Asian Journal of Epidemiology

ISSN 1992-1462

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Asian Journal of Epidemiology 3 (3): 141-147, 2010
ISSN 1992-1462 / DOI: 10.3923/aje.2008.40.46

Studies of the Outbreaks of Foot and Mouth Disease in Uttar Pradesh, India, Between 2000 and 2006*

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Abstract: The present study provides information about the endemicity of the disease in Uttar Pradesh, India that can help to formulate an effective strategy for an FMD control programme. In the Uttar Pradesh state of India, 270 FMD outbreaks were reported during 2000 to 2006. From these outbreaks, 178 tongue epithelial tissues were collected. Out of 270 outbreaks, 131 were confirmed by indirect sandwich ELISA test. Of the prevalent four serotypes, O type FMD virus accounted for the most outbreaks (50.38%), followed by A virus type (30.53%) and Asia-1 virus type (19.08%), while no outbreak due to type C was detected. The study shows clearly that incidences were highest during the winter months and in the South Western semi arid agro-climatic zone. The distribution and density of the FMD-susceptible population in different districts of the state also played major role in disease incidences. Due to the unrestricted movements of animals among different livestock markets, the disease was transmitted either by direct contact or by aerosols from infected to healthy animals.

Key words: Agro-climatic zone, animal movement, foot and mouth disease, transmission, Uttar Pradesh

INTRODUCTION

The economy of India is dependent mainly on agriculture. Livestock production is a vital source of providing dietary protein for the rapidly growing human population and it is therefore important to define strategies for controlling infectious diseases that are undermining the livestock industry. Foot-and-mouth disease virus (FMDV) was identified by Loeffler and Frosch (1898) as the first filtrable viral agent to cause animal disease. It is a highly contagious virus affecting over 60 species of cloven-hoofed domestic and wild animals (OIE, 2007). Morbidity can approach 100% (Woodbury, 1995; Salt *et al*., 1996; OIE, 2007), while mortality is rare in adult animals, though it may be as high as 50% (Woodbury, 1995; OIE, 2007), when the virus replicates in the heart muscles of younger animals (Gulbahar *et al*., 2007) resulting in death. The disease is highly contagious and known as one of the most economically devastating diseases of livestock (James and Rushton, 2002). The recovered animals remain in poor physical condition over long periods of time leading to sustained economic losses for the livestock industry. The annual loss due to FMD in India is roughly estimated at US $800 million (Bandyopadhyay, 2004). In India, foot and mouth disease (FMD) remains-almost throughout the year the greatest and most feared scourge of both domestic and wild cloven-hoofed animals (Chowdhury *et al*., 1992; Basu *et al*., 1999; Bhattacharya and Pattnaik, 1999; Bhattacharya *et al*., 2003). The disease is characterized by the formation of vesicles and subsequent

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Originally Published in Asian Journal of Epidemiology, 2008

ulceration, generally in the mouth, feet and udder portions (Woodbury, 1995; OIE, 2007). The virus exhibits its pathologic effect on pituitary gland, which control the metabolic functions in the body (Alexandersen *et al*., 2003). A chronic panting syndrome characterized by dyspnoea, anaemia, hair overgrowth, and lack of heat tolerance has been reported as a sequela in cattle (Geering *et al*., 1995). In cows, infection of udders and teats may progress to mastitis that causes permanent milk loss. Among the seven distinct serotypes, O, A, C and Asia-1 types are the causal agents for FMD outbreaks in Uttar Pradesh, as in India more generally. Type O FMD virus (FMDV) is responsible for the greatest number of outbreaks, followed by types A, Asia-1 and C. Studies of the pattern of disease in the rest of the country, including the neighboring states, showed similar prevalence of different serotypes of the virus (Berman *et al*., 1990; Ahuja *et al*., 1996). A high priority is now being given to control of the disease, as the export potential of the livestock industry has been greatly reduced by trade barriers imposed by FMD-free countries. With a total geographical area of 238,556 km^2, the Uttar Pradesh state is quite different in terms of its geography from most of the other states of India. There is a long international border with Nepal, along the Northern boundary of the state, and inter-state borders with Uttarakhand, Himachal Pradesh, Haryana, Delhi, Rajasthan, Madhya Pradesh, Chhattisgarh, Jharkhand and Bihar. In terms of agro-climatic conditions, Uttar Pradesh is divided into nine zones: the bhabhar and tarai zone, the Western plain zone, the mid western plain zone, the south western semi-arid zone, the central plain zone, Bundelkhand zone, North eastern plain zone, Eastern plain zone and Vindhyan zone. The endemic pattern of FMD in Uttar Pradesh is marked by regular fluctuations in the frequency of the disease both within and over the years. This study attempts to analyze the outbreaks of FMD in the Uttar Pradesh state in order to define the endemicity of its occurrence for the 7 year period from 2000 to 2006.

MATERIALS AND METHODS

The data source for this study was the information generated and contained in the annual reports of the All India Co-ordinated Research Project (AICRP) for Epidemiological studies on FMD, Regional Centre, Mathura, Uttar Pradesh, India, which comprises the official data from the Veterinary Services. It should be noted that the analysis is based upon the reported cases of FMD outbreaks and an indirect sandwich enzyme-linked immunosorbent assay (ELISA), as described in the protocol given by Bhattacharya *et al*. (1996), has been adopted for confirmatory diagnosis of the virus in the samples from FMD outbreak areas.

RESULTS AND DISCUSSION

In all, 270 FMD outbreaks were recorded from different districts of Uttar Pradesh over the 6 year period from January, 2000 to December, 2006. Out of these, 139 were based on the clinical symptoms viz., vesicles on tongue, gums and feet, while 131 were confirmed by laboratory test (Indirect sandwich ELISA as per the protocol given by Bhattacharya *et al*. (1996). The annual occurrence of FMD outbreaks and distribution of different FMDV serotypes is shown Table 1. Among the four serotypes prevalent in India, the greatest number of incidences were due to type O (50.38%), followed by type A (30.53%), type Asia-1 (19.08%), while no outbreak due to a type C were recorded (Mann *et al*., 1998).

The monthly (mean±standard error [SE]) outbreak pattern of FMD during this period is shown in Table 2 and Fig. 1. The incidences of FMD outbreaks were high during winter months, while in summer months it was low. Densities of FMD-susceptible livestock per square kilometer in different agro-climatic zones of Uttar Pradesh are shown in Table 3. The highest numbers of outbreaks (185) were reported from the South Western semi arid plain zone.

Table 1: Distribution of different serotypes of foot and mouth disease virus in Uttar Pradesh, 2000 to 2006

Years	Total reported cases	Total laboratory confirmed cases	FMD serotypes			
			O	A	C	Asia-1
2000	8	1	-	1.00	-	-
2001	65	30	10.00		-	20.00
2002	22	14	2.00	10.00	-	2.00
2003	140	67	48.00	16.00	-	3.00
2004	10	7	4.00	3.00	-	-
2005	17	4	1.00	3.00	-	-
2006	8	8	1.00	7.00	-	-
Total	270	131	66.00	40.00	-	25.00
%			50.38	30.53	-	19.08

Table 2: Average monthly pattern of outbreaks of foot-and-mouth disease in Uttar Pradesh, 2000 to 2006

Month	Mean	Standard error
January	3.57	1.02
February	5.14	3.06
March	3.86	1.53
April	6.14	3.66
May	1.71	1.41
June	0.86	0.70
July	1.14	0.99
August	1.71	1.19
September	4.00	3.06
October	2.57	1.88
November	4.86	3.32
December	3.00	1.31

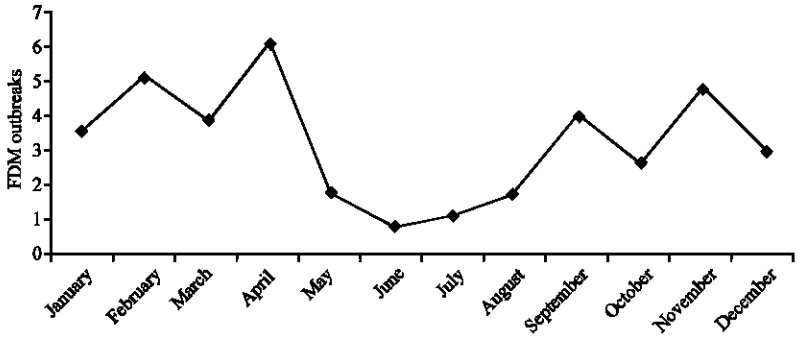

Fig. 1: Average monthly foot-and-mouth disease outbreaks in Uttar Pradesh, 2000 to 2006

Out of 270 reported outbreaks, only 178 samples could be collected. Of these samples, FMDV could not be identified in 47 cases, probably due either to late reporting or to the very poor quality of samples. The possibility that cases could have been misdiagnosed on purely clinical grounds should not be ignored. In many instances the symptoms were confusing and these may have remained undiagnosed. In addition, many of the outbreaks occurred in villages in the interior, where poor transport facilities meant that samples could not be dispatched with sufficient speed to the regional centre at Mathura. The possible reason may be that samples were either not collected at proper time of clinical manifestation of disease or were not suitably preserved (Prasad *et al*., 1992). It may be estimated that only 20 to 30% of the cases of FMD were reported, due to an inadequate reporting system and lack of awareness among farmers. During the period of study, it was observed that cattle suffered most from the disease, accounting for at least 95% of the incidences throughout the state. The remaining 5% of cases occurred primarily in buffaloes and goats. In general, the prevalence of type O was observed higher in Uttar Pradesh. It was also observed that neither A, nor Asia-1 was recovered

Table 3: Density of foot-and-mouth disease susceptible livestock population with number of FMD outbreaks in different districts of Uttar Pradesh, 2000 to 2006

Agro-climatic zone	Districts	Area (km^2)	FMD-susceptible livestock population	Livestock density (km^{-2})	FMD outbreaks	Total No. of Outbreaks
Bhabhar and Tarai zone	Bareilly	4120	919631	223.21	2	7
	Bijnour	4561	1151177	252.40	1	
	Moradabad	3718	1114510	299.76	1	
	Pilibhit	3765	494655	131.37	3	
Western plain zone	Baghpat	1321	464081	351.31	9	42
	Buland Shahar	4352	166734	38.31	9	
	Ghaziabad	1148	628556	547.52	3	
	Meerut	2590	770009	297.30	9	
	Muzaffar Nagar	4008	1120804	279.64	4	
	Saharanpur	3689	859648	233.03	8	
Mid western plain zone	Badaun	5168	1367673	264.64	2	2
South western semi arid plain zone	Agra	4027	1236622	307.08	15	185
	Aligarh	3650	1037932	284.36	10	
	Etah	4446	1180158	265.44	5	
	Etawah	2311	400808	173.43	11	
	Firozabad	2361	767395	325.03	4	
	Mahamaya Nagar (Hathras)	1840	1236622	672.04	15	
	Kannauj	2756	653252	237.03	1	
	Mainpuri	2760	584179	211.66	1	
	Mathura	3340	936508	280.39	123	
Central plain zone	Allahabad	5482	1639161	299.01	2	18
	Barabanki	4402	1066793	242.34	5	
	Kanpur Dehat	3021	735387	243.43	6	
	Pratapgarh	3717	1036047	278.73	4	
	Unnao	4558	887807	194.78	1	
Bundelkhand zone	Jalaun	4565	3108508	680.94	5	5
North eastern plain zone	Faizabad	2014	763021	378.76	1	2
	Kushi Nagar	2906	648587	223.19	1	
Eastern plain zone	Sant Ravidas Nagar (Bhadoi)	1015	270504	266.51	2	6
	Jaunpur	4038	1177031	291.45	4	
Vindhyan zone	Mirzapur	4521	900405	199.16	3	3

during the year (1996 to 1998). It may be due to the movement of animals through borders. Increase in outbreak due to FMDV type O in country may be because of some reasons other than antigenic variation. Although outbreaks due to isolates divergent from reference strain had been reported in field, but the divergent virus disappear from the field and original reference virus remains appropriate as vaccine strain (Ouldridge, 1987; Pattnaik *et al*., 1990).

Climate and Transmission

The incidences of FMD outbreaks were high during winter months in comparison to summer and rainy months. During the rainy season, between June and August, heavy rain, very high relative humidity (>90%) and heavily moist winds may inhibit aerosol transmission of the disease. Transmission of the FMDV from one animal to another through an aerosol pathway is one of the major routes for spread of the disease (Donaldson, 1979; Alexandersen *et al*., 2003; Gloster, 2004). During this season (rainy) also, the movement and transport of animals from one place to another is hindered in some areas by heavy rain or floods. From October onwards, however, the number of reported outbreaks increased due to favorable climatic conditions of dry weather and dry winds with low temperatures and moderate RH. Such favorable climatic factors might cause more rapid propagation of the viral disease among the susceptible animal population. In the month of May, due to extremely hot weather (with average temperatures of 38 to 42°C), the number of FMD outbreaks was greatly

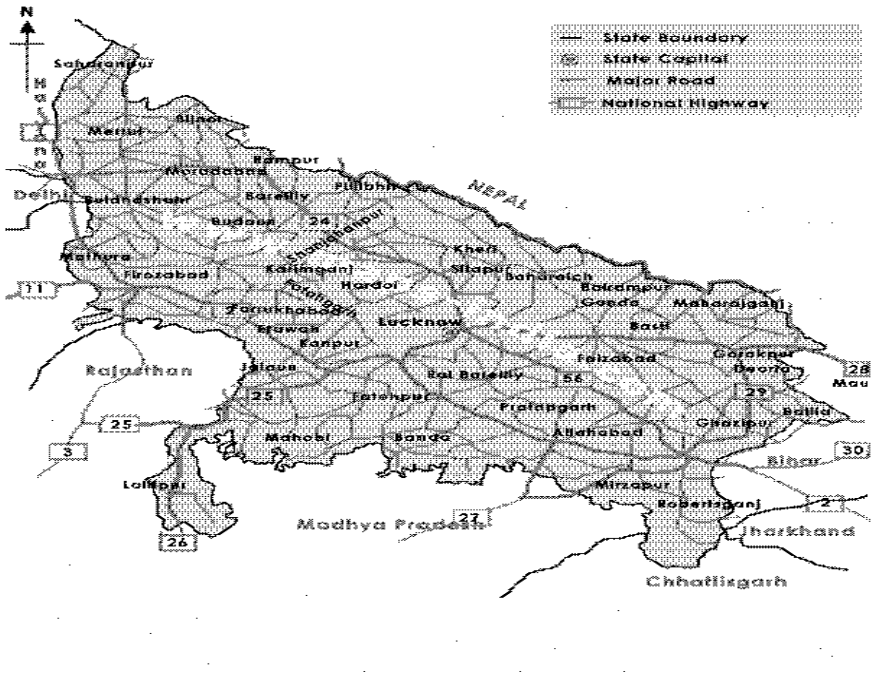

Fig. 2: Map of Uttar Pradesh state showing state and international boundaries

reduced. The effect of environmental factors on the incidence of FMD had also been considered in earlier reports (Sellers, 1971; Donaldson, 1979; Bhattacharya *et al.*, 1984; Chowdhury *et al.*, 1986).

Density, Animal Movement and Transmission

During the study period the highest numbers of outbreaks (185) were reported from the South western semi arid plain zone during this study. These regions have moderate temperature, relatively low humidity and lower average rainfall. These environmental parameters favored the natural spreading of the disease among the susceptible animals of different districts. This region has a higher number of animals- mainly cattle, including crossbred and indigenous-per square kilometer than the other agro-climatic regions of the state. This, in conjunction with higher rates of animal movement throughout the year, meant a large number of animals would be exposed to the disease. River Yamuna flowing through these districts is an important geographical barrier. Being an important source of drinking water, it generates movement and congregation of animals. From adjacent state of Rajasthan (Fig. 2), tens of thousands of animals, comprising mainly cattle and sheep, enter into this belt in waves mainly through Mathura and Agra. While moving along these routes some of the herds branch off Northeast to enter adjacent district Aligarh. Beyond Mathura city, migratory herds fan out to graze in adjacent villages and fields to a depth of 6-7 km from the road; the migratory herds share water and grazing facilities with those of enroute villages. This migration is an annual feature wherein herds start migrating by the end of March, only to return with the onset of monsoon (June/July). Various cattle markets in these areas attract different species of animals including cattle, buffaloes, sheep and goats from distant areas including those of adjacent states of Rajasthan and Haryana. These markets generate congregation and movement of animals. Mathura being a pilgrimage city consumes milk and milk products in

considerable quantities. To meet this demand a number of dairies have been established in and around the city where animals are frequently replaced by input from Haryana and Punjab resulting in the frequent turnover of animal population increasing the possibility of importing and disseminating the infection. The north-eastern and western railways also play roles in transporting animals to and from other states.

The animal population in the districts of the Western Plain Zone is denser; the ratio of cattle to other animals like sheep, goats and buffaloes is larger. This might be the probable reason for the spread of disease. However, natural barriers like rivers, canals and nalas (streams running from canals) separate the areas of this region. Clearly the limitations on animal movements observed within those areas meant less chance of contact between healthy and affected animals. Those factors might have been responsible for the lower number of FMD cases (43) in comparison with South western semi arid plain zone (185) during this period.

In the Bhabhar and tarai region, the number of FMD cases was small, possibly due to the relatively low density of susceptible animals, combined with environmental factors like maximum annual average rainfall and high relative humidity (Brooksby, 1982).

The FMD-susceptible animal population is much less numerous and more scattered in the *Vindhyan region* of Uttar Pradsh (199.16 animals km^{-2}) than elsewhere. Moreover, the climate of this region to some extent inhibits the natural spread of the disease. Thus there were fewer reported outbreaks (3 in all) from this region.

CONCLUSION

This analytical study of FMD in Uttar Pradesh offers valuable insights for better understanding the various aspect of disease transmission as a whole. At the same time, the study also underlines the need to give more attention to key areas that in turn will provide information to help formulate an effective, improved control strategy to prevent the spread of the disease.

ACKNOWLEDGMENTS

The authors are grateful to all the previous professors and research workers who devoted their time to enrich the work of the All India Co-ordinated Research Project for Epidemiological Studies on FMD, Mathura Centre, Uttar Pradesh, India.

REFERENCES

Ahuja, K.L., A. Kumar and S. Prasad, 1996. Incidence and distribution of foot and mouth disease virus types in North West India (1991-1993). Indian J. Virol., 12: 125-127.

Alexandersen, S., Z. Zhang, A.I. Donaldson and A.J.M. Garland, 2003. Review: The pathogenesis and diagnosis of foot-and-mouth disease. J. Comp. Pathol., 129: 1-36.

Bandyopadhyay, S.K., 2004. AICRP report on foot and mouth disease. Indian Veterinary Research Institute, Mukteshwar, India.

Basu, D.K., S. Bhattacharya, D. Saha, A.P. Chattopadhyay, D. Bhattacharya and A. Sikdar, 1999. Report of an outbreak of FMD in an organised dairy farm of West Bengal. Indian J. Anim. Health, 38 (1): 85-86.

Berman, N.N., D.K. Sharma, S.K. Das and B.R. Boro, 1990. FMD outbreaks due to FMD virus type O in N.E. states of India during 1985-1988. Indian J. Anim. Health, 29 (2): 167-169.

Bhattacharya, S., B. Pattnaik and R. Venkataramanan, 1996. Development and application of a sandwich enzyme-linked immunosorbent assay (ELISA) for type identification of foot-and-mouth disease (FMD) virus in direct field materials. Indian J. Anim. Sci., 66: 1201-1209.

Bhattacharya, S. and B. Pattnaik, 1999. ELISA as an immunodiagnostic approach for FMD: An overview. J. Remount Vet. Corps, 38 (1): 7-15.

Bhattacharya, S., R. Banerjee, R. Ghosh, A. Biswas and A. Chatterjee, 2003. Identification of foot-and-mouth disease from a captive kangaroo in a zoological garden in India. Vet. Rec., 153 (16): 504-505.

Bhattacharya, U.K., T.M. Chowdhury and H.M. Bhattacharya, 1984. Foot-and-mouth disease vaccination in cattle in West Bengal: A cost benefit analysis. Indian J. Anim. Health, 23 (1): 105.

Brooksby, J.B., 1982. Portrait of viruses: Foot-and-mouth disease virus. Intervirology, 18 (1-2): 1-23.

Chowdhury, B., U.K. Bhattacharya and H.M. Bhattacharya, 1986. Geo-climatic variation influencing foot and mouth disease outbreaks in West Bengal. Indian J. Anim. Health, 25 (2): 171-174.

Chowdhury, B., R. Majumder and A.K. Bhattacharya, 1992. Foot and mouth disease in gayals (*Bos gaurus frontalis*) in Calcutta zoo. Rev. Sci. Technol. Off. Int. Epiz., 11 (3): 797-798.

Donaldson, A.I., 1979. Airborne foot and mouth disease. Vet. Bull., 49 (9): 653-659.

Geering, W.A., A.J. Forman and M.J. Nunn, 1995. Exotic Diseases of Animals: A Field Guide for Australian Veterinarians. Australian Government Publishing Service, Canberra.

Gloster, J., 2004. New directions: Airborne transmission of foot-and-mouth disease virus. Atmos. Environ., 38: 503-505.

Gulbahar, M.Y., W.C. Davis, T. Guvenc, M. Yarim, U. Parlak and Y.B. Kabak, 2007. Myocarditis associated with foot-and-mouth disease virus type O in lambs. Vet. Pathol., 44: 589-599.

James, A.D. and J. Rushton, 2002. The economics of foot and mouth disease. Rev. Sci. Technol. Off. Int. Epiz., 21 (3): 637-644.

Loeffler, F. and P. Frosch, 1898. Berichte der Kommission zur Erforschung der Maul-und Klauenseuche bei dem lnstitut für lnfektrionskrankheiten in Berlin. Zbl Bakter Abt I Orig., 23: 371-391.

Mann, S., A. Kumar, R. Sharma and K.L. Ahuja, 1998. Prevalence of foot-and-mouth disease virus types in North-West India. Indian J. Virol., 14: 55-57.

OIE, 2007. Foot and mouth diseases Jan 1, 2006 to May 28, 2007. Office International des Epizooties, Paris http//:www.oie.int.

Ouldridge, E.J., 1987. Epidemiology of foot and mouth disease (FMD) in South East Asia. Foot and Mouth Disease Bull., 25 (4): 1-3.

Pattnaik, B., D.V. Rai and R. Venkataramanan, 1990. Characterization of type O FMD virus isolates recovered from outbreaks in India. Indian J. Anim. Sci., 60 (11): 1265-1270.

Prasad, S., A. Kumar, K.L. Ahuja and R. Sharma, 1992. Prevalence of foot and mouth disease virus in North West India. Indian J. Virol., 8: 149-52.

Salt, J.S., A.R. Samuel and R.P. Kitching, 1996. Antigenic analysis of type O foot-and-mouth disease virus in the persistently infected bovine. Arch. Virol., 141: 1407-1421.

Sellers, R.F., 1971. Quantitative aspects of the spread of foot and mouth disease. Vet. Bull., 41 (6): 431-439.

Woodbury, E.L., 1995. A review of the possible mechanisms for the persistence of foot-and-mouth disease virus. Epid. Infect., 114: 1-13.