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FOOT-AND-MOUTH DISEASE AND ITS EFFECT ON MILK YIELD: AN ECONOMIC ANALYSIS ON CATTLE AND BUFFALO HOLDERS IN HYDERABAD, SINDH

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ABSTRACT

An investigation of the impact of foot-and-mouth disease (FMD) on milk production among cattle and buffalo farmers was conducted in Hyderabad, Sindh, Pakistan. 120 farmers who owned buffaloes participated in the study, equally distributed across the upper and lower parts of Hyderabad. Clinical symptoms led to the initial suspicion of FMD, which was later validated by field tests or laboratory findings. Prior to FMD, a buffalo produced an average of 12 liters of milk every day. However, throughout the course of the next 60 days, milk output drastically dropped after the commencement of the clinical illness. In one region, the projected milk loss per buffalo during this time was about 250 liters, whereas in the other, it was about 210 liters. According to the study, the total milk loss for the 120 lactating cattle and buffaloes was about 5,914,800 Pakistani rupees. Based on the supposition that cow milk was worth around 250 PKR per liter and buffalo milk about 200 PKR, this computation was made. This demonstrates the FMD's significant economic impact on local milk production. The expected benefit-to-cost ratio for immunizing all animals in the two locations was calculated to be 6.1 under the assumption that giving a high-quality vaccine that corresponds to the circulating FMD strains might avoid clinical illness.

Keywords: buffalo, cattle, economic analysis, foot and mouth disease, milk yield, Sindh

INTRODUCTION

Agriculture's livestock sub sector has grown in importance and occupies a special place on Pakistan's national economic development agenda. The livestock sub-sector represented 58.92 percent of the value added to agriculture and 11.11 percent of the national GDP in the fiscal year 2017-18. In the country, 8.0 million rural families are involved in cattle raising. The raising of livestock is essential to daily living and is the main source of foods that are very nutrient-dense, like milk, meat, eggs, and cheese. This sub sector also produces important byproducts like leather, hides, and farmyard manure. But because of concerns including a lack of feed and fodder, poor husbandry techniques, and livestock disease problems, livestock productivity in the nation continues to be generally low (GoP, 2018).

Buffalo and cattle are essential to many facets of human existence, including agriculture

and culture. For thousands of years, people have tamed cattle, which includes domesticated bulls, oxen, and cows. They provide vital resources including milk, meat, and leather, making them indispensable to agriculture. Cattle are often employed in religious rites and ceremonies and are seen as symbols of riches in many civilizations. In many agrarian communities, cattle are vital due to their versatility, which includes their ability to plough fields and produce dairy products.

Water buffalo are equally significant. Their meat, milk, and hides are the reasons they are domesticated. Rice fields are frequently plowed by water buffalo, who are ideally suited to wetland habitats. Because of its distinct flavor and higher fat content than cow milk, certain areas choose buffalo milk over cow milk (Steinfeld *et al.*, 2006).

Foot-and-mouth disease (FMD) is a serious infectious illness that mostly affects cloven-hoofed animals and is endemic to Pakistan (Abubakar *et al.*, 2012, 2015, 2018). The low productivity of the subsector is mostly caused by

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the FMD's recurrent nature (Jamal *et al.*, 2011, 2011a, 2011b Ahmed *et al.*, 2017). Poor veterinary infrastructure, limited FMD diagnosis techniques, farmers' ignorance of clinical indicators, and the exorbitant cost of vaccines are all contributing factors to the disease's endemic state (Kivaria, 2003). Animals suffering from FMD experience distress, and farmers' livelihoods are affected. People who directly depend on cattle for their livelihoods endure nutritional difficulties, and the disease causes the subsector to suffer significant economic losses. According to Subramaniam *et al.* (2013), these losses appear as changes in the makeup of the herd, greater morbidity in adult animals, higher mortality rates in young stock, lower milk production, weight loss, and decreased labor efficiency in draught animals. Farm families consequently endure financial hardship and emotional stress due to rising costs for feed, medicine, and housing. Beyond farms, the illness also has an impact on shops and customers, raising costs because of a lack of livestock products.

The main objective of the current study is to calculate the financial losses brought on by decreased milk production and the expenses related to giving high-quality foot-and-mouth disease (FMD) vaccines. This estimate is predicated on the notion that the vaccination is successful in delaying the appearance of clinical symptoms and, consequently, milk loss. Other losses that are less obvious right away have not been included in this study.

Despite the fact that FMD is not a recent disease, there aren't many empirical studies that evaluate its effects on the economy and measure the decline in milk production. The absence of microdata relevant to this part of cattle life is one of the main reasons why there aren't many thorough studies quantifying the effect of FMD on milk yield (Pica-Ciamarra *et al.*, 2011; Zezza *et al.*, 2011). An investigation by Nazlioglu and Orun (1969) into the effects of foot-and-mouth disease (FMD) on milk production in various cattle species and breeds was done in Turkey. According to their research, milk yield losses in cows ranged from 20% to 44%, while losses in sheep were found to be 19%. Another study by Adibes *et al.* (1998) found that different cow breeds, including Holstein, crossbreeds, and local breeds, were affected by FMD-induced milk output decline. The corresponding losses in milk yield were discovered to be 37%, 17%, and 5%.

FMD caused an average milk yield loss of 19% in Turkey according to Tufan (1993), and a 25% decrease in lactation yield for Holstein cows in the UK according to Power and Harris (1973). Young *et al.* (2012) conducted a research with 62 Cambodian cattle producers in a different setting. They discovered that the typical post-FMD infection costs per animal ranged from 216 to 370 USD and included costs for treatment, animal death costs, and draught replacement. Through interviews with 117 livestock keepers in southern Cambodia, Bhavani *et al.* (2012) examined the significance of FMD's effects on low-income households. They discovered that the average short-term impact of FMD on household income is 7.6%. Even more burdensome burdens, exceeding 10%, are experienced by lower-income households, which might be regarded as major shocks to impacted households. From the standpoint of illness control, Bhavani *et al.* (2012) emphasized a number of key factors: (i) Over a six-month period, 84% of the farmers surveyed indicated a willingness to pay \$1.3 per animal for protection; (ii) any disease management programme should include an educational effort to raise awareness among livestock keepers and encourage the implementation of fundamental biosecurity practices.

importance of cattle and buffalo

Through the meat and dairy industries, both cattle and buffalo make substantial contributions to the world economy. Their dung makes a great natural fertilizer, and their hides are used to make leather. Furthermore, many farmers depend heavily on these animals for their livelihoods, especially in underdeveloped nations.

Culturally speaking, buffalo and cattle are highly valued in many communities. They are common symbols of power, fertility, and prosperity in mythology, art, and customs. Cattle fairs and buffalo races are significant cultural festivities in many parts of the world.

To sum up, cattle and buffalo are important animals whose uses go well beyond providing food and resources. Their contributions to agriculture, the economics, and other aspects of human society are profoundly ingrained and cultural heritage. (Steinfeld *et al.*, 2006).

Importance of milk

In both agricultural and human nutrition, milk is extremely important. It is a plentiful supply of vital nutrients that are important for bone health,

muscle growth, and general wellbeing, including calcium, protein, vitamins, and minerals. Beyond its nutritional worth, milk serves as the foundation for a variety of dairy products, including butter, yogurt, and cheese, all of which support varied and well-rounded diets. Furthermore, milk is important economically since it provides jobs in the dairy industry. Culturally, it influences customs, foods, and social customs all over the world (Astrup *et al.*, 2016).

MATERIALS AND METHODS

Research has been developed to monitor specific clinical instances of acute FMD that occurred in farms with cattle and buffaloes. 120 farmers from Hyderabad, Sindh who reported cases they suspected might be FMD cases and who were later interviewed and followed up on could be included in this study. Two zones of Hyderabad were chosen for the farmer selection (upper and lower); two talukas from each zone were chosen at random; and 30 farmers from each taluka were specifically chosen for the interview. In order to obtain thorough data for this study, a structured questionnaire with three primary components was used to collect data:

Individual farm information

This first phase was devoted to learning specifics about various farms. The number of milking animals on the farm at the time of the first case (or cases) of foot-and-mouth disease (FMD) were listed, together with information on the farm's ownership, location, total number of vulnerable animals, and number of milking animals.

Clinical impact of FMD

Data on specific FMD cases that occurred on the farms were to be recorded in the second section of the questionnaire. Evaluation of FMD's clinical effects was the goal. The age of the affected animals and their milking state (i.e., lactating or not) were used to organize the data.

Socio-economic status of the farmer

The third and last item on the survey was designed to gather data on the socio-economic standing of the farmers themselves. Questions about their sources of income, way of life, and other socio-economic aspects that would be important to the study were probably included in this section. This article's systematic strategy to data collection was specifically created to allow the researchers to create a thorough dataset.

This information would be the starting point for a detailed investigation of the socio-economic impacts of FMD on both individual farms and the overall society. The research team sought to accomplish the following goals by segmenting the data collection.

Comprehensive understanding

The methodology made sure that a wide variety of data was gathered, including everything from the characteristics of individual farms (ownership, location, number of livestock) to the precise clinical details of FMD cases (age and milking status of affected animals) and even the socio-economic background of the farmers.

Systematic examination

This methodical analysis of the data was made easier by the structured approach. Researchers could look into the relationships between the clinical effects of FMD and variables including farm size, location, and animal milking status. They could also look into how farmers' socio-economic standing might affect how well they are able to handle the sickness.

Holistic analysis

The researchers were better able to conduct a comprehensive analysis by gathering information on many aspects of the FMD outbreak. They may evaluate the wider ramifications for farmers' livelihoods and well-being in addition to the direct clinical effects on livestock.

Informed decision-making

The resulting dataset would offer a strong basis for making decisions based on evidence. This extensive data could be used by stakeholders and policymakers to establish targeted interventions and policies to lessen the effects of FMD on farms and the overall agricultural industry. In conclusion, this systematic approach to data collecting was a purposeful and well-planned method for assembling a rich and complex data set. It made it possible to thoroughly examine and analyze the different facets of the FMD outbreak, which eventually supported informed decision-making and might have resulted in successful interventions to deal with the issues the disease brought. For people who met two specific requirements—having an acute confirmed clinical diagnosis of foot-and-mouth disease (FMD) and being lactating—a follow-up period was established. The follow-up period was 60 days long, starting with the onset

of FMD-related clinical symptoms. Data on milk production were consistently collected over this time at the following intervals: days 1, 3, 7, 10, 15, and 60.

The researchers thought about various situations for obtaining information on each individual's milk supply in order to assure proper data gathering. Based on information provided by the farmer, milk production data were occasionally collected in situations where the first case on a farm involved a lactating cow both before and soon after the disease's beginning. Farmers in these instances provided the data on milk production. This strategy was used when it was impractical to collect direct measurements because of the outbreak's circumstances. The amount of milk produced was measured using the same procedures that farmers use to sell milk on a regular basis. Liters were chosen as the measurement unit, which is typical in the context of milk production.

This diligent follow-up procedure sought to provide a thorough understanding of how FMD affects milk supply in breastfeeding animals by collecting milk production data over a specified time period and at certain intervals. The approach of acquiring data considered the actual challenges of getting precise information in relation to the outbreak and livestock management techniques. When the presence of the FMD virus was established on a farm, cases where clinical indications of foot-and-mouth disease (FMD) were seen in non-lactating animals on that farm were documented and counted as FMD cases. This method of counting was generally applicable, apart from situations where the farm's initial or "index" case was a non-lactating animal. In such cases, it is possible that the researchers processed or counted the index instance differently, possibly in accordance with standards or circumstances. Any clinical cases noticed among the bulk of the farm's non-lactating animals, however, were taken into consideration and recorded as FMD cases after the virus' presence was determined to exist. This method made it possible to evaluate the FMD outbreak completely, accounting for both lactating and non-lactating animals, and tracking the disease's transmission and effects across the whole cattle community.

The predicted losses were then compared to the typical price for milk that is paid to producers. This price may differ in various parts in Hyderabad; therefore we have calculated an average based on: Cow and buffalo milk are priced at 200 and 250 PKR per liter, respectively

(the source of the milk price was gathered from expert opinions as Hyderabad has no official sources of information on milk prices).

RESULTS

Results presented refer to 120 small-to-medium farmers originally contacted, where we obtained complete data (Table 1 represents the farms distribution by species and age distribution).

Table 1. Framers' composition of the surveyed farms, by species and age

Framers' composition	Number of buffaloes (average number of animals per farmer)			
	Number of farmers	<1 year old	1-2 years old	>2 years old
Mixed farmers	90	160 (1.7)	95 (1.5)	120 (1.3)
Only-buffaloes farmers	10	35 (3.5)	24 (2.4)	37 (3.7)
Only-cattle farmers	20	25 (1.2)	27 (1.3)	70 (3.5)
Total	120	220	146	227

The column 'number of farms' refers to the number of farms for which data have been analyzed. Data in parenthesis refers to the average number of animals per farm. Table 1 shows the number of respondents (farmers) and age group of the of the buffaloes and cattle, among 120 respondents, there are 90 mixed farmers who owns both buffaloes and cattle, 10 farmers have only buffaloes and 20 farmers have only cattle. Maximum age group of the buffaloes and cattle is more than 2 years old, 146 are 1 to 2 years old and 220 are less than 1-year-old.

Table 2. Number of buffaloes with acute clinical FMD and its incidence (in per cent) by species over a 60-day period

Buffaloes and cattle			
Age group	0-1	1-2	>2
Total number of animals	220	146	227
Proportion of animals with acute clinical FMD (in per cent)	50	49	38

FMD, foot-and-mouth disease.

The FMD incidence proportion refers to the share of acute clinical FMD-affected cattle and buffaloes in the sample. The period of observation is 2 months. Table 2 reports the cumulative proportion of animals developing clinical signs during the observation period (clinical cumulative incidence proportion over the 60-day period following onset of clinical signs). The statistical significance of the differences observed was crudely tested through a chi-squared test (chi-squared test equals to 13.98, *P* value <0.05 in cattle, and chi-squared test equals to 5.72, *P* value <0.057 in buffaloes).

Milk production is intended in liters per animal. The statistics in the table refer to famers with 120

buffaloes and cattle. It is recognized that one of the most visible and immediate effects is represented (in FMD clinically affected animals) by the sudden drop in milk production. For the purpose of this study, among the age category older than 2 years, 72 milking cows and 125 milking buffaloes clinically affected were enrolled and their level of milk production before and after the onset of clinical signs has been measured at the fixed intervals indicated above during the follow-up period (Tables 3 report the milk production observed pre- and post-acute clinical FMD infection). A common field observation was that in lactating individuals not developing clinical signs, no such sudden drop in milk yield was observed.

Table 3. Milk production for buffaloes and cattle, pre- and post-FMD infection

	Pre-FMD	Post-FMD						
		Day 1	Day 3	Day 7	Day 10	Day 15	Day 30	Day 60
Average	8.91	3.06	2.14	2.25	2.64	3.08	4.24	6.10
Standard deviation	2.82	1.76	1.48	1.54	1.69	1.78	2.01	2.81

FMD, foot-and-mouth disease.

Table 4. Total amount of milk production scenario for 60 days, without FMD and with acute clinical FMD in buffaloes and cattle

Total amount of milk for 60 days			
Herd size	Scenario without acute clinical FMD	Scenario with acute clinical FMD	Estimated difference in milk production
Buffaloes and Cattle			
Milk Production	5526	35 100	29 574

Total amount of milk is intended in liters. The statistics in the table refer to farmers with up to 120 buffaloes and cattle. The milk loss in the 60-day period of observation was estimated as 35 100 (84.2% of the potential production over 60 days) per each lactating cow and 5526 (18.6% of the potential production over 60 days) per each lactating buffaloes and cattle as contrasted against the expected production should all enrolled individuals not become clinically diseased (Table 4). The total milk loss value for the 120 lactating buffaloes and cattle was estimated to be equal to 5914800 PKR (as stated above, we have assumed that the cost of 1 liter of milk paid to the producer is approximately equal to 200 and 250 PKR/liter, respectively, for buffalo and cattle milk).

DISCUSSION

In order to measure the economic effects of foot-and-mouth disease (FMD), this study primarily

looks at one of the obvious and immediate effects that farmers may experience: a sharp reduction in milk output among the animals that are most severely afflicted by the disease. The estimating technique is solely concerned with the decrease in milk yield that is observed when acute clinical FMD is later confirmed, either through a field test or through laboratory investigation. This careful selection guarantees that the analysis is supported by cases of FMD that have been independently validated, improving the dependability of the findings. This study contributes to a better understanding of the economic implications of FMD in the context of cattle husbandry by focusing on the immediate impact of lower milk production in confirmed FMD cases.

In our study, we didn't take into consideration potential additional costs, such treatment fees, that could be associated with the incidence of clinical cases or other gradual losses, like weight loss. Our main goal was to generate empirical evidence to support the notion that investing in prevention is justified, even when only looking at one of the possible effects of clinical FMD over a short period of time. Over a 60-day period, the cost of milk loss is predicted to be 5.7 times more expensive than the benefit of prevention. A review written by Cox and Barnett (2009) lends support to the idea that high-quality vaccines that precisely match the strains of FMDV that are currently in circulation have a protective effect against clinical illness. The number of vaccination doses necessary to provide protection over a year, including booster doses for young animals, were considered when determining the cost of vaccination. The price of the vaccine and its administration was determined using expert opinions and the present Pakistani market's average prices for imported vaccines that satisfy the OIE's standards for quality, purity, concentration, and safety (OIE, 2000). No fatal occurrences were reported in any of the 50 houses included in the study, not even in the younger age range where such incidents might be seen. This shows that vaccinations help avoid the development of serious diseases. The researchers were able to rule out the existence of FMD and other illnesses that would have complicated the impact on milk supply by field clinical observations. The absence of abrupt decreases in milk yield in lactating animals who were unaffected by clinical symptoms suggests that the decrease in milk yield was a direct result of acute clinical FMD.

Additional research is required to examine other FMD effects, including weight loss, mortality, and treatment costs. These components are crucial for developing a thorough knowledge of the disease's total economic impact. In South Sudan, Barasa *et al.* (2008) reported a benefit-cost ratio of 11.5 for FMD immunization. Improvements in the production of large ruminant livestock in nations using a mixed farming system, like Pakistan, have the potential to raise smallholders' standard of life. Large ruminants are utilized to provide milk, create draught, create manure (which is used as fertilizer), generate energy, and serve as security for loans. International organizations like the OIE and FAO are working to create an international plan to combat FMD in order to lessen its effects at all levels. A method called the FMD-Progressive Control Pathway (FMD-PCP) can help nations, particularly those where FMD is endemic, gradually lower the viral load and lessen the disease's financial effect. According to OIE regulations, the highest stages of the FMD-PCP correspond to the official status of FMD free, with or without vaccination. This study underscores the importance of funding FMD management methods like immunization and advances our understanding of the economic effects of FMD. Decision-makers might not pay immediate attention to the economic consequences in poor nations like Pakistan where FMD is not a zoonotic disease and fatality rates are low. However, sectors like dairy, which are more susceptible to output losses, might greatly benefit from investing in FMD control.

CONCLUSION

It is important to distinguish costs due to disease control measures from those generated by losses in production and productivity. This distinction is particularly relevant in countries where FMD is endemic and eradication policies like stamping out are difficult to implement. Evidence of the economic impact, such as losses in milk production, draft power inability, or mortality in young animals, is crucial for developing targeted policies and interventions. In conclusion, this analysis, although based on a small sample and limited to specific regions in Pakistan, provides insights into the losses caused by FMD outbreaks. The findings can inform the development of policies by NGOs, UN bodies, and local governments to limit the disease's impact and support farmers in coping with it.

AUTHOR'S CONTRIBUTION

N. N. Mari: Designed and executed the project, wrote manuscript.

M. Sial: Data collection and analysis

A. N. Nangraj: Data analysis

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