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IMPACT ASSESSMENT OF RING VACCINATION TO CONTROL ECONOMIC LOSSES OF FOOT AND MOUTH DISEASE IN PAKISTAN

Abid Hussain[1,*], Muhammad Abubakar[2], Hassnain Shah[1], Muhammad Javed Arshed[3], Saira Batool[1] and Muhammad Afzal[3]

[1]Social Sciences Research Institute, PARC-National Agricultural Research Centre, Islamabad, Pakistan; [2]National Veterinary Laboratory, NARC Premises, Islamabad, Pakistan; [3]FAO FMD Project, NARC Premises, Islamabad, Pakistan. [*]Corresponding author's e-mail: abid.parc@gmail.com

Foot and Mouth Disease (FMD) is a major infectious disease of cattle and buffaloes in Pakistan that causes heavy economic losses. Impact of FMD vaccination during the course of the disease outbreak has been assessed based on a field survey conducted in September-October, 2015. The sample size for the study was 90 livestock farmers from all the provinces of the country, and Azad Jamu and Kashmir (AJK); including 66 rural and 24 peri-urban farmers. The disease causes decrease in milk productivity of the affected animals in the range of 60-70 percent during sickness and 40-50 percent after recovery from the disease. Along with this, deterioration in milk quality, increase in calving interval, animal weight loss, abortion cases, loss in drought power, distressed sales and mortality are the losses caused by the disease. Recovery of sick animals due to vaccination was quite satisfactory, more than 90 percent in both cows and buffaloes in rural, as well as in peri-urban livestock farming systems. Mean time durations for recovery from the disease in cow and buffaloes were 10 and 12 days in peri-urban areas, and 9 and 7 days in rural areas, respectively. The vaccination was very effective in controlling the disease, as only few farmers in Punjab and Balochsitan reported new cases of the disease after the vaccination. While, none of the farmers in Sindh, Khyber Pakhtunkhwa and AJK reported outbreak at their farms. Due to vaccination, reduction in severity of the disease was also reported in the affected animals. It is concluded that FMD vaccination of the animals in the face of outbreak is useful to curtail further spread of the viruses to healthy animals, and also results in early recovery of the diseased animals.
Keywords: Livestock disease, cloven footed animals, FMD viruses, disease outbreak, ring vaccination

INTRODUCTION

Livestock is the main sub-sector of agriculture sector in Pakistan. The sub-sector contributes directly in the livelihood of eight million families who are deriving more than 35 percent of their income from livestock production activities. In the year 2017-18, the sub-sector shared 11.11 percent to the national GDP with contribution of Rs. 1377 billion in the economy through value added products. However, many factors such as poor supply of feed and fodder, inadequate husbandry practices and disease outbreaks are the factors that hinder growth of the sub sector (Anonymous, 2017-18). Foot and mouth disease (FMD) is a major infectious livestock disease in the country. It is endemic in nature and frequent outbreaks occur throughout the country mostly during winter and late spring. Moreover, frequency of disease outbreaks is higher in plains than hilly areas (Abubakar *et al*., 2015; Abubakar *et al*., 2012; Qurban, 2012). Serotype O, Asia-1 and A of Foot and Mouth Disease Viruses (FMDV) are most prevalent in the country (Jamal *et al.,* 2010). The disease affects cloven footed animals such as cattle, buffaloes, sheep and goats (Abubakar *et al.,* 2015; Fenner *et al.,* 1993).

FMD causes distress to animals and affects livelihood of the farmers. Sometimes, the people who are directly dependent on livestock for their livelihood are to face big impact in the form of malnutrition. The disease causes heavy economic losses to the sub sector in terms of high morbidity in adult animals and mortality in young stock. The economic losses are mainly due to decrease in milk production, distressed sales/ changes in herd structure, animal weight loss and loss of work efficiency in draught animals (Hussain *et al.,* 2017; Blacksell *et al*., 2008; Venkataramanan *et al.,* 2006; Grubman and Baxt, 2004; Otte *et al*., 2004). This also results into increase in expenditures on feed, medication and shelter. Farm families are affected emotionally and suffer stress, strain and distress. Furthermore, FMD affects access to markets and export potential of dairy, meat, hides and carpet industries (Jamal *et al*., 2010). Usage of improved livestock production technologies is also discouraged due to the disease (Ganesh *et al*., 2012).

Beyond farm, the disease also cost retailers and consumers higher prices due to shortage of livestock products. The disease can be tackled in two ways; eradication by stumping out of affected animals, and control through vaccination on regular basis as well as in the face of outbreak. Though eradication is the low cost policy; however, when it is not feasible, it is economically beneficial to protect high producing livestock by vaccination. Most of the countries

having endemic nature of FMD follow high costing vaccination strategy (James and Rushton, 2002) which is also supported by application of zoo-sanitary measurers and restriction on the movement of infected animals (Knight and Rushton, 2013). In this perspective, an initiative was taken by FAO project (GCP/PAK/123/USA) in 2013 with a hope to provide framework for progressive control of FMD in the country. Specific objectives of this study are to describe main reasons of disease outbreak, assess the losses occurred at farm level due to disease outbreak, and evaluate the impact of FMD vaccinations in cases of disease outbreaks.

MATERIALS AND METHODS

In the first step, a team of social scientists and technical experts held consultation meetings to finalize study plan and ensure quality of data. In these meetings questionnaire preparation, survey design and arrangements for the training of enumerators were finalized. In the second step, based on review of literature a comprehensive questionnaire was developed and pretested. Many learned social as well as animal scientists having scientific knowledge about FMD were also consulted to finalize the questionnaire. The details of the study area by farming types i.e. list of districts by region and rural and peri-urban divide are given in Table 1.

The study is based on a completely representative sample and valid data, as all the cases of the disease outbreak covered under the project are included in the sample for study. Distribution of the farms of the respondents by farming types i.e. rural livestock farms and peri-urban/dairy units and regions are given in Table 2. Ninety farmers were interviewed for the study. However, two questionnaires were discarded due to incomplete information. Thus, total sample size for the study was eighty-eight. Out of these, 64 were rural livestock farms and 24 were peri-urban/dairy colony farms.

Veterinary officers and staff of provincial livestock and dairy development departments were engaged to record data for the study. As the members of data collection team were veterinarian by profession, therefore an exhaustive two days training program for comprehension and pre-testing of questionnaire was organized. Technical officials of FAO-FMD project office and a team of socioeconomists trained the data enumerators. This helped to develop common understanding of the survey team for the variables included in the survey tool, and further improve the questionnaire.

Table 2. Distribution of sample rural farms and dairy units across provinces (Number).

Provinces	Farming types		
	Rural livestock farms	Peri-urban/Dairy colony farms	Total
Punjab	26	0	26
Sindh	10	5	15
KP	14	11	25
Balochistan	10	7	17
AJK	4	1	5
Total	64	24	88

The study included collection of detailed farm level information through a formal survey. Thus, training program helped in ensuring quality data and its subsequent processing, to have an in-depth understanding based on first hand farm level information on different socioeconomic aspects of FMD in the country. Situation analysis has been performed by assessing the impact of animal vaccination through the project on disease control in face of outbreak. Milk productivity losses have been estimated at two stages; a) during the disease period, b) after recovery or for the remaining lactation period in case of non-recovery. As, Ferrari *et al*. (2014) reported that significant decrease in milk yield occur in two months following the onset of the disease. Data has been analyzed by using Statistical Package for Social Sciences SPSS-22. Descriptive statistics including frequencies and percentages were computed for herd size, reasons of disease outbreak, loss in milk production and deterioration in milk quality (fat content /thickness; changes in taste, colour and odor/smell) etc.

RESULTS AND DISCUSSION

Mean herd size at surveyed farms by farming types and regions is presented in Table 3. Mean number of animals at 64 farms in rural areas was 24, including 20 large ruminants (83%) and 4 small ruminants (17%). Similarly mean herd size

Table 1. Study area (districts) by farming types.

Dairy Production Systems	Regions				
	Punjab	Sindh	Khyber Pakhtunkhwa	Balochistan	AJK
Rural Livestock Farms	1. Jhang	1. Hyderabad	1. Abbottabad	1. Lasbella	1. Mir Pur
	2. Lahore	2. Larkana	2. Dir Lower	2. Pishin	
	3. R. Y. Khan	3. Matiari	3. LakkiMarwat	3. Quetta	
	4. Sialkot	4. Nowshero Feroze	4. Sawat		
Peri- Urban/ Dairy Colony	--	1. Hyderabad	1. Abbottabad	1. Lasbella	1. Mir Pur
		2. Larkana	2. Dir Lower	2. Pishin	
		3. Matiari	3. LakkiMarwat	3. Quetta	
			4. Sawat		

Table 3. Mean number of dairy animals at sample farms by farming types.

Farming types	Animal types	Regions					
		Punjab	Sindh	KP	Balochistan	AJK	Overall
Rural	Cattle	11	22	6	15	5	12
	Buffaloes	10	24	1	0	2	8
	Sheep & Goats	5	0	3	5	2	4
	Total	26	46	11	20	9	24
Peri-Urban/	Cattle	-	40	15	59	5	33
Dairy Colony	Buffaloes	-	68	8	24	3	24
	Sheep & Goats	-	0	0	6	1	2
	Total	-	108	23	89	9	59

at 24 surveyed farms in peri-urban/ dairy colony farms was 59, including 57 large ruminants (97%) and two small ruminants (3%).

Animal vaccination against the infectious disease of FMD before the onset of outbreak at sample farms was low, only 16% of the farmers in rural areas and 29% in peri-urban areas reported to vaccinate their animals. The results are in line with the findings of baseline survey conducted for the project in 2013, according to which only 24% of livestock farmers reported to vaccinated livestock against FMD (Shah *et al.*, 2014). Both in peri-urban/ dairy colony and rural farming systems, maximum number of farmers reported that their animals were vaccinated more than one month to three months before the onset of outbreak (70% and 58% in rural livestock farming and peri-urban/dairy colony systems, respectively). In the rural livestock farming, remaining farmers (30%) reported vaccination of animals even less than one month before the disease outbreak. In peri-urban areas remaining farmers reported animal vaccination less than one month (29%) or more than six month (13%) before the disease outbreak. In rural areas of the country, FMRDC (VRI, Lahore) and Russian vaccines are main types administered to livestock, 40 percent and 30 percent of the farmers reported to use these vaccines, respectively. At peri-urban sample farms, Russian vaccination was reported as most common type used to prevent the disease incidence, used by 57 percent of the farmers. Use of Aftobin and UVAS vaccines were also reported by few farmers in rural (10%) and peri-urban (14 %) areas.

FMD is an infectious disease that gets transmitted through aerosol, infected urine, milk, semen and faces of diseased animals (FAO, 2016). Two-third of peri-urban dairy farmers (67%) and about one-half of rural livestock farmers (47%) reported that unvaccinated newly purchased animals were main sources of infection of the disease at their farms (Fig. 1). Disease outbreaks in the same village or surrounding village are reported other important reasons of FMD infection, both in peri-urban and rural livestock farming systems. Farm managers/ workers visit to the FMD affected farm(s) and recent history of FMD vaccination were reported as minor sources of outbreak of infectious disease at surveyed farms.

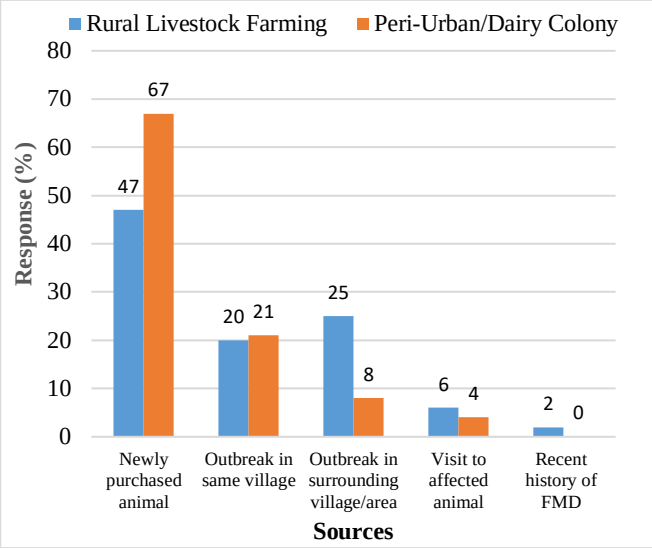

Figure 1. Possible sources of FMD infection at sample farms.

Economic losses occurring in dairy animals due to the disease by specie are presented in succeeding sections. High milk productivity losses were reported during the disease period across all the regions (Table 4). In rural livestock farming, milk loss during disease period in cows was ranged from 5.0 to 8.0 liter per day per animal across regions, with a mean loss of 6.6 liter per day per animal (about 57% of milk yield before disease). Average milk loss after recovery of animals was 4.0 liter per day per animal (about 34% of milk yield before disease). In peri-urban dairy colonies, milk loss during disease period in cows was ranged from 5.0 to 11.0 liter per day per animal across regions, with a mean loss of 10.0 liter per day per animal (about 64% of milk yield before disease). Average milk loss after recovery of animals was 6.7 liter per day per animal (about 43% of milk yield before disease).

In rural livestock farming, milk loss during disease period in buffaloes was ranged from 6.7 to 7.9 liter per day per animal across regions, with a mean loss of 7.5 liter per day per animal (about 71% of milk yield before disease). Average milk loss after recovery of animals was 4.3 liter per day per animal

Table 4. Milk loss at different stages in buffaloes due to FMD by regions (liter/day/animal)

Farming types	Animal types	Yield before disease	Yield during disease	Loss during disease	Yield after recover	Loss for rest of lactation
Cows	Rural	11.6 (4.4)	5.0 (4.0)	6.6 (4.4)	7.6 (3.3)	4.0 (2.9)
	Peri-Urban/Dairy Colony	15.6 (6.1)	5.6 (3.4)	10.0 (4.5)	8.9 (4.7)	6.7 (4.4)
Buffaloes	Rural	10.6 (2.3)	3.1 (1.4)	7.5 (1.8)	6.3 (5.6)	4.3 (6.0)
	Peri-Urban/Dairy Colony	11.5 (3.1)	4.0 (1.7)	7.5 (1.8)	7.5 (4.6)	4.0 (2.9)

Note: Figures in parenthesis are percentages.

(about 41% of milk yield before disease). In peri-urban dairy colonies, milk loss during disease period in buffaloes was ranged from 6.8 to 12.5 liter per day per animal across regions, with a mean loss of 7.5 liter day per animal (about 65% of milk yield before disease). Average milk loss after recovery of animals was 4.0 liter day per animal (about 35% of milk yield before disease). In rural areas milk yield loss were higher in buffaloes than cows both during the disease and after the recovery. While in peri-urban areas the case was opposite i.e. milk production losses in cows were higher than buffaloes in both phases of the disease.

Relatively a greater number of farmers in rural areas (25%) reported to observe changes in quality of milk of FMD affected cows than their counterparts in peri-urban areas/ dairy colonies (8%). However, opposite was the case about effect of the disease on milk quality of buffaloes; 73% farmers in peri-urban areas and 61% in rural areas reported changes in milk quality. Most likely reason may be production of milk mainly for domestic consumption in rural areas, thus farmers are comparatively more concerned about milk quality in rural areas than their counterparts in peri-urban areas, where livestock production is commercially oriented. Changes in taste and low fat contents in the milk of FMD affected cows were main impacts of the disease; however, change in odor and low fat contents were main effects on milk quality of FMD affected buffaloes.

In both cows and buffaloes in rural as well as urban farming systems increase in calving interval (due to late heat) was reported as main effect of the disease. Forty-nine and fifty four percent of the farmers in rural and peri-urban areas reported disturbance in calving interval in cows, respectively. While, only twenty-one and nine percent of the farmers in rural and peri-urban areas reported disturbance in calving interval of buffaloes, respectively. In rural farming system, the disturbance was reported in two cows and one buffalo per farm, with mean duration of about three & half month in cows, and five months in buffaloes. Similarly in peri-urban areas, disturbance in calving interval was reported in two cows per farm, and in ten buffaloes at just one surveyed farm, with mean duration of two & half month in cows and about one year in buffaloes. Due to increase in calving interval losses are mainly caused by decreased milk production and increase in number of non-pregnant animals at the farm. Number of services per conception also rise due to increase in calving interval, thus non-milk producing animals may increase at the farm (Dhindsa, 2014).

The disease causes weakness in the animals and weight loss. Sometimes drastic decrease in weight may results into death of animals. Relatively high percentage of the farmers reported weight loss in cows as compared in buffaloes. In rural areas, eighty-nine and fifty-eight percent of the farmers reported weight loss in cow and buffaloes, with mean losses of 37kg and 45 kg per animal, respectively. In peri-urban areas, ninety-two and fifty-five percent of the farmers reported weight loss in cows and buffaloes, with average decrease of 59 kg and 71 kg per animal, respectively. In rural livestock farming, two death cases per farm of cows and buffaloes each were reported by 16 and 13 percent of the sample farmers, respectively. In peri-urban/ dairy colony system of livestock production, five death cases per farm of cows and buffaloes each were reported by 13 and 18 percent of the sample farmers, respectively. In this way, mortality rate in animals was about 2% of the total population of large ruminants at sample farms. About ten percent of the sample farmers reported abortion cases in sick cows and buffaloes, on an average one case in cows and two in buffaloes occurred per farm both in rural and peri-urban settings. In rural areas, four of the sample farmers (2 each in Punjab and Sindh provinces) reported to use cattle bulls, and one of the sample farmers in Punjab reported to use buffalo bull for drought power. All these farmers reported to face losses in animal draught power at their farms due to the disease.

Most of the sample farmers reported to improve feeding of diseased animals along with providing them medical treatment for quick recovery. Seventy-seven percent and 88% of cow keeping farmers, and 83% and 55% of buffalo keeping farmers in rural livestock farming and peri-urban dairy colonies reported improvement in feeding of animals, respectively. Durations of improvement in feeding regime by farming and animal types were quite same and averaged about 3 weeks. A large number of the cow keeping farmers in rural areas (91%) and all sample farmers in peri-urban farming (100%) systems reported to provide medical treatment to sick animals. Mean costs of the treatment per cow in rural and peri-urban areas were Rs. 1432 and Rs.2531, respectively. About two-third (63%) of the buffalo farmers in rural livestock farming and one-half (54%) in per-urban system of livestock production reported average treatment costs of Rs. 1875 and Rs. 2292 per animal, respectively.

Distressed sales of animals due to decrease in milk productivity were also reported by the sample farmers. Such sales are relatively low in rural areas (reported by 3% of the buffalo and 25% of the cow keeping farmers) as compared to peri-urban areas (reported by 36% of the buffalo and 50% of the cow keeping farmers). Both in rural and peri-urban livestock production systems, mean number of cow sales per farms was two, while buffalo sales were one animal per farm in rural areas and five animals per farm in peri-urban localities. Thus, farmers had to face considerable economic losses due to distressed sales of the sick animals.

Vaccination of animals against FMD during the phase of outbreak was high in rural areas than in peri-urban settings. Eighty percent of cow keeping farms in rural areas and fifty percent in peri-urban areas reported to vaccinate their animals against the disease during outbreak phase. Similarly, ninety percent of buffalo keeping farms in rural areas and forty-five percent in peri-urban areas reported to vaccinate animals against the disease during phase of outbreak. Details about the vaccination by animal types and regions are presented in Table 5.

Primary animal vaccination was administered after one week of the onset of disease in peri-urban livestock farming. While, booster dose of the vaccination is generally administered after 3-4 weeks of primary vaccination. About half of the sample farmers in rural livestock farming reported to administer booster dose of the vaccination (47 and 53% in cows and buffaloes, respectively). While, in peri-urban livestock production system about one-fourth of the sample farmers administered the booster dose of vaccination (25 and 27% in cows and buffaloes, respectively). Details about vaccination of sick animals at sample farms are given in Table 6. Data given herein is useful for gauging farm level spread of disease in different regions of the country by animal and farming types. It can be noticed from last column of Table 6, that at rural sample farms disease have had wide spread in cows as compared to buffaloes. FMD sickness was reported in twenty-seven and seventeen percent of cow and buffalo population at

Table 5. Vaccination against FMD during the phase of outbreak (Percent Farms)

Farming types	Animal types	Regions					
		Punjab	Sindh	KP	Balochistan	AJK	Overall
Rural Livestock Farming	Cows	100	100	30	60	100	80
	Buffaloes	100	75	80	0	100	90
Peri-urban/	Cows	-	60	55	50	100	50
Dairy Colony	Buffaloes	-	40	100	25	100	45

Table 6. Vaccination of sick animals by farming types and regions. (Percent population)

Farming types	Animals	Regions					
		Punjab	Sindh	KP	Balochistan	AJK	Overall
Rural Livestock Farming	Cows	31	15	28	33	74	27
	Buffaloes	20	13	32	0	0	17
Peri-urban/ Dairy	Cows	-	7	45	7	20	15
Colony	Buffaloes	-	7	44	13	0	15

Table 7. Early recovery of sick animals due to the vaccination by farming types and regions.

Farming types	Animals	Regions					
		Punjab	Sindh	KP	Balochistan	AJK	Overall
I. Farms reporting recovery of sick animals (Percent)							
Rural Livestock Farming	Cows	78	88	100	80	0	78
	Buffaloes	71	88	60	-	-	66
Peri-urban/ Dairy Colony	Cows	-	100	100	686	0	92
	Buffaloes	-	100	100	25	-	64
II. Animals recovered (Percent)							
Rural Livestock Farming	Cows	89	100	96	96	-	90
	Buffaloes	94	86	100	-	-	92
Peri-urban/ Dairy Colony	Cows	-	100	100	96	-	98
	Buffaloes	-	96	100	82	-	94
III. Early recovery duration (Number of days)							
Rural Livestock Farming	Cows	10	8	10	9	-	9
	Buffaloes	9	4	13	-	-	7
Peri-urban/ Dairy Colony	Cows	-	12	7	15	-	10
	Buffaloes	-	5	12	15	-	12

Note: In part I, figures in parenthesis are percentages and in part II, are percentage out of total population of sick animals.

Table 8. FMD outbreak at farms after vaccination and prevalence of the disease in animals by farming types and regions.

Farming types	Animal types	Regions					
		Punjab	Sindh	KP	Balochistan	AJK	Overall
I. Outbreaks of the disease (Percent farms)							
Rural Livestock Farming	Cows	4	0	0	20	0	5
	Buffaloes	5	0	0	0	-	3
Peri-urban/	Cows	-	0	0	29	-	9
Dairy Colony	Buffaloes	-	0	0	0	-	0
II. Number of new cases							
Rural Livestock Farming	Cows	1	-	-	4	-	5
	Buffaloes	4	-	-	-	-	4
Peri-urban/ Dairy Colony	Cows	-	-	-	5	-	5
	Buffaloes	-	-	-	-	-	0
III. Disease Prevalence (Number of days)							
Rural Livestock Farming	Cows	16	11	16	16	5	14
	Buffaloes	13	9	22	14	4	12
Peri-urban/ Dairy Colony	Cows	-	16	13	11	6	13
	Buffaloes	-	8	60	14	0	19

Note: Figures in parenthesis are percentages

sample farms. While, in peri-urban areas the level of disease spread in cows and buffaloes was same (15%).

Farms reported early recovery of sick animal; percentage of sick animals recovered, and time period of early recovery are given in sections, I, II and III of Table 7, respectively. Seventy-eight and ninety-two percent of the farmers in rural areas and peri-urban areas reported early recovery of sick cows, respectively. About two-third of the sample buffalo farmers in rural areas and peri-urban areas each (66%) reported early recovery of sick animals. Recovery of FMD vaccinated sick animals was quite satisfactory, more than ninety percent in both cows and buffaloes in rural as well as peri-urban settings. Mean recovery time duration in cow and buffaloes were 10 and 12 days in peri-urban areas, and 9 and 7 days in rural areas, respectively.

After vaccination of animals through the project, a few farmers reported outbreak of the disease at their farms (Table 8, Part I). None, of the sample farmers in Sindh, KP and AJK reported new cases of the disease at their farms. Just one cow and buffalo keeping farmers each in Punjab, and two cow and buffalo keeping farmers each in Balochistan reported the disease outbreak at their farms after vaccination. Thus, project intervention was very effective in controlling the disease outbreak. Five new cases of FMD in cows in rural livestock farming and peri-urban areas each were reported (Table 8, Part II). Only four new cases of the disease in buffaloes in rural areas of Punjab were reported. Both in peri-urban and rural settings, the disease prevailed for about two weeks in cows (Table 8, Part III). However, in buffaloes disease prevalence was longer in peri-urban areas than in rural areas, 19 and 12 days, respectively.

***Conclusion*:** FMD causes considerable economic losses in cattle and buffaloes in the country. Vaccination of animals in the face of the disease outbreak is effective in its control and avoids further spread. It results in early and better recovery of sick animals. Decrease in severity of the disease also occurs due to the vaccination. Thus, health losses to animals, financial losses to farmers and damage to the livestock economy of the country are minimized through vaccination. Thus, macro level vaccinations programs are recommended for effective control of the disease in the country.

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