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Original Research Article

Epidemiological analysis and economic impact assessment of foot-and-mouth disease at Landhi dairy colony Karachi

Umer Farooq[1]*, Khalid Naeem[2], Aamer Bin Zahur[3], Muhammad Azeem Khan[4], Umer Sidique[5] and Subhan Qureshi[6]

[1,2,3] Department of Animal Genomics and Biotechnology, PARC Institute of Advanced Studies in Agriculture (PIASA)
[1,2,3,4] National Agricultural Research Centre, Islamabad. 45500.
[5,6] Faculty of Animal Husbandry and Veterinary Sciences, The University of Agriculture, Peshawar, Pakistan

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**Corresponding author email:*
umerfarooq@usa.com

Abstract

Epidemiology of a foot-and-mouth disease (FMD) was studied at Landhi Dairy Colony (LDC), Karachi, Pakistan and its economic impact was assessed. Of 4528 buffaloes surveyed, 3.6% animals were infected with FMD. The causative agent was confirmed from the clinical samples by indirect sandwich ELISA. The estimated milk loss was 307.8 liters per animal in 45 days. The total damage due to FMD in sampled buffaloes was found to be Rs. 6.7 million and extrapolated price for entire animal population at Landhi Dairy Colohy (LDC) and Karachi was Rs. 290.8 and Rs. 1454.4 million, respectively. The present study indicated that FMD is prevalent in dairy animals at Landhi Cattle Colony, Karachi causing huge economic looses to the farmers. An effective control strategy with a focus on education of farmers regarding proper husbandry practices and use of efficient FMD vaccination strategy may be helpful in reducing the burden of diseases.

Keywords: Foot-and-mouth disease, epidemiology, Landhi Dairy Colony, economic impact.

Introduction

Livestock industry in Pakistan is expanding both at commercial and small holder level to meet increasing demand of growing human population. An ever increasing trend of urbanization has resulted in the development of dairy colonies around all major cities of the country and the largest being around Karachi (Afzal and Hussain, 2006; Afzal, 2003). Dairy colonies are distinct type of production system. In this system, high yielding animals are kept for milk production and are stall fed with a high turnover rate. There are about more than 1 million animals in different dairy colonies around Karachi. The bovine stock at Landhi Dairy Colony (LDC) is 0.2 million and among these 95% are buffaloes (Afzal and Hussain, 2006; Afzal, 2003). In dairy colonies, animals are lodged in limited space which makes animals more prone to acquire infection present in the locality especially in case of eruption of a transboundary animal disease.

Foot-and-mouth disease (FMD) is a transmissible viral disease of cloven hoofed animals (Carrillo et al., 2005) caused by an Aphthovirus of family picornaviridae (Belsham, 1993) and is one of the most economically important infectious diseases of production animals globally (Gullberg et al., 2016). The virus positive sense RNA genome, smaller in size and lacks envelop (Ryan et al., 1991). The seven serotypes of virus are A, O, C, Asia 1, SAT 1-3 (Domingo et al., 2003). The

disease is transmitted horizontally from infected animal to healthy susceptible population physically or by contact (Alexandersen et al., 2003). The defense in case of disease sometimes is not possible as the animal infected with one serotype remains susceptible to other serotypes (Alexandersen et al., 2003; Alexandersen and Mowat, 2005). This is the biggest challenge in preparation of suitable vaccine for control of FMD.

Various FMDV serotypes are distributed all over the world and on the basis of circulating serotypes seven virus pools are identified. Among these pools, Pakistan belongs to West Eurasia and Middle East (Pool 3) with serotypes O, A and Asia 1 (FAO/EU-FMD, 2016). FMD is present in a slight or severe form under field conditions throughout the year (Akhtar and Haq, 1993; Klein et al., 2008). The Progressive Control of Foot and Mouth Disease Project implanted by Food and Agriculture Organization of the United Nations (FAO), Pakistan reported 57 FMD outbreaks during July 2016 only prevalently caused by FMDV serotype by O (35.1%), followed by Asia 1 (28.1%) and A (10.5%) (FAO/EU-FMD, 2016). The most common among these serotypes is O which is distributed worldwide and in Pakistan its reported prevalence during 2011 was 61% (Saeed et al., 2011). The information regarding the distribution of various FMDV serotypes and subtypes is very important for effective FMD control.

Although the main mechanisms of virus transmission are well known, yet the epidemiology of FMD is very complex. It can vary particularly under different animal management systems and husbandry practices (Donaldson, 1993). Unfortunately FMD is causing severe losses in dairy colonies around Karachi and is proving to be a continuous menace for dairy farmers particularly at LDC. Globally, more than 100 countries are being affected by FMD causing huge economic impact which has been estimated about US$10,000,000,000 annually (Knight-Jones and Rushton, 2013). The primary and secondary FMD harms in Pakistan have not been properly investigated; however, Zulfiqar (2003) reported approximate losses due to FMD worth US$ 180 million per annum. It is mandatory for the exports of livestock and its by-products that a country must be free from FMD.

Keeping in view the intensity of disease, a project was designed to study epidemiology along with the economic impact of FMD at LDC, Karachi.

Materials and Methods

Data collection, disease intelligence and confirmation

Data was collected by visiting 35 different farms having overt cases of FMD identified by the local veterinary staff. Structured epidemiological investigations were carried out to study the aspects of the disease such as risk factors, effect of disease on productivity and control measures adopted at the farms. The information of animals number present, affected and at risk at the farms was gathered along with the feeding practices, husbandry practices, history of vaccines used, its source, signs and injuries caused by disease, medical judgement, handling, deaths, earlier ailment at farm and eruption of disease at adjoining farms, arrival of new animals and their quantity, isolation time given to new and diseased animals, parasitic control, damages and price incurred on remedial measures were noted. The study was conducted from September, 2014 to August, 2015

The diseased animals were examined physically. Fluid accumulated in from a burst or non-burst skin of mouth, tongue, and on feet was collected in biological shipment medium (glycerol and 0.04 M phosphate buffer in equal amount containing antibiotics, pH 7.2–7.6). Samples were analysed at Animal Health Laboratories, Animal Sciences Institute, National Agricultural Research Centre, Islamabad using an indirect sandwich ELISA kit (BDSL, UK) for the identification of FMDV (Ferris and Dawson, 1988; Roeder and Le Blanc Smith, 1987). Briefly, the rows A & E; B & F; C & G and D & H of the multi-well plates were coated with 50µl rabbit antisera diluted 1:1000 in carbonate coating buffer (1ml of 0.5M carbonate/Bicarbonate in deionized water, pH=9.6±0.05) of each the four FMDV sero-types (O, A, C & Asia 1), respectively. The plate was placed on an orbital shaker set at 100–120 revolutions per minute in a 37°C incubator for 1 hour. After incubation the micro-titration plates were washed thrice with wash solution (0.002M PBS pH=7.4± 0.2). Before adding the control antigens in the micro-titration plate, a volume of 50 µl/well diluent buffer A (0.01M PBS, pH=7.4± 0.2 plus 0.05% V/V Tween-20) was added in all well of columns 1-6 (Rows A to H). Fivefold serial dilution were made by adding an amount of 12.5 µl of control antigen O, A, C and Asia 1 was added to row

A & E; B & F; C & G and D & H of the multi-well plate, respectively.

After through mixing with multi-channel micro pipette an amount of 12.5µl was transferred to 2nd column and mixed. Again an amount of 12.5µl was transferred to 3rd column, mixed. Similarly, 12.5µl was transferred to 4th column mixed and 12.5µl from 4th column was discarded. The column 5 and 6 were kept as blank controls. Test sample 1, 50 µl was added in rows A to D in column 7, 8; similarly, sample 2 was added to column rows E to H in column 7, 8 and so on and the micro-titration plate was incubated at 37°C±2°C for 1 hour on shaker 100-120 revolution per minute. After incubation micro-titration plate was washed thrice with wash solution (0.002M PBS pH=7.4± 0.2). Then, 100 fold diluted guinea pig antiserum in Diluent Buffer B (Diluent Buffer B =Diluent Buffer A+5%W/V skimmed milk) was added to row A & E (sero-type O); B & F (sero-type A); C & G (sero-type C) and D & H (sero-type Asia 1) and again incubated at 37°C±2°C for 1 hour on shaker 100-120 revolution per minute. After incubation the plate was washed thrice with wash solution (0.002M PBS pH=7.4± 0.2). After this, 50 µl/well anti antiserum of guinea pig 200 fold diluted in diluent buffer B (30 µl conjugate and 6 ml diluent buffer B=diluent buffer A, 0.01M PBS, pH=7.4± 0.2 plus 0.05% V/V Tween-20 PLUS 5% W/V skimmed milk) was added in each and every well of the plate. The place was re-incubated at 37°C±2°C for 45 minutes on shaker 100-120 revolutions per minute and washed thrice with wash solution. Then, 50 µl chromogen substrate was added to all wells of micro-titration plate. Chromogen substrate was made by adding 6 ml of OPD (1 tab OPD in 50ml of 0.05M phosphate citrate buffer, pH5.0, stored at room temperature in dark) in 30 µl H_2O_2 (3% W/V, H_2O_2 =882 mM; 1 H_2O_2 tab was dissolved in 10 ml distilled/de-ionized water and stored in dark at 1°C -8°C). It was once again incubated at room temperature (18-25°C) for 15 minutes without shaking in dark. Finally, 50 µl stop solution (1.25M H_2SO_4; by adding 68ml of concentrated sulfuric acid (18M) slowly to 932 ml of distilled/de-ionized water) was added to all wells of micro-titration plate and read under 492nm in ELISA reader.

Data analysis

Data was analyzed using statistical package, STATA 13 and the financial assessment of the losses was made by using partial budget technique (Ellis, 1993; FAO, 2016).

Results

In the present study, data from the 35 farms was collected at LDC Karachi. Total 4528 animals with an average of 129 animals per farm were housed at these dairy farms. Prophylactic FMD vaccine was administered at all farms. The origin of vaccine was either local or imported. The local vaccines were Sindh Research Institute (SRI) and Veterinary Research Institute (VRI) Lahore, whereas the imported vaccines were Aftebin (Czech Republic) and Aftovax (Merial, France). Of 4528 animals, 161 (3.6%) were facing FMD and 4367 animals (96.4%) were having danger of disease. The antibiotics (penicillin, oxytetracycline, amoxicillin and enrofloxcin) were used for treating animals. The mortality and case fatality rate was 0.4% and 11.2%, respectively. Number of slaughtered animals among diseased animals was 5.6% (n=9). All these farms were not having disease earlier. In past 8.6% neighboring farms faced the disease. Fresh animals were presented at 74.3% farms with 7.2% per month induction rate and at 77.1% farms prophylactic FMD vaccination was given to newly brought animal. Parasitic control measures were adopted at 68.6% farms. Newly brought animals at these farms were not isolated from already existing animals (Table 1).

Average FMD milk loss per day per animal was observed 9.7 liters. The observed disease period for FMD was 9 days and the average milk production after disease period per animal was found to be 6.3 liters. The average FMD milk loss per animal per 45 days (disease recovery period) was 307.8 liters per diseased animals, worth Rs. 23,085 (Table 2).

A total loss of Rs. 3.1 million was estimated due to reduced milk production. The estimated losses were calculated on 3.6% animals affected. FMD damage was Rs. 136.6 for 0.2 million animals at Landhi and it worth Rs. 683.2 million for 1 million animals at Karachi (Table 3).

Samples (n=79) were analysed using an indirect sandwich ELISA at Animal Health Laboratories, Animal Sciences Institute, National Agricultural Research Centre, Islamabad and 86.1% (n=68) were found positive for FMDV.

An average amount of Rs. 1591 was incurred on cure of diseased animal and total damage experienced on

the treatment was Rs. 0.3 million in diseased animal (n=161).

The projected losses worth at LDC was calculated on 3.6% diseased animals. The intended treatment charge were Rs. 11.3 million for 0.2 million animals at Landhi and it worth Rs. 56.6 million for 1 million animals at Karachi (Table 3).
The recorded mortality was 11.2% and the case fatality rate was 0.4%. The losses due to death of diseased animals were worth Rs. 2.9 million. The projected losses worth was Rs. 126.5 and Rs. 56.6 million was observed at LDC and Karachi, respectively (Table 3).
Number of slaughtered animals among diseased animals was 5.6% (n=9). The cost for low price sale of diseased animal was found to be Rs. 0.4 million. The predictable ruin worth was Rs. 16.4 and Rs. 82 million was observed at LDC and Karachi, respectively (Table 3).
The complete FMD damages worth Rs. 6.7 million, Rs. 290.8 and Rs. 1454.4 million were calculated for sampled animals, animals at LDC and Karachi respectively (Table 3).

Table 1: The details of various factors recorded to study the epidemiology and economic losses due to Foot and mouth disease in Landhi Cattle Colony, Karachi

Factors		Total
a	Farms (No.)	35
b	Total animals at farms	4528 (129)
c	Animals affected (No.) (c/b*100)	161 (3.6)
d	Animals at risk (No.) (d/b*100)	4367 (96.4)
e	Mortality (e/c*100)	18 (11.2)
f	Case fatality Rate (e/b*100)	18 (0.4)
g	Slaughtered among diseased animals (g/c*100)	9 (5.6)
h	Presentation of fresh animals at farm (No.) (h/a*100)	26 (74.3)
i	Fresh animals introduced (No.) (i/b*100)	324 (7.2)
j	Vaccination of fresh animals (No. of farms) (j/a*100)	27 (77.1)
k	Parasitic control measures (No. of farms) (k/a*100)	24 (68.6)
l	Neighboring farms facing disease (l/a*100)	3 (8.6)
m	Isolation period given to fresh animals (m/a*100)	Nil
n	Earlier disease history (n/a*100)	Nil

Values in parenthesis are percentages

Table 2: The estimation of economic losses due to milk reduction in Foot and mouth disease affected animals at Landhi Cattle Colony, Karachi

a	Daily average animal milk production (before disease)	11.2 L
b	Daily average animal milk production (during disease)	1.5 L
c	Daily milk loss per animal (in disease) (a-b)	9.7 L
d	Average disease period (days)	9
e	Reduced milk (during disease) (d*e)	87.3 L
f	Daily average animal milk production (after disease)	6.3 L
g	Daily less milk per animal (after disease till recovery)	4.9 L
h	Milk losses till recovery (45 days) (g*45)	220.5 L
i	Reduced milk (after disease till recovery) (e+h)	307.8 L
j	Milk value per liter (Rs.)	75
k	Reduced milk worth per animal (Rs.) (j*i)	23085

L=Liters

Table 3: The economic losses assessment in Foot and mouth disease affected animals at Landhi Cattle Colony, Karachi

Detail of animals	Factors	Number of sampled animals	Total number of animals at Landhi	Total number of animals at Karachi
	Total animals (a)	4528	200000	1000000
	Affected animals (b)	161 (3.6%)	7111 (3.6%)	35557 (3.6%)
Decreased milk production	Milk loss/animal (Rs.) (c)			23085
	Animals Recovered (d)	134 (83%)	5919 (83%)	29594 (83%)
	[A]Total loss (million Rs.) (c*d)	**3.1**	**136.6**	**683.2**
Losses incurred on treatment	Treatment cost /affected animal (Rs.) (e)			1591
	[B]Treatment cost (million Rs.) (b*e)	**0.3**	**11.3**	**56.6**
Losses due to mortality	Case Fatality (%) (deaths/a)			18 (0.4%)
	Mortality (%) (deaths/b)			18 (11.2%)
	Cost of an animal (Rs.) (f)			159139
	[C]Total loss (million Rs.) (deaths*f)	**2.9**	**126.5**	**632.6**
	Animals slaughtered (No.) (g)	9 (5.6%)	398 (5.6%)	1988 (5.6%)
	Low price Losses (Rs.) (h)			41246
	[D]Total damage (million Rs.) (g*h)	**0.4**	**16.4**	**82**
Total loss due to FMD (million Rs.) (A+B+C+D)		**6.6**	**290.9**	**1454.3**
Harm per farm (million Rs.) (A+B+C+D)/farms				**0.2**

Discussion

FMD productivity damages are well measured against a common background of low productivity (Ferris *et al*, 1992). However, the farmers at dairy colonies particularly at LDC exploit the production potential of animals to its maximum by feeding them a concentrated ration. In addition they also use Bovine Somatotrophin hormone (BST). Under such circumstances, disease outbreaks especially that of FMD become hindrance to efficient production. Since there is no trend of outbreak investigation and estimation of economic losses due to diseases, dairy farming continues in inefficient manner without adopting appropriate control measures. The present study was therefore undertaken to understand some aspects of epidemiology of the disease at LDC.

In our study, an estimated loss of 170.5 liters of milk per animal was recorded during 45 days at 35 farms located at LDC, Karachi with an average of 3.7 liters per animal per day. Similar findings were observed by Ferrari *et al*. (2014), they estimated 220 liters in cattle and 201 liters in buffaloes during initial 60 days at 50 farms located in Sindh, Punjab and Islamabad.

It was found that the overcrowding and congestion, inappropriate management practices and poor hygienic conditions are the common features at LDC. Such conditions always favor occurrence of various infectious diseases at Landhi and other dairy colonies around Karachi. A previous study estimated 12.4% FMD prevalence at different dairy colonies around Karachi (Ali *et al.*, 2006). However, this study reported less cases of FMD i-e, 3.6%.

The high prevalence of FMD in previous study could be due to the reason that farmers are introducing 74.3% animals without quarantine. It is quite interesting that during this study we found that 77.1% of the animals were vaccinated against FMD and farmers were well aware of advantages of using FMD vaccine. However, despite vaccination FMD continues to be reported from the field. The possible reasons could be the quality and the strains used in the preparation of these vaccines. A variety of vaccines were used at LDC including vaccine by Veterinary Research Institute (VRI) Lahore, Punjab. It is formalin inactivated alum precipitated vaccine containing serotype O and is recommended twice a year for use.

This is an established fact that an effective vaccine must be potent, safe and antigenically matching against the circulating strains of the virus. None of the available FMD vaccine was effective and protective. Knight-Jones *et al*. (2016) controlled FMD in Turkey using biannual mass vaccination of cattle using more effective vaccines and vaccination strategies. However, vaccine become less efficacious due to certain factors including, improper cold chain maintenance, non-matching of vaccine and field virus strains and husbandry practices (Lombard and Schermbrucker, 1993). Previous studies suggests that three FMDV serotypes (O, A and Asia 1) are prevalent in Pakistan therefore, trivalent vaccine containing serotypes circulating in the country would give effective protection against FMD. Few private companies provide trivalent FMD vaccines to the farmers but these vaccines are very expensive (Rs. 120/ dose). There is no trend of monitoring herd immunity against FMD even after vaccinating the animal flocks. Besides this FMDV sero-monitoring facility are lacking. Parthiban *et al*. (2015) reported the shedding of FMDV in vaccinated and non-vaccinated cattle. Results also indicated that the farmers at LDC introduce (7.2%) new animals into their herds regularly from different markets of Punjab and Sindh provinces. A previous study has reported the monthly turnover rate of 10-12% at different dairy colonies in Karachi (Afzal and Hussain, 2006). In these conditions the chances of spread of FMD become greater when animals from different areas are mixed together without following any quarantine protocol. Data also showed that indirect methods (like fomites) are also an important way of transmission of FMDV from one farm to another in the LDC. The farms in LDC are very close to each other and in most of the instances they are separated by a single wall. The farm workers visit neighboring farms frequently thereby increasing the chances of spread of disease. Moreover, a moderate wind blows across Karachi and particularly at Landhi being very close to the sea with a high relative humidity. Donaldson and Alexandersen (2002) reported that FMDV can be transmitted over long distances via aerosols under certain geographical and climatic issues.

The study indicated that FMD is prevalent in dairy animals at Landhi Cattle Colony, Karachi causing huge economic looses to the farmers. An effective control strategy with a focus on education of farmers regarding proper husbandry practices and use of efficient FMD vaccination strategy may be helpful in reducing the burden of diseases.

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Conflict of interest statement

The authors declare that there is no conflict of interest in this research.

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