Transboundary and Emerging Diseases

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ORIGINAL ARTICLE

Farm Community Impacts of Foot-and-Mouth Disease Outbreaks in Cattle and Buffaloes in Karnataka State, India

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Keywords:
foot-and-mouth disease; mortality loss; distress sale; milk yield loss; treatment cost; extra labour expenses

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Received for publication July 30, 2015

doi:10.1111/tbed.12450

Summary

This study was conducted to assess the impact of Foot-and-Mouth Disease (FMD) outbreak in cattle and buffaloes on farming community in Kolar district, Karnataka state, India. Primary data were collected using pre-tested schedule from 178 sample farms using multistage random cluster sample technique. The results revealed that 78% of surveyed villages were affected with FMD. The FMD incidence risk was high across the herd sizes, whereas the mortality risk was high in small herds. In indigenous cattle, the highest loss due to FMD was distress sale (208 USD) followed by other losses, whereas, in Crossbred cattle, the highest loss was mortality loss (515 USD) followed by distress sale (490 USD), milk yield loss (327 USD), treatment cost (38 USD) and extra labour engagement expenses for nursing of FMD-affected bovines (30 USD). In local and upgraded buffaloes, the mean total loss per affected animal was 440 USD and 513 USD, respectively. A very high variability in the loss per animal was observed across the type of losses in the Crossbred cattle, and it may be due to differences in age of the FMD-infected animal, value of the animal, milking stage, lactation levels, herd sizes and labour engagement levels, etc. In local and upgraded buffaloes, the mean total loss per animal was 639 USD and 1008 USD, respectively. The sensitivity analysis for 5% change in price revealed that the mean total loss per animal was positively correlated with price. Further, the social impact elicitation revealed that majority of the livestock owners perceived FMD had caused permanent asset loss, which in turn increased psychological stress of the family. The estimated losses and social impact due to FMD signify the importance of the intervention to control the disease and thus socio-economic gain to the farmer and society at large.

Introduction

Livestock is one of the fastest growing agricultural subsectors in India. In 2010–2011, livestock generated outputs worth USD 34.58 billion (2004–05 prices) which comprised 4% of gross domestic product (GDP) and 26% of agricultural GDP. Livestock sector grew at an annual rate of 5.3% during 1980s, 3.9% during 1990s and 3.6% during 2000s (Report of the working group on Animal Husbandry and Dairying XII Five-Year Plan (FYP) (2012–2017) submitted to planning commission, Government of India, New Delhi). Despite deceleration, growth in livestock sector remained about 1.5 times larger than that in the crop sector which implies its critical role in cushioning agricultural growth (Roop Raj and Gupta, 2015). The livestock sector growth in India is mainly driven by rapid increase in demand for livestock products due to high population growth, urbanization and increasing incomes. Livestock provides stability to the income of the farmers especially in the arid and semi-arid regions of the country and is an insurance against the vagaries of nature due to drought, famine and other natural calamities. The relevance of the livestock sector is underlined by the National Agricultural Policy, 2000, which emphasizes livestock as an important driver for achieving the targeted 4% growth in the agricultural sector by 2020. The XII FYP envisages an overall growth rate of 5–6% for the livestock sector (In India, FYPs are centralized and integrated national economic programs developed, executed and monitored by the Planning Commission of India, with the Prime Minister as the ex-officio Chairman. The First FYP was launched in 1951 to achieve economic development through the growth in agriculture, industry and service sector). The smallholders and landless farmers together possess 75% of the country's livestock resource and earn nearly half of their income from it. India is composed of 29 states and seven union territories. The states and territories are further subdivided into districts, taluks, blocks and villages for administrative purpose. District is the higher strata and village is the lower strata. Each district, in general, comprises of 3–4 taluks, each taluk comprises of 4–5 blocks, and each block comprises about 10–20 villages. The number of taluks, blocks and villages in each district may vary within a state and across the states.

The growth in livestock can be achieved by primarily focusing on nutrition and control of important livestock diseases, most importantly foot-and-mouth disease (FMD). FMD is an acute highly contagious disease of cloven-hoofed animals and causes high morbidity (up to 100%) and mortality particularly in young animals (50%) (Verma et al., 2008, 2012). India has FMD-susceptible livestock population of 512 million (Department of Animal Husbandry, Dairying & Fisheries (DAHD&F), Government of India, 2012). The control of FMD is significant for protecting livestock and for improving livelihood and income generation for millions of farmers in the developing countries like India where FMD is endemic. In 2004, Government of India launched Foot and Mouth Disease Control Programme (FMD-CP) in 54 specified districts in eight states of the country of 29 states and seven Union territories in the first phase with 100% central funding (for cost of vaccine, cold chain maintenance and logistic support) to undertake vaccination with the objectives to prevent economic losses due to FMD and development of herd immunity in cloven-footed animals (Singh et al., 2008a). At the current success rate under FMD-CP, it is expected by 2018 that the disease situation in entire southern India, comprising the states of Kerala, Tamil Nadu, Puducherry, Karnataka and Andhra Pradesh, will be under control and it is expected that zoning of the country as per the disease control measure using vaccination could be achieved in accordance with the World Organisation for Animal Health (WOAH-OIE) standards all over the country by 2025, thereby enabling India to enter international livestock product market and improve global food security and rural livelihood (Patnaik et al., 2012).

Karnataka is one among eight states which was covered under FMD-CP; however, factors like negligence on the part of farmers to get the cattle and buffaloes vaccinated, delay in starting the seasonal vaccination by the state animal husbandry department, unrestricted animal movement, resulted in severe FMD outbreaks during 2013 (The Hindu Newspaper, 2015). It has caused widespread uproar from all the stakeholders including the farming community. FMD affected not only the animal owners but also the nation as a whole due to ripple effect on the downstream and upstream stakeholders. An expert committee was formed by Government of Karnataka to assess the reasons for FMD outbreaks in the state. The primary etiological agent in the current outbreak and mortality in different parts of state was due to FMD virus serotype 'O' which was confirmed by the histological observations of chronic necrotising lymphocytic myocarditis and detection of FMD virus in the cardiac tissue by different serological and molecular assays/tests (Report on investigation on FMD outbreak in Karnataka, 2013–2014, Submitted to Secretary, Department of Animal Husbandry and fisheries, Government of Karnataka).

In India, there are few studies that reported the country level losses due to FMD and they were based on secondary information of various time periods' data (Singh et al., 2013). Some studies considered few factors/components, viz. mortality and culling (Thirunavukkarasu and Kathiravan, 2006), milk loss (Goel, 1989), milk loss, depreciation in market price, hide and skin, working capacity in cattle and buffaloes (Prabu et al., 2004), milk and draught power loss in cattle and buffaloes (Thirunavukkarasu and Kathiravan, 2010). Most of the above studies estimated milk yield loss, draught power loss, treatment cost and mortality loss, whereas other important loss components like short- and long-term milk loss, distress sale of the FMD-infected animals and extra labour for nursing the affected cattle and buffaloes on the basis of primary information from the FMD-infected livestock farms are lacking. In literature, the species-level (indigenous cattle, Crossbred cattle, local and upgraded buffaloes) loss estimates on the above components are also not available. Hence, to address the gap, the present research on farm community impacts of FMD in cattle and buffaloes was undertaken in Karnataka state, India.

Material and Methods

Sampling frame

Multistage random cluster sampling technique was followed to collect data on demographic profile of the farmers, livestock inventory, incidence of FMD in cattle and buffaloes, quantitative and qualitative information on impact parameters, etc. In the first stage, Kolar district of Karnataka state was purposively selected as there was very high incidence of FMD outbreak during 2013–2014. In the second stage, two taluks, viz. Kolar and Malur in Kolar district, were selected randomly. In the third stage, in each of the selected taluk, two blocks were selected randomly. In the fourth stage, in each of the selected block, one cluster comprising five to seven villages was selected. In the last stage, simple random sampling was followed to select the livestock farms in each of the identified village. A total of 178 livestock farms in 23 villages of four blocks were surveyed in Kolar district during March 2014 using pre-tested schedule developed for the purpose. The sample size for the study was based on the formula (Cochran, 1963).

$$SS = \frac{Z^2(P) \times (1 - P)}{e^2}.$$

where SS is the sample size needed, Z is the Z-value (for 95% confidence interval 1.96), P is the percentage picking a choice as decimal (0.5 used for sample size needed), and e is the acceptable sampling error, expressed as decimal (0.07).

The calculated sample size was 198, whereas the total samples surveyed were 178 as some of the livestock farmers were not interested to participate in the survey. The data on number of households owning cattle and buffaloes were not available in taluk/block level. Hence, in the last stage, based on number of households owning cattle and buffaloes in the identified cluster of villages, the number of samples to be surveyed was proportionately allotted and the samples were surveyed randomly.

To identify a FMD-affected animal, a case definition comprising the clinical symptoms such as fever, vesicles on foot, in and around mouth and on the mammary glands, rupturing of vesicles, anorexia, profuse salivation, lameness and reluctant to move and lesions on coronary band were stated in schedule. If majority of the above symptoms are noticed by farmers in their animals, it was considered as FMD affected. The total number of animals owned by the surveyed farmers were considered as animals at risk and the duration of infection in the animals refers to the first day when farmers identify the disease till complete recovery of animals. In the study area, FMD outbreak was reported during September–October 2013 and the survey was carried out during February–March 2014, and hence, for analysis, it was assumed that there was no change in population size in the farm.

Study area

In India, Karnataka is seventh largest state in area covering 191 976 square kilometres. As per 2012 census, total livestock population in this state was 12 986 989, of which cattle population was 9 516 484 and buffalo population was 3 470 504. The total livestock population in Kolar district was 274 912, of which cattle population was 229 036 and buffalo population was 45 876 (Department of Animal Husbandry, Dairying & Fisheries (DAHD&F), Government of India, 2012). The geographical location of the study area is presented in Fig. 1.

Classification of breeds, categories and herd size

The post-stratification was carried out to classify the herds based on number of animals, viz. small (1–2 animals), medium (3–4 animals) and large (five and above animals) herds (Ganesh Kumar et al., 2006). Similarly, the number of animals in different species [indigenous, Crossbred cattle, local and upgraded buffaloes (non-descript buffalo has been inseminated with semen of high productive buffalo breed available in India (e.g. Murrah breed)] in each category of animals like milch cow/buffalo (the animals which is in milking period), dry cow/buffalo (that were not giving milk), heifer (female cow/buffalo before first calf), bull/he buffalo (uncastrated adult male), bullock (castrated male animal of any age), immature male (male of 1–3 years of age), male calf (young male up to 1 year of age) and female calf (young female up to 1 year of age) was also post-stratified for assessing the incidence risk, mortality risk and associated losses due to FMD.

Estimation of incidence risk and mortality risk due to FMD

The data on livestock inventory, bovines infected due to FMD (based on the clinical signs noticed by farmers) and death due to FMD were collected to estimate incidence risk and mortality risk due to FMD (Mazengia et al., 2010).

Incidence risk of FMD was calculated as:

$$I = (F_a/A_r) \times D \times 100,$$

where I, incidence risk of FMD (%); F_a, number of new FMD-infected cases observed; A_r, animals at risk (Number), D, duration of infection (a year).

Mortality risk due to FMD was calculated as:

$$M = (A_f/A_r) \times D \times 100,$$

where M, mortality risk due to FMD (%), A_f, animals died due to FMD (Number), A_r, animals at risk (Number), D, duration of infection (a year).

Estimation of losses

In this study, only visible loss due to FMD like milk yield reduction, decline in draught power availability, cost incurred to treat the infected animals, loss due to extra labour engagement to nurse the animals during the period of illness and mortality of different category of animals due

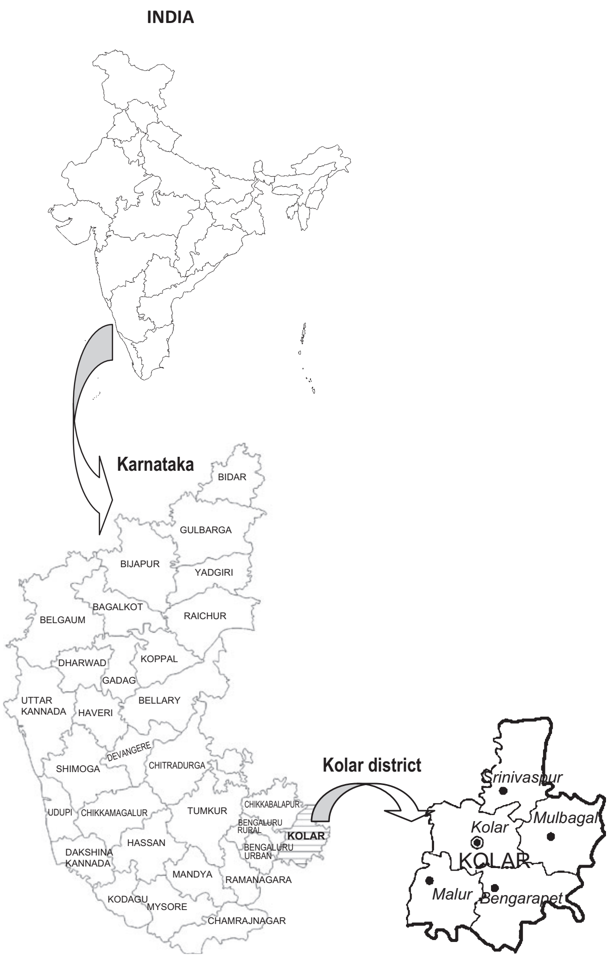

Fig. 1. Represents the study area in Kolar district, Karnataka, India.

to FMD was considered. The estimated loss due to FMD was based on the response of the FMD-affected farm families on various qualitative and quantitative parameters.

Average loss due to milk yield reduction per animal

In this study, both short- and long-term milk yield reduction loss was calculated. In short term, the milk yield loss calculation was from the period of FMD infection till the recovery of milch animals, and for long term, milk yield loss was from the recovery till the completion of that lactating period was considered (Fourichon et al., 1999).

Average short-term loss due to milk yield reduction per animal:

$$S_{\mathrm{y}} = 1/n \sum_{1}^{n} (E - A) \times D \times P,$$

where S_{Y}, average short-term loss due to milk yield reduction per animal (USD); E, expected milk yield (litres/day); A, actual milk yield till recovery from FMD (litres/day); D, duration of infection in lactating animals (days); P, price/litre of milk (USD); n, number of lactating animals recovered from FMD.

Average long-term loss due to milk yield reduction per animal:

$$L_{\mathrm{y}} = (E \times 0.15) \times N \times P,$$

where L_{Y}, average long-term loss due to milk yield reduction per animal (USD); E, average expected milk yield (litres/day); N, remaining lactation period after recovery (days); P, price/litre of milk (USD).

In long term, 15% decline in expected yield of milk was considered across the species (Lyons et al., 2015). The lactation period considered in cattle and buffaloes was 240 days and 270 days, respectively (Kumar et al., 2012). In this study, the variations on account of natural decline in milk yield according to the various orders and stages of lactation were considered as normally distributed.

Average loss due to milk yield reduction per animal:

$$A_{\mathrm{y}} = S_{\mathrm{y}} + L_{\mathrm{y}},$$

where, A_{Y}, average loss due to milk yield reduction per animal (USD); S_{Y}, average short-term loss due to milk yield reduction per animal (USD); L_{Y}, average long-term loss due to milk yield reduction per animal (USD).

In case of indigenous and Crossbred cattle, milk price considered was \$0.40/l, and for local and upgraded buffaloes, the price considered was \$ 0.43/l. The price was based on farm-gate price prevailed during March 2014.

Average loss due to draught power reduction per animal:

$$L_{\mathrm{D}} = 1/n\sum_{1}^{n}(D \times \mathrm{adj}) \times W,$$

where L_{D}, loss due to draught power reduction per animal; D, disease persistency in the bullocks (number of days); W, hiring charges/day (USD); n, number of bullocks recovered from FMD; adj = adjustment factor.

Draught power in agriculture is not used year round. Farmers opined that they engage farm animals for draught power on an average of 90 days a year for agricultural operation. Hence, the ratio 90/365 (0.246) is used as adjustment factor to change the duration of illness (days) to effective bullock working days lost. One working day refers to a pair of bullocks employed for agricultural operations for 5 h/day.

Average treatment costs per animal:

$$L_{\mathrm{T}} = 1/n\sum_{1}^{N}(F + M + I),$$

where L_{T}, average treatment costs per animal (USD); F, fees for veterinarians/farm (USD); M, cost of medicines/farm (USD); I, cost of indigenous treatment during the infected period (USD); N, number of farms; n, total number of animals infected by FMD.

Treatment cost includes veterinarian fee and medicine costs and many a times the combined payment was made by the farmer. In the study area, a veterinarian treats more than one infected animal per visit, and hence, per farm treatment cost was calculated and then converted to per animal. Indigenous treatment refers to the local remedies followed by some of the sample farmers in treating FMD-infected animals, viz. topical application of honey for mouth blisters, application of neem paste [a thick paste prepared with neem leaves (*Azardiracta indica*) and water], application of turmeric paste [turmeric (*Curcuma longa*) powder mixed with water] on wounds, application of fish/fish water on hooves to avoid secondary infection, etc.

Average extra labour engaged for nursing the affected animal:

$$L_{\mathrm{EL}} = 1/n\sum_{1}^{N}[(M_{\mathrm{Post}} - M_{\mathrm{Pre}}/8)] \times D \times W,$$

where L_{EL}, average extra labour engaged for nursing the animal (USD); M_{post}, manpower during FMD period (hours/day); M_{pre} , manpower during pre-FMD period (hours/day); D, duration of infection (days); W, wage rate/day (USD); N, number of farms; n, total number of animals infected by FMD.

All the species of cattle and buffaloes are reared by farmers under one roof, and hence, farmers could not differentiate the hours spent for nursing indigenous cattle, crossbred cattle, local and upgraded buffaloes individually. Therefore, for calculating extra labour expenses, it was assumed that extra labour engaged for nursing the affected animal is equal for all species.

Average loss due to distress sale per animal:

$$L_{\mathrm{s}} = 1/n\sum_{1}^{n}(A - S),$$

where, L_{S}, average loss due to distress sale per animal (USD); A, market value of animals before FMD (USD); S, sale value of animals after FMD (USD); n, total number of animals infected by FMD and sold.

Average loss due to mortality per animal:

$$L_{\mathrm{M}} = 1/n\sum_{1}^{n}A_j \times V_j,$$

where L_{M}, average loss due to mortality per animal in indigenous cattle (USD); j, category of animals, viz. In-milk, dry, bull, bullocks, immature males, heifer, male calf and female calf; A_{j}, number of animals in different categories; V_{j}, average value of animals (USD); n, total number of animals infected by FMD and died.

Similarly for other species (Crossbred cattle, local and upgraded buffalo), mortality loss was calculated.

Total loss per animal:

$$E_{\mathrm{T}} = L_{\mathrm{y}} + L_{\mathrm{D}} + L_{\mathrm{T}} + L_{\mathrm{EL}} + L_{\mathrm{S}} + L_{\mathrm{M}},$$

where E_{T}, total loss per animal (USD); L_{Y}, average loss due to milk yield reduction per animal (USD); L_{D}, average loss due to draught power reduction per animal (USD); L_{T}, average treatment costs per animal (USD); L_{EL}, average extra labour engaged for nursing the animal (USD); L_{S}, average loss due to distress sale per animal (USD); L_{M}, average loss due to mortality per animal (USD).

The prevailing market prices of different category animals were considered for calculating the mortality loss. The wage rate and bullock hiring charges prevailing in the survey villages were considered for calculating the loss due to extra labour engagement for nursing the animal and bullock power loss, respectively. The farm-gate price of milk was considered for calculating the milk reduction loss. 1USD = 60 INR was the exchange rate considered for conversion of INR to USD. Sensitivity analysis for total losses was carried out for the scenario of 5% rise and fall in prices that were calculated in terms of INR and then converted to USD. The assumption of 5% change in price was based on growth rate in value of output (constant prices) of livestock sector in India (2004–2005 to 2012–2013) (Department of Animal Husbandry, Dairying & Fisheries (DAHD&F), Government of India, 2012).

Social impact

To assess the social impact, qualitative data were collected in the open ended format. The collected data were post-classified, and frequency tables were prepared. The percentage analysis was carried out to know the social impact of FMD on the farming community in the study region.

Statistical analysis

The chi-square test was employed to determine the significant differences in incidence risk and mortality risk between herd sizes and between different category in Crossbred cattle. Fisher's exact test was used to determine the significant difference in farm-level incidence risk and mortality risk due to FMD between different categories in local buffaloes as the expected counts of cells in contingency tables were less than five. A one-way ANOVA was used to test the significant difference in milk yield loss, treatment cost, extra labour expenses, mortality loss and distress sale loss across the species.

Results

Profile of sample livestock farms and farmers

The results of the sample survey revealed that there is no considerable difference in age of the livestock owners (Table 1). In the surveyed district, the education level of majority of the livestock owners was up to primary level and only few had high school and college education. The results of livestock inventory in sample households revealed that the Crossbred population (Holstein–Friesian and Jersey) was high (80%) followed by local buffaloes (10%), indigenous cattle (9%) and upgraded buffaloes (1%). The results also revealed that 78% of surveyed villages were affected with FMD.

Incidence risk and mortality risks due to FMD

Incidence risk across farm size, breeds and different category of animals

The incidence risk in different farms revealed that it was high in all the herd sizes and ranged from 81% (CI 77–88) to 85% (CI 74–91) (Table 2). The chi-square results revealed that the FMD incidence risk (χ^2 = 1.3, P = 0.51) across herd sizes is not significantly different. In indigenous cattle, FMD incidence was observed in three category of animals, viz. lactating cow, bullocks and female calf, with highest disease incidence in lactating cow (50%; CI 10–91) followed by bullocks (33%; CI 19–52) and female calf (25%; CI 1–78). The overall FMD incidence in indigenous cattle was 34% (CI 21–51). In Crossbred cattle, the FMD incidence was observed in lactating cow, dry cow, heifer, immature male, male calf and female calf. The highest disease incidence in the Crossbred cattle was in immature males (100%; CI 5–100) followed by lactating cow (93%; CI 87–96), heifer (91%; CI 82–96), dry cow (78%; CI 62–89), female calf (64%; CI 49–77) and male calf (40%; CI 7–83) with the overall incidence of 87% (CI 83–90).

Among the local buffaloes, the disease incidence was noticed by farmers in lactating cow, dry cow, heifer, male calf and female calf category of animals. The highest disease incidence was observed in lactating cow (81%; CI 54–95) followed by dry cow (78%; CI 40–96), female calf (67%; CI 35–89), heifer (50%; CI 26–74) and male calf (40%; CI 14–73). The overall incidence level in local buffalo breed was 64% (CI 50–75). Among upgraded buffaloes, the disease incidence was observed in lactating cow and male calf with incidence percentage of 67% (CI 13–98) and 100% (CI 5–100), respectively. The overall incidence level in the upgraded buffaloes was 75% (CI 22–99). The chi-square and Fisher's exact results revealed that there was significant

Table 1. General characteristics of sample farmers and FMD status in surveyed villages and farms in Kolar, Karnataka

	Number	Percentage
Age (years)	46.9	
Education		
Illiterate	85	47.8
Primary	42	23.6
High school	34	19.1
College and above	17	9.6
Total	178	100
Head of the family		
Male	151	84.8
Female	27	15.2
Total	178	100
Livestock inventory in sample households		
Indigenous cattle	44	9.1
Crossbred cattle	383	79.5
Local buffaloes	49	10.5
Upgraded buffaloes	6	1.2
Total	482	100
No. of villages surveyed	23	100
Villages affected	18	78.3
No. of farms surveyed	178	100
Farms affected	151	84.8

Table 2. FMD incidence risk and mortality risk (%) across herd sizes, species and category of animals in Kolar, Karnataka

	Categories	No. of animals morbid	Morbidity (%) to total animals	CI for morbid	No. of animals died	Mortality (%) to total animals	CI for mortality
Herd sizes groups	Small (93)	156	80.5	76.6–87.9	78	39.4	34.4–48.9
	Medium (62)	160	80.8	72.8–84.4	41	22.0	15.1–26.6
	Large (23)	73	85.0	74.1–90.6	29	22.3	23.8–44.3
	Overall (178)	389	81.2	77.7–84.8	148	31.2	26.9–35.4
	χ^2 value	1.32 (P = 0.51)			20.7 (P = 0.000)		
Species							
Indigenous cattle	Lactating cow	2	50.0	9.9–90.8	0	0	0
	Bullocks	11	33.3	18.5–51.8	0	0	0
	Female calf	1	25.0	1.3–78.1	0	0	0
	Overall	14	34.1	20.5–50.6	0	0	0
Crossbred cattle	Lactating cow	192	93.2	88.6–96.1	56	27.2	21.3–33.8
	Dry cow	32	78.0	61.9–88.8	11	26.8	14.7–43.2
	Heifer	73	91.3	82.2–96.1	37	46.3	35.1–57.7
	Immature Male	1	100.0	5.4–100.0	0	0.0	0
	Male calf	2	40.0	7.2–82.9	1	20.0	1.1–70.1
	Female calf	32	64.0	49.1–76.7	21	42.0	28.5–56.7
	Overall	332	86.7	82.7–89.8	126	32.9	28.3–37.8
	χ^2 test value	43.56 (P = 0.000)			12.93 (P = 0.002)		
Local buffaloes	Lactating cow	13	81.3	53.6–95.0	5	31.3	12.1–58.5
	Dry cow	7	77.8	40.2–96.0	2	22.2	3.9–59.8
	Heifer	8	50.0	25.5–74.5	4	25.0	8.3–52.6
	Male calf	4	40.0	13.7–72.6	3	30.0	8.1–64.6
	Female calf	8	66.7	35.4–88.7	5	41.7	16.5–71.4
	Overall	40	63.5	50.3–74.9	19	30.2	19.5–43.2
	Fisher's exact test value	13.94 (P = 0.000)			6.60 (P = 0.004)		
Upgraded buffaloes	Lactating cow	2	66.7	12.5–98.2	1	33.3	1.7–87.7
	Male calf	1	100.0	5.4–100.0	1	100.0	5.4–100.0
	Overall	3	75.0	21.9–98.6	2	50.0	9.1–90.8

Figures in parentheses indicate number of farms in each category of farms.

difference in Crossbred cattle (χ^2 = 43.9, P = 0.000) and local buffaloes (Fisher's exact = 13.9, P = 0.000), implying wide variation in FMD incidence level across the category of animals.

Mortality risk due to FMD across farm size, breeds and different category of animals

The results of mortality levels across farm size and different category of animals are presented in Table 2. The mortality risk due to FMD was high in small herds (39%; CI 34–49) than medium (22%; CI 15–27) and large herds (22%; CI 24–44) with overall mortality risk of 31% (CI 27–35). The chi-square results showed that there was significant difference (χ^2 = 23.2, P = 0.000) in mortality risk across the herd sizes. The mortality was not observed in the indigenous cattle and it may be due to their inherent resistance to the disease. Among the Crossbred cattle, the mortality risk was observed in all categories except immature male with highest mortality risk in heifer (46%; CI 35–58) followed by female calf (42%; CI 29–57), lactating cow (27%; 12–59), dry cow (27%; 4–60) and male calf (20%; 8–65). In local buffaloes, the mortality risk was observed in all the category of animals with the highest mortality in female calf (42%; CI 17–71) followed by lactating cow (31%; CI 12–59), male calf (30%; CI 8–65), heifer (25%; CI 8–53) and dry cow (22%; CI 4–60). The overall mortality in upgraded buffaloes was 50%, whereas it was 33% and 30% in crossbred cattle and local buffaloes, respectively. The chi-square test and Fisher's exact test revealed that in Crossbred cattle (χ^2 = 12.3, P = 0.000) and local buffaloes (Fisher's exact = 13.9, P = 0.004), the mortality risk levels due to FMD across the category of animals are significantly different.

Losses due to FMD

The visible loss due to FMD like milk yield reduction, decline in draught power, treatment cost, labour expenses and mortality was assessed.

A perceptible milk yield loss due to FMD was observed in short term and long term. In indigenous cattle, average duration of illness was 38 days with per animal milk yield loss in short term and long term was 60 USD and 23 USD, respectively. In Crossbred cattle, average duration of illness was 43 days with milk yield loss in short term was 216 USD/animal and in long term was 111 USD/animal. In local and upgraded buffaloes, short-term milk yield loss was 52 USD/animal and 121 USD/animal, respectively, whereas long-term loss was 37 USD/animal and 65 USD/animal, respectively (Tables 3 and 4). The total milk yield loss across the species revealed the highest loss of 327 USD/animal in Crossbred cattle (ranging from 31 to 1022 USD) followed by upgraded buffaloes (207 USD/animal), local buffaloes (96 USD/animal) and indigenous cattle (83 USD/animal) (Tables 3 and 5).

In the study area, the sample farmers derive draught power for agricultural and non-agricultural operations from indigenous cattle only. The number of effective draught power working days loss in Kolar district was 11 (ranging from 7–15 days) (Table 4). The loss of draught power unavailability due to FMD ranges from 19 to 55 USD with overall loss of 40 USD per bullock. The treatment cost includes both the professional and indigenous treatments for mitigating FMD and its spread. In indigenous cattle, the treatment cost incurred by the farmers ranges from 7 to 92 USD with overall cost per animal of 33 USD. In Crossbred cattle, the treatment cost incurred by the farmers ranges from 17 to 292 USD depending on the disease severity and duration of illness. The cost incurred by the farmers in controlling the disease in local buffaloes ranges from 16 to 150 USD with overall treatment cost of 34 USD. In upgraded buffaloes, the treatment cost ranges from 20 to 45 USD with overall cost of 22 USD.

Among the sample farms, no death was observed in the indigenous cattle, whereas it was observed in other species. Among the deaths observed, majority were in Crossbred cattle (126/147 = 86%) followed by local buffaloes (19/147 = 13%) and upgraded buffaloes (2/147 = 1%). Among Crossbred cattle, majority of the deaths were in adult animals (104/126 = 83%). Similar results were observed in local buffaloes also. The weighted average results revealed that the loss due to death in Crossbred cattle ranges from 83 to 1042 USD with overall loss of 515 USD followed by upgraded buffaloes (275 USD) and local buffaloes (209 USD with a range of 8–500 USD). The average expenses incurred for additional labour to nurse the affected animal during FMD were 30 USD (ranging from 12–225 USD). The distress sale inflicted considerable loss to the farmers. The distress sale was observed especially when the hope to recovery of ailing animals was less. The number of animals sold under distress was high in Crossbred cattle (22/28 = 79%) followed by local buffaloes (4/28 = 14%) and indigenous cattle (2/28 = 7%). The average loss due to distress sale was high in Crossbred cattle ranges from 3 to 1225 USD with overall loss of 490 USD, as majority of the animals sold were adult (19/22 = 86%) animals of high value. The average loss due to distress sale in indigenous cattle and local buffaloes was 208 and 78 USD, respectively. The results of ANOVA revealed that milk yield loss (F (3,205) = 12.4, P = 0.000) and mortality loss (F (3,146) = 9.8, P = 0.000) were significantly different, whereas treatment cost (F(3,388) = 3.8, P = 0.01) and distress sale due to FMD (F(2,21) = 2.6, P = 0.09) were not significantly different across the species.

The sensitivity analysis for 5% change in price for indigenous cattle indicated considerable change in losses. In scenario II (5% increase in price in INR), the estimated loss

Table 3. Average short-term and long-term losses due to milk yield reduction (USD/animal)

Species	Milk yield loss		
	Short term	Long term[a]	Total
Indigenous cattle	60 (48–72)	23 (9–36)	83 (57–108)
Crossbred cattle	216 (24–720)	111 (7–302)	327 (31–1022)
Local buffaloes	52 (17–104)	37 (5–95)	89 (22–199)
Upgraded buffaloes	121 (121–121)	65 (65–65)	186 (186–186)

[a]15% of the expected milk yield from recovery to the remaining lactation period was considered as loss in quantity of milk yield reduction (Lyons et al., 2015).

Table 4. Losses due to milk loss and draught power loss per FMD-affected animals in Kolar district

Species	No. of FMD recovered animals	Average duration of illness in days	Average quantity of milk lost in litres	Effective draught power working days loss[a]
Indigenous cattle (milch animals)	2	38 (40–45)	150 (120–180)	–
Crossbred cattle (milch animals)	190	43 (25–120)	561 (60–1800)	–
Local buffaloes (milch animals)	13	32 (12–90)	120 (40–240)	–
Upgraded buffaloes (milch animals)	1	28 (28–28)	280 (280–280)	–
Indigenous cattle (Bullocks)	11	44 (30–60)	–	11 (7–15)

[a]An adjustment factor of 0.246 which was used to change duration of illness into effective working days lost.

Table 5. Average losses due to milk yield reduction, draught power, treatment, mortality and distress sale per FMD-affected animals in Kolar, Karnataka (USD/animal)

Species	Scenario	Milk yield loss (Total)	Draught power loss	Treatment cost	Mortality loss	Extra labour expenses	Distress sale	Total loss
Indigenous cattle	I	83 (57–108)	40 (19–55)	33 (7–92)		30 (12–225)	208 (208–208)	521
	II	90 (67–116)	42 (23–59)	35 (12–96)		32 (14–229)	218 (218–218)	541
	III	74 (50–97)	38 (17–51)	40 (5–87)		29 (9–223)	206 (206–206)	512
Crossbred cattle	I	327 (31–1022)		38 (17–292)	515 (83–1042)	30 (12–225)	490 (12–1225)	1941
	II	340 (38–1038)		40 (23–298)	541 (87–1051)	32 (14–229)	515 (16–1248)	2013
	III	315 (24–1004)		36 (14–284)	489 (76–1033)	29 (9–223)	488 (6–1216)	1899
Local buffalo	I	89 (22–199)		34 (16–150)	209 (8–500)	30 (12–225)	78 (18–175)	639
	II	96 (29–199)		36 (21–158)	219 (15–517)	32 (14–229)	82 (23–183)	660
	III	82 (17–189)		32 (11–143)	199 (5–492)	29 (9–223)	77 (13–164)	622
Upgraded buffalo	I	186 (186–186)		22 (20–45)	275 (275–275)	30 (12–225)		1008
	II	207 (207–207)		23 (23–49)	289 (289–289)	32 (14–229)		1035
	III	197 (197–197)		21 (16–41)	261 (261–261)	29(9–223)		982
		$F(3,205) = 12.4$, ($P = 0.000$)		$F(3,338) = 3.8$, ($P = 0.01$)	$F(3,146) = 9.8$, ($P = 0.000$)		$F(2,21) = 2.6$, ($P = 0.09$)	

F-test was carried to know the significance difference across species in scenario I; Figures in parentheses indicate range values.

due to milk yield loss was 90 USD (67–116), whereas it was 74 USD in scenario III (5% decrease in price in INR). Similarly, in distress sale, it was 218 USD (scenario II) and 206 USD (scenario III), respectively. The results of draught power loss, treatment cost and extra labour expenses incurred for nursing the infected animals revealed that under scenario II, it was 42 USD, 35 USD and 32 USD, respectively, whereas it was 38 USD, 34 USD and 29 USD in scenario III, respectively. Similar results in losses were observed in Crossbred cattle, local and upgraded buffaloes under different price scenarios (Table 5).

In indigenous cattle, the highest loss was from milk yield loss and distress sale which accounts to 74% of total loss, followed by draught power loss (10%), extra labour engaged for nursing the FMD-affected animals (8%) and treatment cost (8%) (Fig. 2). In Crossbred cattle, the highest loss was mortality loss (37%) followed by distress sale of infected animals (35%), milk yield loss (23%) treatment cost (3%) and extra labour engaged for nursing the affected animals (2%). The important loss component in local buffaloes was mortality loss (48%), followed by milk yield loss (20%), distress sale (18%), treatment cost (8%) and extra labour engaged for nursing the affected animals (7%). In upgraded buffaloes, the mortality loss amounts to 54%, followed by milk yield loss (30%), extra labour engaged for nursing the affected animals (6%) and treatment cost (4%).

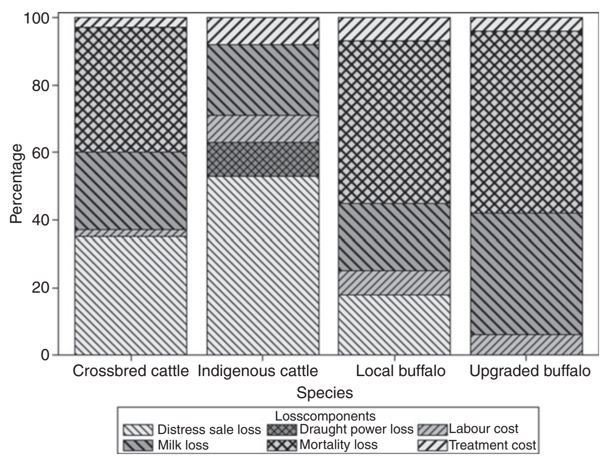

Fig. 2. Percentage of losses in the total loss due to foot-and-mouth disease (FMD) in different livestock species.

Social impact

Majority (99%) of the livestock farmers in the study area opined that their important permanent asset was lost and further asset creation and multiplication was curtailed due to widespread mortality of FMD-infected animals. Around 82% and 78% of farmers experienced psychological stress (financial burden) and affected agricultural productivity (less attention in crop cultivation and lack of cow dung), respectively. A sizable number of affected farmers (48%) also lost their employment in their farms due to this disease. The FMD-affected farm households also suffered due to increased borrowing for meeting consumption needs of the family (25%), additional medical expenses for the family (24%) and negative impact on education of their children (13%). Other social impacts perceived by the farmers are presented in Tables 6.

Discussion

The study was based on the primary data collected through survey, and hence, the results are to be visualized with certain limitations, for example the clinical signs observed by the farmer rather than the laboratory diagnosis were considered to assess the infection of FMD. Farmers in the study area do not maintain farm records, and majority of information were collected based on memory recall, and hence, there may be certain recall bias on various facets of FMD-related parameters.

High incidence of FMD was observed across all the herd sizes, and it may be due to same risk factors responsible for the infection and spread. The high mortality risk was observed in small herds, than medium and large herds. The small farmers lack much resource to treat the infected animals at right time, and it might have resulted in more mortality among these herds. In case of Crossbred cattle and local buffaloes, the observed incidence risk across various age and sex group categories of animals is significantly different. It might be due to varying susceptibility rates among different category of animals. In the surveyed district, the incidence risk and mortality risk were high in Crossbred population than the local breeds, and similar results were reported by Mekonen et al. (2011).

In the present study, long-run milk yield loss was less than short-run, as majority of FMD-affected in-milk animals were in mid- and late stage of lactation. Most of the reviews (Senturk and Yalcin, 2005; Mathew and Menon, 2008; Singh et al., 2013) reported that the milk yield loss was highest followed by other losses, whereas, in this study, the mortality loss was highest followed by other losses which is in line with Baluka et al. (2014), who reported that the highest per cent to the total economic loss was due to mortality loss (40%) in small herds. The average effective working days lost was 11 days amounting to 40 USD, and the results are on par with Jemberu et al. (2014), who reported that effective working days lost was 5 days worth an average of USD 15 in Ethiopia. In this study, the average treatment cost per FMD-affected animal was 33 USD, whereas Young et al. (2013) reported a 15.13 USD in Cambodia. The average mortality loss was 515 USD, 209 USD and 275 USD in Crossbred cattle, local and upgraded buffaloes, respectively, and these results are in line with Jemberu et al. (2014), indicated that mortality loss per head in cattle in crop-livestock mixed and pastoral system were 129 USD and 151 USD in Ethiopia. Several studies revealed that calves are prone to myocarditis resulting in death, whereas the outbreaks occurred during 2013 in the study area caused severe mortality in adults resulted in huge loss to the farmers. The earlier notion that FMD disease usually results in heavy morbidity, but not mortality, does not hold true in the present scenario because of improved livestock, improved animal husbandry practices and facility for fast trading of animals existing in the states. Besides, climatic factors also favoured the transmission of FMD virus and its full expression in the susceptible hosts, causing heavy mortality (Singh et al., 2008b).

Table 6. Social Impact caused due to FMD in the study area

Social Impact FMD has caused for the Farmers	Number of farmers
Livestock asset of the farm families and its creation is lost	150 (99.3)
Regular income loss affected their savings pattern	114 (75.5)
Affected the education of their children	20 (13.2)
Affected household asset creation like building, machineries, gold.	13 (8.6)
Affected daily food consumption pattern	37 (24.5)
Increased their borrowing for meeting consumption needs	25 (16.6)
Affected social life like marriage and other related family events	4 (2.6)
Increased psychological stress	123 (81.5)
Affected medical expenses burden for family	36 (23.8)
Affected agricultural productivity (less attention in crop cultivation and lack of cow dung)	117 (77.5)
Employment of the farmer/farm labour is lost	73 (48.3)

Figures in parentheses indicate percentage to the total affected farms.

The distress sale loss was one of the major losses as only 5% of the actual value of the animal was realized by farmer. The distress sale not only incurred loss to the farmers but also a very important mechanism of spreading the disease. Hence, the farmers are to be educated and advised to desist from selling the FMD-infected animals. In this study, the average total loss in indigenous cattle, Crossbred cattle, local and upgraded buffaloes were 521, 1941, 639 and 1008 USD, respectively. A very high variability in the loss due to FMD was observed across the type of losses in the crossbred cattle, and it may be due to differences in age of the animal, value of the animal, milking stage, lactation levels and labour engagement levels, etc. Similar results of variability in loss were reported by Jemberu et al. (2014). Considering the differences in value of the animal, prices of animal products, differences in wage and rental rates, exchange rates in different countries, the quantification of loss varies across the countries.

Besides financial losses, majority of the farmers opined that the FMD caused huge burden on the family in both the short run and long run. They felt that their important permanent income earning asset is lost due to FMD, as small holders are highly dependent on livestock for their daily household consumption and income generation on regular basis. They additionally felt that mortality of animals restricted the asset creation and multiplication as they consider livestock as an asset of economic and social value.

Around 82% of the farmers experienced psychological stress as majority of them are small holders whose livelihood depends on one or two animals owned by them. Their agricultural productivity is also affected due to diversion of their managerial and labour resources for nursing the animal than raising crops, thus paying less attention in performing important and timely agricultural operations. Hence, it can be inferred from the findings that FMD caused huge financial burden on livestock farmers as well as their social well-being.

Conclusion

It is evident from the study that FMD inflicted huge loss to the farmers. The incidence risk and mortality risk due to FMD among different species and age groups showed considerable variation, emphasizing differences in susceptibility levels to FMD. Accordingly, the loss due to FMD was also found higher in high productive Crossbred cattle, followed by upgraded buffaloes, indigenous cattle and local buffaloes. As a coping mechanism, farmers were forced to sell their animals under distress condition, unable to bear the financial burden caused due to FMD, resulting in psychological stress of the smallholders. It was observed that despite the study area which was under FMD-CP, the outbreak has occurred in large scale, causing severe morbidity and mortality which clearly indicates the need for timely vaccination coverage by animal husbandry department, educating and motivating the livestock farmers to vaccinate their animals and to reduce the subsequent loss. The losses due to FMD have caused huge socio-economic burden and its control signifies the socio-economic gain to farmers.

Acknowledgements

Authors would like to thank Project Directorate on Foot and Mouth Disease, Mukteshwar, Nanital, India, and Indian Council of Agricultural Research (ICAR), New Delhi, for funding the project. We extend our thanks to Karnataka State Animal Health Department, field veterinarians, para-veterinarians and other livestock health officials, for their assistance during data collection. We thank the farmers and other stakeholders for their active participation in the study.

Conflict of Interests

The authors declare that they have no conflict of interests.

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