

## EPIDEMIOLOGICAL STUDIES AND ECONOMIC IMPACT OF FOOT AND MOUTH DISEASE OUTBREAKS IN HARYANA: I (2014-2016)

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### ABSTRACT

During 2014-2016, nine FMD outbreaks were recorded from five districts (Hisar, Kaithal, Kurukshetra, Rewari and Yamunanagar) of Haryana. FMDV serotype O was detected in 17 clinical samples out of 18 tested using typing sandwich enzyme linked immunosorbent assay (ELISA). All the nine outbreaks were recorded during the winter season (December to April). The species involved were only cattle (02 outbreaks), only pigs (02) and cattle & buffaloes (05). Of the total economic losses of INR 7.19 lakhs, the maximum loss (INR 3.52 lakhs) was observed due to the mortality followed by losses due to cost of treatment of the affected animals (INR 2.38 lakhs). In addition, 233 serum samples from healthy, infected and recovered animals at the time (n=112) and one to four months after the FMD outbreak (n=121) were analyzed by single dilution liquid phase blocking ELISA for the protective antibody titres against the structural proteins of FMDV serotypes O, A and Asia-1. The animals showing protective antibody titres ( $\geq 1.8 \log_{10}$ ) against FMDV O, A and Asia-1 were 83.9, 69.6 and 83.0%, respectively at the time of outbreak while it was 92.6, 90.9 and 98.3%, respectively one to four months after the outbreak as FMDV vaccination was carried out as soon as outbreaks were suspected. Of the 130 serum samples tested for indirect DIVA ELISA, 50 (38.5%) demonstrated percent positivity against 3AB3 non-structural protein of FMDV, thus indicating virus circulation in those areas.

**Keywords:** Economic impact, Epidemiology, Foot-and-mouth disease outbreaks in Haryana, FMD virus serotype O

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Foot-and-mouth disease (FMD) is one of the most contagious and devastating viral diseases affecting cattle, buffaloes, sheep, goats, pigs and several cloven hoofed wild life species; characterized by fever and vesicles with subsequent erosions in the mouth, muzzle, feet, along with excessive salivation, lameness, depression and decreased milk production. FMD is endemic in India and neighboring countries and caused by FMD virus (FMDV). Of the seven serotypes prevalent worldwide, FMDV serotypes O, A and Asia-1 are currently circulating in India. Of these, FMDV serotype O continues to be the most predominant, serotype C has not been reported from India since 1995 (Bhattacharya *et al.*, 2005) while serotype Asia-1 and A have not been reported from Haryana since 2009 and 2010, respectively. During 2013-14, the total loss due to FMD in cattle and buffaloes was estimated to be INR 208.97 billion in India (Govindaraj *et al.*, 2020).

The FMD outbreaks and distribution of FMDV serotype in Haryana have been reported previously (Sharma *et al.*, 2002; Kakker and Sharma, 2003; Sharma and Kakker, 2005; Sharma *et al.*, 2006; Kakker and Sharma, 2007; Kakker and Sharma, 2008; Sharma and Kakker, 2009; Kakker and Sharma, 2012). The present communication describes the detailed epidemiological studies of FMDV outbreaks in Haryana from January, 2014 to December, 2016.

### MATERIALS AND METHODS

The clinical tissues including tongue, gum & feet epithelium (from FMD suspected live animals) and heart (from post-mortem cases) were collected in 50% sterile buffered glycerol (0.04 M PBS, pH 7.2-7.6) for FMDV detection and serotyping. In addition, a total of 233 blood samples were collected from cattle, buffalo and pigs at the time of FMD outbreaks (112 samples) and one to four months after recovery/vaccination (121 samples). The serum was separated from the blood using standard protocols. The clinical samples were transported to lab under cold conditions at 4°C taking all the biosafety measures using triple packing and stored at -20 °C till further use.

**FMDV detection and serotyping:** The clinical tissues were processed for FMDV detection and serotyping by sandwich ELISA as developed and reagents provided by ICAR-Project Directorate on FMD (PDFMD), Mukteswar and described earlier (Kakker and Sharma, 2012). The optical density (OD) of each well of ELISA plate was measured at 492 nm in ELISA Reader (Tecan, Austria). The interpretation of the results was done on the basis of corrected OD value (OD of test well-OD of negative antigen control well). If the OD value of the test sample with a particular FMDV serotype serum was  $>1.0$ , then that sample was identified as belonging to that particular serotype. The OD in other wells of the test sample should be at least three times less.

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**Detection of antibodies against structural and non-structural proteins of FMDV:** The serum samples were subjected to single dilution liquid phase blocking ELISA (sdLPBE) for detection of antibodies against structural proteins (SP) of FMDV serotype O, A and Asia-1 developed and reagents provided by ICAR-PDFMD. The animals exhibiting antibody titres  $1.8 \log_{10}$  were considered as protective against that particular serotype. The serum samples were also subjected to 3AB3 NSP-ELISA for detection of antibodies against 3AB3 non-structural protein (NSP) of FMDV as developed and reagents provided by ICAR-PDFMD and described earlier (Bora *et al.*, 2014). The results were interpreted as 3AB NSP antibody positive, if percent positivity (PP) value (calculated by dividing the OD of the test serum by that of the positive control serum and then multiplying with 100) was  $\geq 40\%$ ; and negative, if PP value was less than 40%.

**Economic impact:** Direct economic losses were calculated taking into consideration the four major parameters i.e. loss due to mortality, draught power, milk production and cost of treatment of the affected animals. The average milk production of the affected milch animal came down from 12 to 3 litres (average) per day per buffalo and 8 to 2 litres (average) per day per cattle. The cost of buffalo and cow milk in village was estimated to be INR 35 and 30 per litre of milk, respectively. There were no productivity losses in calves but treatment expenses were there. The economic losses of mortality is calculated by assessing the approximate cost per adult, heifer and calves in case of buffaloes as INR 28000, 20000 and 15000, respectively while for cattle as INR 20000, 15000 and 10000, respectively. The treatment cost per adult, heifers and calves were estimated to be INR 2000, 1500 and 1000, respectively.

## RESULTS AND DISCUSSION

During the period January 2014 to December 2016, a total of nine FMD outbreaks were recorded from five districts of Haryana. Maximum outbreaks were observed in Hisar (04) followed by Rewari (02) and only one each in Kaithal, Kurukshetra and Yamunanagar (Table 1). The species involved were only cattle in two FMD outbreaks (No. 1 & 2), only pigs in two (No. 4 & 9), cattle and buffaloes in five (No. 3, 5 and 6-8) (Table 2). In the present study, all the nine FMD outbreaks were recorded during very cold to mild winter season i.e. December to April (Fig. 1). Earlier also, the FMD outbreaks reported from Haryana were in the months of December to April (Sharma and Kakker, 2005; Sharma *et al.*, 2006; Kakker and Sharma, 2007; Kakker and Sharma, 2008; Sharma and Kakker, 2009; Kakker and Sharma, 2012).

In two outbreaks (No. 1 & 2), a total of three cattle were affected with no mortality. The affected animals were brought from the neighboring State and were not vaccinated. Likewise, there were two outbreaks (No. 4 & 9) in which only pigs were involved with one death (No. 4). These outbreaks may have occurred because of lack of FMDV vaccination being practiced in pigs of Haryana. The FMDV did not spread further to the other susceptible population, perhaps due to good protective herd immunity developed as a result of regular vaccination being done in cattle and buffaloes in these areas. This is also evident from the protective antibody titres ( $\geq 1.8 \log_{10}$ ) exhibited in more than 91 and 87% of cattle and buffalo at the time of outbreak no. 4 and 9, respectively against FMDV serotypes O, A and Asia-1 (Table 3). In outbreak no. 9, four out of 16 samples (25%) tested were found to be positive for anti-3AB NSP antibodies using DIVA ELISA.

The remaining five outbreaks (No. 3 and 5 to 8) involved cattle and buffaloes with highest mortality (10 cattle and 7 buffaloes) in outbreak no. 6 (Table 2). In this particular outbreak, nine months had elapsed between last vaccination and reported outbreak. High antibody titres were observed against all the three FMDV serotypes because of vaccination after the outbreak. However, high DIVA reactivity was also observed in serum samples of cattle and buffaloes at the time of outbreak (30%) as well as one month post FMDV outbreak/vaccination (42.3%).

The FMD outbreak (No. 5) was investigated retrospectively from village Gumthala Garhu, district Kurukshetra. More than 92% of the animals tested two months post outbreak/vaccination exhibited protective antibody titres against the SP of FMD serotypes O, A and Asia-1 (because of vaccination after the outbreak) but the high DIVA reactivity (53.6%) indicated the presence of virus in the area (Table 3). High antibody titres were observed against all the three FMDV serotypes because of vaccination after the outbreak.

There were four FMD outbreaks (No. 1, 2, 5 and 8) wherein the time elapsed between last vaccination and reported outbreak was 2-4 months (Table 2). Likewise, three FMDV outbreaks (No. 3, 6 and 7) were recorded in which the time elapsed between last vaccination and reported outbreak was more than five months (Table 2). The decrease in protective antibody titres against FMDV is evident from the sero-epidemiology data (Table 3).

At the time of outbreaks, animals exhibiting protective antibody titres against FMDV serotypes O, A and Asia-1 as well as DIVA reactivity (indication of FMDV circulation) are shown in Table 3. Of the 130 serum samples tested in indirect DIVA ELISA, 50 (38.5%) were positive for the

**Table 1****Details of clinical samples collected from FMD suspected animals from different parts of Haryana (2014-2016)**

Outbreak No.	Month and Year	Location/ Village (District)	Species	Tissue material collected	No. of samples collected
1	February 2014	Jainabad (Rewari)	Cattle	Tongue epithelium	1
2	February 2014	Nimoth (Rewari)	Cattle	Tongue epithelium	2
3	March 2014	Ladwi (Hisar)	Cattle & buffalo	Gum epithelium, heart	4
4	April 2014	Patel Nagar (Hisar)	Pig	Heart	1
5	December 2015	Gumthala Garu (Kurukshetra)	Cattle & buffalo	NA*	0
6	January 2016	Kishanpura (Yamunanagar)	Cattle	Gum epithelium	2
7	March 2016	Siswala (Hisar)	Buffalo	Tongue epithelium	1
8	March 2016	Dadwana (Kaithal)	Cattle & buffalo	Gum epithelium & heart	5
9	April 2016	Mirzapur (Hisar)	Pig	Foot epithelium	2
				TOTAL	18

\*On the basis of clinical symptoms as reported by Dept. of Animal Husbandry and Dairying, Govt. of Haryana and subsequently by observing NSP reactivity in >53% samples tested (Table 3)

**Table 2****Species-wise epidemiological details of FMD outbreaks in Haryana (2014-2016)**

Outbreak No.	Number of animals at risk	Number of animals affected	Number of animals died	Month & year of last FMD vaccination (Time elapsed)
1	C= 422 B= 2089	C=1	Nil	October 2013 (Four months)
2	C= 224 B= 1401	C=2	Nil	October 2013 (Four months)
3	C= 453 B= 1822 S= 230 G= 40	C=2 B=18	Nil	October 2013 (Five months)
4	C= 1410 B= 2695 S= 817 P= 130	P=2	P=1	No FMD vaccination in pigs
5	C= 849 B= 1875 S= 60 G= 40 P= 50	C= 44 B= 11	Nil	October 2015 (Two months)
6	C= 387 B= 435 G= 25	C=26 B=29	C=10 B=7	April 2015 (Nine months)
7	C= 269 B= 984 S= 90 G= 150	C= 7 B= 15	C= 2 B= 1	October 2015 (Five months)
8	C= 86 B= 366	C= 2 B= 3	C= 1 B= 1	November 2015 (Four months)
9	C= 746 B= 2182 S= 548 G= 543 P= 131	P= 4	Nil	No FMD vaccination in pigs
TOTAL	C= 4846 B= 13849 S= 1745 G= 798 P= 311	C= 84 B= 76 P= 06	C= 13 B= 09 P= 01	

C= Cattle, B= Buffalo, S= Sheep, G= Goat, P= Pig

**Table 3**

**Serum antibody titres in susceptible animals against FMDV structural and non-structural protein antigens during and after the outbreaks in Haryana (2014-2016)**

Outbreak No.	Species	Time of Serum sample collection	Samples tested for SP antibodies using sdLPBE	Number (%) of animals showing protective antibody titres ( $\geq 1.8 \log_{10}$ ) against SP of FMDV serotypes			Serum samples tested for anti-3AB NSP antibodies using DIVA ELISA		
				O	A	Asia-1	Total samples tested	Samples positive	Percent Positivity
1 & 2	Cattle	Apparently healthy (In-contact) and affected	17	12 (70.5)	6 (35.2)	14 (82.4)		NA	
3	Cattle + Buffalo	At the time of outbreak	15	4 (26.7)	4 (26.7)	6 (40.0)		NA	
	Cattle + Buffalo	One month post FMD outbreak/ vaccination	12	12 (100.0)	12 (100.0)	12 (100.0)		NA	
	Cattle + Buffalo	Four months post FMD outbreak/ vaccination	20	17 (85.0)	18 (90.0)	19 (95.0)		NA	
4	Cattle + Buffalo	One month post FMD outbreak/ vaccination	34	33 (97.1)	31 (91.2)	33 (97.1)		NA	
5	Cattle + Buffalo	Two months post outbreak	28	26 (92.9)	27 (96.4)	28 (100.0)	28	15	53.6%
6	Cattle + Buffalo	At the time of outbreak	44	43 (97.7)	35 (79.6)	38 (86.4)	40	12	30.0%
	Cattle + Buffalo	One month post outbreak/ vaccination	27	24 (88.9)	22 (81.5)	27 (100.0)	26	11	42.3%
7	Cattle + Buffalo	-	NA	-	-	-	-		
8	Cattle + Buffalo	Healthy (in-contact) animals at the time of outbreak	20	20 (100.0)	19 (95.00)	20 (100.0)	20	8	40.0%
9	Cattle + Buffalo	At the time of outbreak	16	15 (93.8)	14 (87.5)	15 (93.8)	16	4	25.0%
	TOTAL	At the time of outbreak	112	94 (83.9)	78 (69.6)	93 (83.0)	130	50	38.5%
		One to four months after the outbreak	121	112 (92.6)	110 (90.9)	119 (98.3)			

NA: Not available

detection of antibodies against 3AB3 NSP of FMDV, which indicated virus circulation in that area. The overall case attack rate per thousand animals for FMDV in cattle, buffalo and pig was found to be 17.3, 5.5 and 19.3, respectively during the overall period of three years (2014-2016). The mortality rate per thousand animals for FMDV in cattle, buffalo, and pig was 2.7, 0.65 and 3.2, respectively for these three years.

FMDV serotype O was detected in 17 samples out of 18 tested during 2014-2016 from all the nine outbreaks in

Haryana. None of the sample demonstrated FMDV serotype A or Asia-1. FMDV serotype Asia-1 and A have not been reported from Haryana since 2009 and 2010, respectively.

There were direct economic losses due to FMD outbreaks as the average milk production of the affected milch animals came down from 14 to 3 litres (average) per day per buffalo and 10 to 2 litres (average) per day per cattle. However, there were no productivity losses in calves but treatment expenses were there for all the

**Table 4**  
**Economic losses (INR) due to FMDV outbreaks in Haryana (2014-2016)**

Year	Number of outbreaks	Loss due to mortality	Loss of draught power	Loss of milk production	Loss due to cost of the treatment	Total losses
2014	4	19000	68550	0	39000	126550
2015	1	0	12000	18225	75500	19225
2016	4	333000	116775	0	124300	574075
Total	9	352000	197325	18225	238800	719850

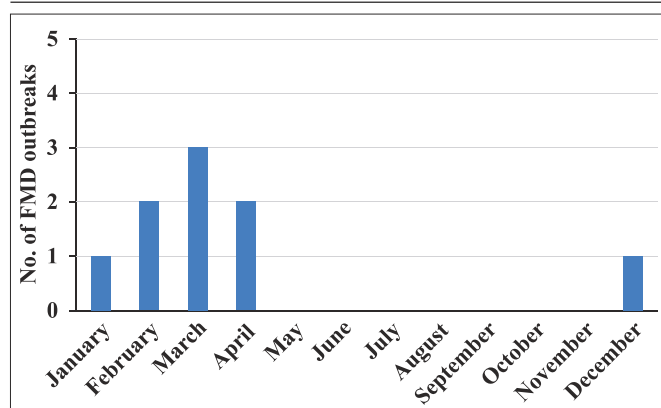


Fig. 1. Month-wise distribution of FMD outbreaks in Haryana (2014-2016)

animals (Table 4). Of the total economic losses of more than INR 7.19 lakhs, the maximum economic loss (INR 3.52 lakhs) was observed due to mortality followed by the cost of treatment (INR 2.38 lakhs) of the affected animals, loss due to draught power (INR 1.97 lakhs) and loss of milk production (INR 0.18 lakhs). Although equal number of outbreaks (four each) were observed in 2014 and 2016 (Table 4) but economic losses were higher in 2016 (INR 5.74 lakhs) than 2014 (INR 1.26 lakhs) because of losses due to higher mortality, draught power and treatment cost to more number of affected animals in 2016 than 2014 (Table 2 & 4).

There was a remarkable decline in FMD incidences in Haryana after the initiation of FMD-CP through mass vaccination of cattle and buffaloes. This report suggests that there should be timely vaccination of susceptible livestock population as well as implementation of strict regulations related to unvaccinated livestock movement for effectively controlling the disease.

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#### REFERENCES

- Bhattacharya, S., Banerjee, R., Ghosh, R., Chattopadhyay, A.P. and Chatterjee, A. (2005). Studies of the outbreaks of Foot and Mouth Disease in West Bengal, India, between 1985 and 2002. *Rev. Sci. Tech.* **24**: 945-52.
- Bora, M., Sharma, R. and Kakker, N.K. (2014). Detection of anti-non-structural protein antibodies against foot and mouth disease virus in the bovine population of Haryana during FMD control programme in the year 2012. *Haryana Vet.* **53**(1): 8-12.
- Govindaraj, G., Ganesh, K.B., Krishnamohan, A., Hegde, R., Nandakumar, S., Prabhakaran, K., Mohan, V., Kakker, N., Lokhande, T., Sharma, K., Kanani, A., Limaye, A., Natchimuthu, K., Khan, T.A., Misri, J., Dash, B.B., Pattnaik, B. and Rahman, H. (2020). Economic impact of FMD in cattle and buffaloes in India. *Indian J. Anim. Sci.* **90**(7): 971-976.
- Kakker, N.K. and Sharma, R. (2003). Foot and mouth disease outbreaks in Haryana during the year 2001. *Haryana Vet.* **42**: 15-18.
- Kakker, N.K. and Sharma, R. (2007). Foot and mouth disease outbreaks after the launch of FMD control programme in Haryana. *Haryana Vet.* **46**: 65-68.
- Kakker, N.K. and Sharma, R. (2008). Retrospective diagnosis of FMD outbreaks by liquid phase blocking ELISA. *Haryana Vet.* **47**: 28-31.
- Kakker, N.K. and Sharma, R. (2012). Epidemiological studies on foot and mouth disease outbreaks in Haryana during the years 2009 and 2010. *Haryana Vet.* **51**: 19-23.
- Sharma, R. and Kakker, N.K. (2005). Scenario of foot-and-mouth disease outbreaks in Haryana state during the years 2003 and 2004. *Haryana Vet.* **44**: 47-51.
- Sharma, R. and Kakker, N.K. (2009). Incidence of foot and mouth disease outbreaks in Haryana during the years 2007 and 2008. *Haryana Vet.* **48**: 97-100.
- Sharma, R., Kakker, N.K. and Kumar, A. (2002). Occurrence of foot and mouth disease outbreaks in Haryana during 2001. *Haryana Vet.* **41**: 12-17.
- Sharma, R., Kumar, A., Kakker, N.K. and Ahuja, K.L. (2006). Incidence and distribution of foot and mouth disease virus serotypes in Haryana between 1997-2000. *Haryana Vet.* **45**: 61-64.