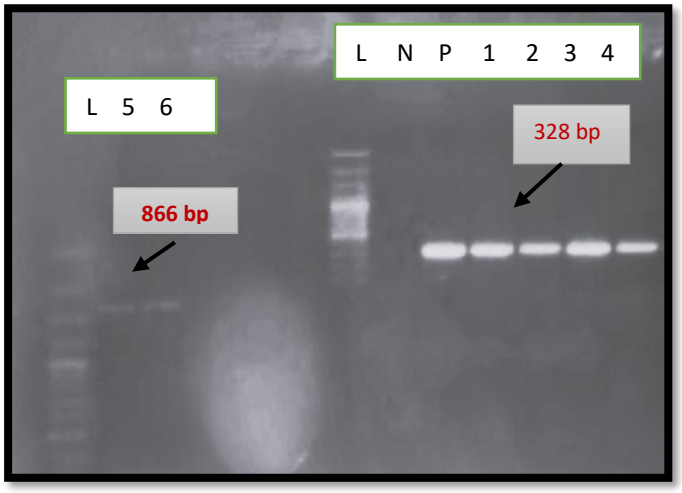

Fig 3: Screening of clinical samples by PCR for FMD and serotyping
L = 100 bp DNA Ladder, **Lane N & P** = Negative and Positive control;**1-4**= samples tested positive for FMD with 328 bp amplification; **5-6**= samples typed as serotype O with 866 bp amplification

Similarly, few more studies reported an approximate 25% productivity loss in FMD-infected animals, including reduced milk production and other costs associated with outbreaks, such as drug expenses and mortality (Bradhurst et al., 2019). Similar studies have shown that milk reduction, treatment costs and mortality in calves are among the primary components of these losses (Knight-Jones et al., 2013). Despite the significant economic losses incurred, unrestricted animal movement, delays in seasonal vaccination and the lack of quarantine measures are major contributors to frequent FMD outbreaks. Addressing these factors is crucial for effective disease control.

Conclusions

The economic impact assessment reveals substantial losses incurred by livestock owners, in terms of reduced milk yield, treatment expenses and other costs. The significant decrease in milk production in affected animals post-FMD compared to pre-FMD levels underscores the profound effect of the disease on productivity. Furthermore, the treatment and veterinary costs per infected animal underscore the financial burden imposed by FMD outbreaks. The average estimated losses per infected cattle provide a part of the comprehensive picture of the economic burden the livestock farmers face in the region alone due to this disease. The study highlights the urgent requirement for control measures in terms of effective and robust vaccination policy to decrease the detrimental impacts of FMD outbreaks on the lives of livestock farmers.

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Conflict of Interest

The authors have no relevant financial or non-financial interests to disclose.

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