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Economic analysis of foot-and-mouth disease in Turkey-I: Acquisition of required data via Delphi expert opinion survey

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ABSTRACT

The main obstacle in assessing the impact of Foot and Mouth Disease, which is considered to be economically most important disease both in Turkey and the other countries in the world, on Turkish Economy is unavailability of reliable data.

Considering this issue, this study aimed at using a Delphi Expert Opinion Survey Method to obtain data required form economic analysis of FMD in Turkey.

This study concluded that although there were problems in obtaining some information from the experts, in general the Delphi technique is a promising way of obtaining animal health data which is missing and/or not regularly recorded in developing countries.

Key words: Foot-and-mouth-disease, delphi, economic analysis, Turkey.

INTRODUCTION

Foot and mouth disease is endemic in majority of developing countries. It not only results in severe production losses at the infected animals, but also loss of export potential of livestock and livestock products which could be a locomotive in the development of the livestock sector in the developing countries. On the other hands, a substantial amount of money and man powers have been invested to prevent from or control the disease.

In recent years, a computerised disease control decision support systems have frequently been used in order to estimate direct and indirect losses from contagious animal diseases and costs and benefits of alternative disease control/eradication strategies in many countries.

In spite of the fact that the needs for economic analysis of disease induced financial/economic losses due to contagious animal disease, and cost and benefits of alternative disease control/eradication strategies have frequently been emphasized in Turkey (Sakarya, 1991), studies in this field is limited. Zog (1992) developed a simulation model to estimate the FMD induced financial losses in Turkey, and costs-benefits of several alternative FMD control/eradication strategies. However, majority of the required data, particularly those related to production losses due to infection was not available in the currently maintained database in Turkey. He, therefore, obtained most of the required data from published literature and/or his guestimates, which undermined the reliability of model estimates to be used as a decision support tool.

Availability of reliable data/information is the pre-requisite of reliable estimates of disease induced losses and cost benefit analysis of alternative control/eradication strategies, which is the main handicap in developing countries.

The most reliable way of assessing FMD induced production losses is under controlled experiments where animals are experimentally infected and its effects on economically important yield parameters are observed. However, this is not allowed for FMD, since the disease is too infectious and highly transmissible. Alternatively, the FMD induced production losses would be estimated by obtaining data/information from producers surveys of FMD infected herds or expert opinion.

Abıbeş et al. (1998) estimated FMD induced production losses in Turkish field situations by obtaining data relied on 28 producers' observations of FMD infected livestock in 10 provinces of Turkey. This study produced some useful information related to FMD induced production losses. However, majority of livestock herds in Turkey are small-scale whose owners are not well educated, and do not have good habit of record keeping. Furthermore, majority of the producers are reluctant to provide information on such a sensitive contagious disease.

From this point of view, this study aimed at obtaining information required for economic analysis of FMD induced losses and cost of control activities, which were either unavailable or unreliable, by conducting Delphi Expert Opinion Survey (DEOS).

The Delphi technique, originally developed by the RAND Corporation to forecast future development in technological progress, is a structured process which utilises a series of questionnaires or rounds to gather and to provide information (Sariaslan, 1994). More generally, the technique is seen as a procedure to ''obtain the most reliable consensus of opinion of a group of experts (Rowe and Wright., 1999; Keeney et al.,2001).

It is growing in popularity especially for health researchers. Gupta and Clarke (1996) reviewed 27 health related researches used the Delphi Technique. In livestock science, Asseldonk et al. (1999) used the technique to investigate information technology and information needs of Dairy enterprises in Netherlands; Fels-Klerx et al. (2000) used it to determine risk factors of Bovine Respiratory Disease in Calves and Bennett and IJpelaar (2003) obtained the missing information from veterinary experts on parameters required to estimate the costs of 35 endemic disease in Great Britain. Horst et al. (1998) used "Conjoint Analiyis" and "ELI" Techniques which are based on eliciting information based on expert opinions from a one-round-meeting, to obtain information required for risk assessment and computerised decision support model for six different contagious diseases including FMD.

The novelty of this research is the application of DEOS to obtain information required to estimate cost of FMD (disease induced production losses plus disease control expenditure) in Turkey.

MATERIALS AND METHOD

The materials of the study were the data obtained from DEOS included 25 Turkish state veterinarians working at the Department of Animal Health of Turkish Ministry of Agriculture, and having good field experience on FMD outbreaks.

In this study, first of all, the data required to calculate FMD induced financial losses in each livestock species affected were specified. Secondly, an availability of the required data in Turkey was explored. The data either unavailable or available, but unreliable were determined. Thirdly, a questionnaire form including unavailable and unreliable data required to be obtained from expert opinions was prepared.

Before conducting in the field, the questionnaire form was sent to 4 veterinary experts to test its suitability and clarity. As soon as obtaining their response, it was corrected and re-organised according to the suggestions of the vets, and sent to 81 state vets working at the Department of Animal Health of Ministry of Agriculture in each of 81 provinces of Turkey.

The survey was conducted as 2 rounds. In the first round 25 vets were responded. For each question, median and inter quartile range (IQR) was determined. When the respond of a question was outside the IQR, it was re-asked to the experts in order to re-consider their answers, and let them to re-state their answers considering the general tendency of median and IQR values of all experts. The experts not changing their outlier answers were asked to state reason(s) for insisting on their outlier answers.

All 25 experts participated in the second round of the Delphi survey. After analysing the responds of the second round, no further round was considered necessary.

RESULTS

The results of DEOS related to Information required to estimate FMD induced production losses in infected livestock

3.1.1. States of animals after FMD infection

The medians and Inter Quartile Range (IQR) of probabilities of being in different states (cull or death) after FMD infection are shown in Tables 1 to 3.

Table 1. The results of DEOS on the probabilities of being in different states (cull or death) after FMD infection of dairy cow, heifer and female calf.

State of animal*	Probabilities (%)								
	Dairy cow			Dairy heifer			Female calf		
	Holstein	Cross	Local	Holstein	Cross	Local	Holstein	Cross	Local
Culled	10 (5-15)**	7 (4-12)	4 (1-5)	10 (5-20)	7 (4-13)	5 (1-5)	10 (1-15)	10 (3-15)	5 (2-10)
Death	5 (2-5)	2 (1-3)	1 (1-2)	5 (2-7)	3 (1-5)	2 (1-3)	20 (10-50)	15 (10-40)	10 (5-15)

*Prob. of staying in a herd =1-prob. of cull + Prob. of death, ** The data in parenthesis state Inter Quartile Ranges

Table 2. The results of DEOS on the Probabilities of being in different states (cull or death) after FMD infection of beef cattle and male calf.

State of Animal	Probabilities (%)					
	Beef cattle			Male calf		
	Holstein	Cross	Local	Holstein	Cross	Local
Culled	15 (10-25)*	10 (5-20)	5 (2-5)	5 (1-10)	5 (0,5-10)	5 (0,5-5)
Death	3 (2-5)	2 (1,5-5)	1 (1-2)	20 (7-45)	11 (5-40)	5 (4-15)

* The data in parenthesis state Inter Quartile Ranges.

Table 3. The results of DEOS on the Probabilities of being in different states (cull or death) after FMD infection of small ruminants.

State of Animal	Probabilities (%)				
	Sheep	Hog (12-18 month old)	Lamb**	Goat	Kid**
Culled	5 (2-10)	7 (3-10)	5 (1-10)	4 (2-5)	5 (5-10)
Death	2 (1-3)	3 (2-5)	15 (5-40)	2 (1-4)	10 (5-40)

* The data in parenthesis state Inter Quartile Ranges. * *Animals not weaned.

As can be seen from Table 1 and 2, both probability of culling and death due to FMD is lowest in local breeds, and highest in the exotic breeds as expected. Another important finding seen in these tables is that mortality rate due to FMD in young cattle is much higher than those of mature animals.

Table 3 shows that, there is no notable difference in the rate of culling due to FMD amongst adult and young small ruminants. However, the mortality rate due to FMD in young small ruminants is 5 to 7.5 times higher than those of mature animals.

3.1.2.Effects of FMD on milk yield

The results of DEOS on milk yield losses in infected dairy cows are presented in Table 4.

Table 4. The results of DEOS on milk yield losses in the infected dairy cows.

Breed	Probabilities of maintaining previous milk yield level after the infection (%)	Milk yield losses if an infected cow returns her previous yield (%)	Probabilities of not maintaining previous milk yield level after infection (%)**	Milk yield losses if an infected cow does not return her previous yield (%)
Holstein	65(60-70)*	22(15-40)	35(30-40)	40(30-50)
Cross	70(65-80)	20(10-30)	30(20-30)	30(25-40)
Local	80(80-90)	10(8-20)	20(10-20)	25(20-30)

* The data in parenthesis state Inter Quartile Ranges. ** Calculated according to the first column.

When the table is examined, it is seen that the irreversible damage in udder due to FMD in cross and exotic breeds are much greater (30 and 35 % respectively) compared to that of local breed (20%). On the other hand, if the infection results in irreversible damage in udder, milk yield losses become much greater (depending on breeds, it is 1.5 to 2.5 times higher than those occurred in reversible udder damage).

3.1.3. Effects of FMD on fertility parameters

The results of DEOS on risk of aborts in FMD infected adult livestock are presented in Table 5.

Table 5. The results of DEOS on risk of aborts in FMD infected adult livestock.

	Dairy cow			Dairy heifer			Small ruminants	
	Holstein	Cross	Local	Holstein	Cross	Local	Sheep	Goat
Expected abort rate for healthy animals (%) (A)	5 (4-10)*	5 (3-5)	3 (1-5)	7 (5-10)	5 (3-5)	3 (2-4)	5 (3-10)	5 (1-10)
Expected abort rate in FMD infected animals (%) (B)	15 (10-20)	10 (7-15)	7 (4-10)	15 (10-20)	10 (6-15)	7 (5-10)	15 (6-25)	10 (5-15)
Net effect of FMD (A-B)	10	5	4	8	5	4	10	5

* The data in parenthesis state Inter Quartile Ranges.

General trends in expert opinions in the Table 5 reveal that the impact of FMD on abort rate in exotic cattle and sheep were almost 2 times higher than other breeds and/or species shown in the table.

The results of DEOS related to the effect of FMD on age at first calving (AFC) of dairy heifer and calf are presented in Table 6.

Table 6. The results of DEOS related to the effect of FMD on age at first calving of dairy heifer and calf.

	Dairy heifer			Dairy calf (0-6 month)		
	Holstein	Cross	Local	Holstein	Cross	Local
If abortion occurs (days)	120 (70-150)*	90 (50-100)	70 (40-90)	70 (30-90)	50 (30-60)	40 (20-60)
If aborts does not occurs (days)	60 (45-60)	50 (40-60)	40 (25-50)			

* The data in parenthesis state Inter Quartile Ranges.

The findings on the effect of FMD on the delay in AFC of dairy cattle differ significantly according to breed and occurrence of aborts after the infection. In general, it varied between 40 and 120 days, highest in exotic breeds and lowest in local breeds. On the other hand, if the infection results in abortion, the delay would almost be doubled.

The results of DEOS related to the effect of FMD on calving intervals (CA) of dairy cow is revealed in Table 7.

Table 7. The results of DEOS related to the effect of FMD on calving intervals of dairy cow.

	Holstein	Cross	Local
If aborts occurs (days)	91 (80-150)*	90 (60-120)	60 (45-90)
If aborts does not occurs (days)	60 (60-75)	50 (40-60)	30 (20-60)

* The data in parenthesis state Inter Quartile Ranges.

Table 7 shows that delay in calving interval due to FMD vary between 30 and 91 days depending on breeds and occurrence of abortion after infection. Compared to that of local breeds, delay in CA in exotic and cross breeds are 50% and 100% higher respectively. Similarly, Occurrence of aborts after infection increases the delay by 1.5 to 2 folds depending on breeds.

<u>Effect of FMD on live-weight gain</u>

The results of DEOS related to the effect of FMD on live-weight gain (LWG) is presented in Table 8.

Table 8. The results of DEOS related to the effect of FMD on live-weight gain (%)

	Dairy cow	Dairy heifer	Beef cattle	Calf	Sheep and hog	Lamb	Goat	Kid
Holstein	20 (15-30)	20 (12-25)	25 (15-30)	15 (10-20)	10 (10-20)	10 (6-20)	10 (10-20)	10 (5-15)
Cross	15 (12-25)	15 (13-20)	20 (13-25)	10 (8-20)				
Local	10 (7-17)	10 (7-15)	15 (10-20)	10 (5-15)				

* The data in parenthesis state Inter Quartile Ranges.

General opinion of the experts shows that decreases in LWG are between 15-25% in exotic cattle, 10-20% in cross breed cattle, 10-15 in local cattle and 10% in small ruminants.

The results of DEOS related to Information required to estimate FMD related expenditure for disease control

Number of FMD outbreaks in Turkey in 1999

The statistics published by General Directorate of Disease Protection and Control of Ministry of Agriculture related to number of FMD outbreak in Turkey have frequently been criticized for not being reliable (Adıbeş et al., 1998). For this purpose, the experts were asked if the statistics depict actual field condition in Turkey, if not, how much the actual figure of FMD outbreaks was differ from the officially reported statistics.

The median and IQR values for this figure were calculated to be 30% and 12-50% respectively.

Morbidity of FMD in Turkey

The results of DEOS on the morbidity rate of FMD at the infected herds are presented in Table 9.

Table 9. The results of DEOS on the morbidity rate of FMD at the infected herds

Regions	Dairy cattle (%)			Beef cattle (%)			Sheep (%)	Goat (%)
	Holstein	Cross	Local	Holstein	Cross	Local		
High livestock density	70 (25-85)*	70 (20-80)	50 (15-70)	70 (25-80)	60 (25-80)	50 (15-70)	50 (15-75)	30 (10-55)
Low livestock density	40 (15-60)	30 (10-60)	25 (5-40)	50 (20-70)	40 (20-60)	30 (10-40)	20 (10-50)	15 (5-40)

* The data in parenthesis state Inter Quartile Ranges.

As expected, morbidity rate of FMD infection is higher in High Livestock Density Regions (changes between 30% and 70% depending on animal species and breeds) compared to that of Low Livestock Density Regions (changes between 15% and 50% depending on animal species and breeds). On the other hand, morbidity rate amongst Holstein and cross bread cattle was higher than that of local bread cattle. The lowest morbidity rate was stated for goat.

Magnitude of expenditure for FMD outbreak management

The median and IQR values of the expert survey on the relative magnitude of FMD outbreak management costs compared to cost of vaccine are presented Table 10.

Table 10. The results of DEOS on the relative magnitude of FMD outbreak management costs compared to cost of vaccine (cost of vaccine=1)

Cost Items	Regions	
	High livestock density	High livestock density
Cost of vaccination and disinfection **	4 (3-10)*	5 (3-8)
Other costs***	3 (2-5)	4 (2-7)

* The data in parenthesis state Inter Quartile Ranges.
** Includes cost of stocking vaccine, personnel (vet, vet technician and driver), travel, disinfectant.
*** Includes disease surveillance, diagnosis, quarantine and other overhead costs.

As seen from the table, "cost of vaccination & disinfection" and "other costs" in high livestock density regions were stated 4 and 3 time higher than cost of vaccine respectively. On the other hand, these costs were 5 and 4 times higher than cost of vaccine respectively in low livestock density regions.

Magnitude of expenditure for annual FMD vaccination programmes in Turkey

Similarly, DEOS results on relative magnitude of the cost of FMD control compared to cost of vaccine in routine disease prevention activities, are presented in Table 11.

Table 11. The results of DEOS on the relative magnitude of cost of FMD control compared to cost of vaccine (cost of vaccine=1)

Cost items	Regions	
	High livestock density	High livestock density
Cost of vaccination and disinfection **	3 (2-5)*	3 (2-5)
Other costs***	2 (1-3)	2 (1-3)

* The data in parenthesis state Inter Quartile Ranges.
** Includes cost of stocking vaccine, personnel (vet, vet technician and driver), travel, disinfectant.
*** Includes disease surveillance, diagnosis, quarantine and other overhead costs.

As can be seen from the table, "cost of vaccination & disinfection" and "other costs" were stated to be 3 and 2 time higher than cost of vaccine both in high and low livestock density regions respectively.

4. DISCUSSION

FMD related production losses

The literature related to impact of FMD on production and productivity of livestock is limited. Because, majority of studies on the economics of FMD have been carried out in developed nations where all susceptible animals in outbreak zone are slaughtered. Therefore, it is impossible to observe the disease effects on production and productivity of infected animals in the field conditions of these countries. On the other hand, in countries where the disease is endemic, research efforts have mainly been focussed on the aetiology and epidemiology of FMD and technical aspects of FMD control.

This section, therefore, is focussed on the evaluations of the research findings, and comparison of the research finding with the limited number of literature. It is worth to mention in advance that many factors (such as type of infection, environmental factors, characteristics of farming systems in different countries and regions, combating effort for FMD etc) affects the FMD induced losses and morbidity and epidemiology of infection. Without considering these factors, proximity of the published figures in the literature could not depict their reliability.

Mortality rates due to FMD infection

The median values of increase in the mortality rate due to FMD in this study were 1-5% in adult cattle, 5-20% in young cattle, 2% in sheep and goat and 10-15% in lamb and kid.

Adıbeş et al. (1998) reported FMD related mortality rate in Holstein cows as 6 per cent in Turkey. Whereas, no FMD related mortality was reported for cross and local breed cows in their study. The figures reported for Holstein, cross and local breed calves, lambs and kids were 47.1%, 16.7%, 9.5%, 9.7% and 13.3% respectively. These figures are in the same line with the median values of the delphi survey except that for Holstein cow.

Zog (1992) assumed the FMD induced mortality rate as 1-5% depending on breeds, which was supported by the findings of the Delphi Survey.

On the other hand Brownlie (2001) reported the rate as 2% in mature cattle and 60-90% in calves in the UK. The latter is notably higher than that reported by the studies conducted in Turkey. Lower mortality rate due to FMD in young cattle in Turkey than that in developed countries would be explained by several factors: Firstly, the disease is endemic in Turkey, therefore, calves would have better resistance to FMD infection thanks to material antibodies. Secondly, Turkey conducts annual FMD vaccination programme which has not been permitted in majority of the developed countries in recent years.

Milk yield depression due to FMD infection

Nazlıoglu and Orun (1980) studied on milk yields of different species and breeds of livestock before and after FMD infection in Turkey. They observed %20-44 milk yield loss in cow, and % 19.6 losses in sheep. Adıbeş et al. (1998) reported FMD induced milk yield depression in Holstein, cross and local breed cows as 37%, 17% and 5% respectively. Tufan (1993) reported on average 19% milk yield loss due to FMD in Turkey, but he did not differentiate the losses in breed basis. Power and Harris (1973) stated 25% depression in the lactation yield of Holstein cows in the UK. Neither of these studies differentiates the milk yield loss according to reversible and irreversible effect of the infection. However, estimated milk yield loss due to FMD in this research is in fair agreements with those reported by the literature except that for local breed cow reported in Adıbeş et al. (1998).

Increase in abort rate due to FMD infection

Adıbeş et al. (1998) reported FMD related abort rate 28.8% in Holstein cow and 4% in cross breed cows and 0% in Holstein and cross breed heifers. The figure reported for cross breed cows is similar to that of general opinions of experts (5%), but that for Holstein cow is too high compared to that of expert opinions (10%). On the other hand, the reported abort rates for dairy heifers seem to be unreliably low in above mentioned study. It should, however, be noted that the rate calculated from the observations of few number of animals (only 8 heifers).

On the other hand, Zog (1992) assumed these figure between 4-10% according to his communication with experts, of which our study findings agrees with.

Delay in “age at first calving” and “calving interval due to FMD infection

Zog (1992) stated delay in “age of first calving” and “calving interval” as 2 months and 1-3 months respectively. General trend of the expert opinion in our study agrees with these finding of the above mentioned study.

Live-weight loss due to FMD infection

Nazlıoglu and Orun (1980) and Adıbes et al.(1998) reported live-weight loss due to FMD infection 6.2% and between 10-27 % in Turkey respectively. On the other hand, Power and Harris (1973) reported live-weight loss due to FMD infection as 12.5% in the United Kingdom, and Kazimi and Shah (1980) observed on average 26.1 kg body weight loss (about 15% loss) in local cattle in Pakistan. The median value of expert opinion (15-25%) in this study is within the range of the above published figures.

FMD control during outbreaks

Number of reported outbreaks

Adıbeş et al. (1998) argued that FMD is under-reported in Turkey and in real incidence of outbreaks could be 2 or 3 times greater than the officially reported figures. The stated figures of our experts were much lower (the median value was 30% and IQR were between 12-50%). We did expect much higher figure. However, the majority of the expert hesitated to answer this question since they were civil servant. These attitudes suspected us of the reliability of the data. Since such information has great impact on the results of economic analysis of FMD at national scale, more reliable data and/or sensitivity analysis is needed when it used in economic analysis.

Morbidity rate

The experts were asked about FMD induced morbidity rate for different livestock species and breeds both in low and high livestock density regions. Previous studies reported the morbidity rate did not differentiate the rate according to livestock density. The comparison is, therefore, made on average morbidity rate for cattle and small ruminants. The average mortality rate was 49% in cattle and 32% in small ruminants in this study.

Adıbes et al.(1998) reported the morbidity rate for Exotic cattle as 60-90%, for cross breed as 70-83% and for local breed cattle as 52-68% and local breed sheep as 50-100% in ten provinces in Turkey. The figures reported for cattle are in the same line with the results reported in our study, whereas, the figure for sheep is much higher than that of our study. However, it should be noted that the figures for sheep in the study of Adibes et al. (1998) obtained from only 3 sheep farms.

Tufan (1993), reported the average mortality rate in cattle and small ruminants in 3 difference provinces (Van, Konya and Denizli) in Turkey as 52.8% and 54.4% respectively.

The lower mortality rate reported in this research would be due to the contribution of two different reasons. Firstly, the question was asked to all experts. But some of them worked in area where small ruminant population was too small, therefore, their expertise on this question would be questionable. Secondly, latent infections are often observed in small ruminants.

CONCLUSION

This study depicted that information required for economic analysis of FMD induced losses and cost of control activities which were either unavailable or unreliable can be obtained via Delphi expert opinion survey. Majority of the answers obtained from the experts were as expected. But, It was the first time the Delphi Survey Technique used to obtain information about contagious disease in Turkey. Therefore, the experts were not familiar enough to answer all questions easily. They were eager to answer all questions except that on "their opinion on actual number of disease outbreak" since they all work as a civil servant. Except this question we do not suspect the reliability of the data generated in this survey. However, accuracy of information from Delphi expert opinion survey may be improved if "level of expertise" is stated by experts for each question so that a researcher can distinguish the answers according to level of expertise.

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