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Economic analysis of foot-and-mouth disease in Turkey- II: An assessment of financial losses in infected animals and cost of disease at national level

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ABSTRACT

This research paper, the second of this study series, aimed at estimating cost of FMD in Turkey in 1999, considering financial values of FMD induced production losses in different livestock species and breed in Turkish field conditions, and expenditures for FMD outbreak management and annual vaccination programs, estimated by using data from Delphi Expert Opinion Survey.

The average financial losses per infected animal were estimated to be US$294 for milking cow, US$152 for dairy heifer, US$197 for beef cattle, US$69 for sheep and US$64 for goat. However, the amount of the financial losses were considerably varied amongst the animals depending on species, breeds, age and sex.

The overall cost of FMD in 1999 was estimated to be US$51.3 million of which financial losses, disease control expenditures at the outbreaks and rutin disease prevention expenditures accounted for %33.6, %2,6 and %63,8 respectively.

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

INTRODUCTION

Contagious animal disease results in severe financial and economic losses both at a farm level and a national scale. On the other hand, disease control/eradication activities require allocation of substantial amount of national resources. For this reason, needs for economic analysis of disease induced financial/economic losses and cost and benefits of alternative disease control/eradication strategies have frequently been emphasized (Howe, 1985; Sakarya, 1991).

In order to carry out an economic analysis to optimize resource allocation decisions for animal disease control; first of all financial/economics losses due to disease needs to be estimated. Then, cost-benefit analyses of each alternative disease control options needs to be carried out.

It is clear from the forgoing paragraph that it is not possible to carry cost benefit analysis of alternative disease control options without having information on disease induced financial/economic losses. The latter is also dependent upon availability of reliable data required for economic analysis of the disease induced losses. However, majority of the required data particularly related to production losses due to infection was not available in the currently maintained database in Turkey. Therefore, previous studies investigated the cost and benefit of contagious animal diseases obtained most of the required data from published literature (Zog, 1992) and their guestimates, which undermined the reliability of model estimates to be used as a decision support tool.

Nazlıoglu (1967) and Nazlıoglu and Orun (1969) estimated FMD induced production losses during FMD infection (duration of infection assumed to be 20 days both in cow and sheep) by comparing past yield records of few number of livestock before and after FMD infection in several state livestock farms.

Abıbes 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.

As an alternative to field observations, eleciting information from expert opinions have been getting popular in studies related to technical and economic aspect of livestock diseases recently (Horst et al.,1998; Fels-Klerx et al, 200; Bennett and IJpelaar, 2003).

From this point of view, in the first of this study series, Delphi Expert Opinion Survey (DEOS) was conducted in order to obtain information required for economic analysis of FMD induced losses and cost of control activities which were either unavailable or unreliable in Turkey.

In the second of this study series aimed at estimating cost of FMD in Turkey in 1999, including financial values of FMD induced production losses in different livestock species and breed in Turkish field conditions and expenditures for FMD outbreak management and annual vaccination programs, with the ait of information retrieved from the DEOS survey.

MATERIALS AND METHOD

The materials of this study include primary data collected via DEOS together with secondary statistics from General Directorate of Protection and Control of Ministry of Agriculture, State Statistical Institute, State Planning Organisation, Turkish Cattle Breeding Associations, Livestock Boards and related literature.

Procedures Followed During Calculations of FMD Induced Losses

In order to calculate FMD induced financial losses, firstly FMD related loss components for each species and each breed within particular animal species were determined. Secondly, the availability of data was explored in the current databases. The data either unavailable and those available but considered to be unreliable were collected via DEOS.

FMD induced losses were estimated separately for cattle in different sex (female and male), age (e.g. calf, heifers and mature cattle) and breed (Holstein, cross and local). The estimation did not made for buffalos; Angora goat and exotic sheep breed since their population in Turkey were negligible. The FMD related losses were estimated for each age and sex groups of sheep and goat as well.

The probabilities of survival, culling and death were considered in the loss estimation. The detail of loss components considered in the estimation are given in Tables 1 and 2

Table 1. The financial loss components considered in the calculation of FMD induced production losses in cattle

Species	If stayed in a herd after FMD Infection	If culled\slaughtered due to FMD Infection	If died after FMD Infection
Dairy cow	• Milk yield losses • Loss due to extended CI*	• Loss due to premature culling • Loss due to abortion	• Loss due to mortality • Loss due to abortion
Dairy heifer	• Loss due to delay in AFC**	• Loss due to premature culling • Loss due to abortion	• Loss due to mortality • Loss due to abortion
Female calf	• Loss due to delay in AFC**	• Loss due to premature culling	• Loss due to mortality
Beef cattle and male calf	• Decrease in live-weight gain	• Loss due to premature culling • Loss in expected profit	• Value of death animal • Loss in expected profit

*CI= Calving Interval; **AFC=Age at first calving

Table 2. The financial loss components considered in the calculation of FMD induced production losses in small ruminants

Species	If stayed in the herd after FMD Infection	If culled due to FMD Infection	If died after FMD Infection
Ewe and female goat	• Milk yield losses • Loss due to abortion • Decrease in live-weight gain	• Loss due to premature culling • Loss due to abortion	• Loss due to mortality • Loss due to abortion
Male and female hog*	• All infected animals were assumed to be culled	• Loss due to premature culling	• Loss due to mortality •
Female and male lamb and kid	• All infected animals were assumed to be culled	• Loss due to premature culling • Loss in expected profit	• Loss due to mortality • Loss in expected profit

* lamb about 12-18 month-old

Calculation of milk yield losses in infected animals: The probabilities of cows' being in lactation period and irreversible udder damage after the infection were taken into account when estimating milk yield loss in infected cows. Saving in feed consumption as a result of milk yield reduction was also considered. Since, milk production is seasonal in small ruminants; probabilities that the infection is occurred in different seasons were taken into consideration as well.

Calculation of fertility losses in infected animals: As oestrus is not seasonal in cattle, if cows stay in a herd after infection, 'extended calving interval due to FMD (CI)' rather than 'increase in abortion rate' was used as a loss component, Extended CI considered probabilities of being pregnant at time of infection and occurrence of aborts during and after infection. Number of days delay in the CI as a result of infection was obtained from DEOS. This figures than multiplied by the cost of 1-day delay in CI. The latter was obtained from the study of Yalcin (2000). Estimates of 'losses due to increased abortion rate' took accounted of probabilities that animals' being pregnant, and for small ruminants seasons in which infection occurred. In the estimation, abortion assumed to happen at the middle of pregnancy. Both loss components include losses of income in calf sales, milk sales and cost of extra feeding.

Similarly, 'loss from delay in age at first calving (AFC) due to FMD' was estimated by multiplying average number of days delay in age at first calving obtained from DEOS with cost of 1-day delay in AFC obtained from the study of Yalcin (2000).

Calculation of losses due to premature culling: The financial value of increased culling rate due to the infection was calculated as the difference between market price of healthy and reformed cows.

Calculation of live-weight losses:

FMD related live-weight loss in beef cattle and male lamb was calculated by considering average body-weight at the time of infection and, FMD related body-weight losses. Information on FMD caused percentage loss in live-weigh in small ruminants was obtained from the DEOS.

Calculation of loss in expected profit:

It was assumed that when infected fattening cattle, male calves and young small ruminants (lamb and kid) was culled or died, new animals for fattening were not purchased. In order to consider financial losses due to an idle capacity in the production factors 'losses in expected profit' was calculated. In doing this, a daily profit margin was calculated. Occurrence of infection was assumed to be at the middle of fattening period, since such information was not available.

Calculation of national level losses from FMD and cost of the disease

Financial value of farm level losses due to FMD at national scale were estimated by considering the above calculated financial losses due to FMD in infected animals, together with the estimated number of FMD outbreaks (the officially reported number of FMD outbreaks were revised according to DEOS) For this purpose, diameter of outbreak area was considered to be 10km, and number of FMD susceptible livestock population in outbreak area in different regions in Turkey were obtained from 1999 livestock census[1] of State Statistical Institute.

The below stated formula was used in the calculation of FMD induced losses at national scale in Turkey.

$$\sum(O_i D P M_j L),$$

Where;

O_i : Number of FMD outbreak occurred in each province of Turkey (i=1.....76)
D : Diameter of outbreak area ($10km^2$)
P : Population of FMD susceptible livestock in 1 square km
A_i : Probability of susceptible animals being infected in different livestock density regions (j=1,2)
L : FMD induced financial losses in infected animals of different species and breeds

Lastly, cost of outbreak control and annual vaccination programmes in Turkey in 1999 were estimated. For this, information obtain from DEOS on the relative magnitude of "cost of vaccination and disinfection" and "other costs" compared to cost of vaccine (cost of vaccine=1) during outbreak management and annual vaccination programme was used. Details of the calculations is presented in 3.

"cost of vaccination and disinfection" included expenditures for stocking vaccine, personnel (vet, vet technician and driver), travel and disinfectants used. Other cost included expenditures on disease surveillance, diagnosis, quarantine and other overhead costs.

Table 3. Details of calculations of Cost of FMD in Turkey in 1999.

Cost components of FMD	**Explanations**
1. National level financial losses	See the formula in the text.
2. Estimated public expenditure for FMD outbreak in 1999	**a+b+c**
a) Cost of vaccine	Price for 1 dose * number of vaccine doses used
Number of vaccine used in cattle	Number of outbreaks* diameter of outbreak area*number of susceptible cattle
Number of vaccine used in small ruminants	number of outbreaks* diameter of outbreak area*number of susceptible cattle
Price of one dose of FMD vaccine (cattle)	$ 0,59 /dose
Price of one dose of FMD vaccine (small ruminants)	$ 0,21/dose
b) Cost of vaccination and disinfections	Obtained from DEOS
c) Other costs	Obtained from DEOS
3. Estimated expenditure for annual FMD vaccination	**a+b+c**
a) Cost of vaccine	Price for 1 dose * number of vaccine doses used
Number of vaccine used in cattle	Taken from official reports
Number of vaccine used in small ruminants	Taken from official reports
b) Cost of vaccination and disinfections	Obtained from DEOS
c) Other costs	Obtained from DEOS
Total cost of FMD in Turkey in 1999*	**1+2+3**

[1] It was the latest published statistics at the time when the research was carried out.

The estimated cost of FMD in Turkey in 1999 included FMD induced losses at national scale, outbreak management costs and cost of annual FMD vaccination programmes.

In all calculations current prices in 2003 in Turkish markets were used.

RESULTS

The estimated FMD induced financial losses in livestock of different species and breeds in Turkey are presented in Tables 4 to 11.

Estimated FMD related financial losses in dairy cow

Estimated FMD related financial losses in dairy cow of different breeds in Turkey are presented in Table 4.

Table 4. Estimated FMD related financial losses in dairy cow (US$/infected cow)

	Holstein		**Cross**		**Local**	
	US$	**%**	**US$**	**%**	**US$**	%
I-If stayed in the herd after FMD Infection	**467,8**	**23,6**	**290,1**	**18,6**	**76,3**	**9,4**
1.1. Milk yield losses	266,3	56,9	165,6	57,1	46,5	60,9
1.2. Losses due to extended Calving Interval	201,4	43,1	124,5	42,9	29,9	39,1
II-If culled\slaughtered due to FMD infection	**395,9**	**20,0**	**331,0**	**21,2**	**192,6**	**23,6**
1.1. Losses due to premature culling	387,3	97,8	327,4	98,9	190,9	99,1
1.2. Losses due to abortion	8,6	2,2	3,6	1,1	1,7	0,9
III-If died after FMD infection	**1.115,2**	**56,4**	**938,9**	**60,2**	**547,1**	**67,0**
1.1. losses due to mortality	1.106,6	99,2	935,3	99,6	545,5	99,7
1.2. Losses due to abortion	8,6	0,8	3,6	0,4	1,7	0,3
Weighted average total financial losses*	**493,0**	**100,0**	**306,0**	**100,0**	**85,7**	**100,0**

1$=1.43 Turkish Lira Weighted by probability of occurrence of each of three states of animals after the infection Table 4 depicts that, the FMD related financial losses in dairy cow vary between $86 to $493 according to breeds. Compared to the losses in local breeds, those in cross and exotic and breed cows were estimated to be 3 and 5 times higher, respectively. As the details of the loss estimates are examined, it is noticed that the most important loss component was the losses due to mortality (56 to 67% of the total losses depending on breeds). In Holstein cows, the losses were lowest if infected cows reformed (20%), and in local and cross breeds the lowest loss were estimated for animals stayed in a herd after infection (9-18%). Other notable findings in the table is that although the losses due to aborts did have minor impact in the total loss when cows were either died or reformed after infection, delay in calving intervals which accounted for losses due to abortion had a significant contribution in the total losses (39-43%) if cows stayed in herds after infection.

Estimated FMD related financial losses in dairy heifer

Estimated FMD related financial losses in dairy heifer of different breeds in Turkey are presented in Table 5.

The weighted average total losses in infected heifers were estimated to be about half of those in infected cows. Similar to those in cows, the FMD related financial losses in cross and exotic breed heifers were estimated to be approximately 3 and 5 fold higher respectively than that of local breed heifers. Losses occurred when heifers died due to the infection accounted for majority of the total losses (between 65-71% of the total losses depending on the breeds). Another notable finding in the table is that, FMD induced losses in a Holstein heifer in the case of staying in a herd was much higher compared to those of local and cross breeds.

Table 5. Estimated FMD related financial losses in dairy heifer (US$/infected heifer)

	Holstein		Cross		Local	
	US$	**%**	**US$**	**%**	**US$**	**%**
I-If stayed in the herd after FMD infection	**206,9**	**12,1**	**95,8**	**7,0**	**29,9**	**3,9**
Losses due to delay in Age at First Calving	206,9		95,8		29,9	
II-If culled\slaughtered due to FMD infection	**392,9**	**23,0**	**330,3**	**24,2**	**192,3**	**25,0**
1.1. Losses due to premature culling	387,3	98,6	327,4	99,1	190,9	99,3
1.2. Losses due to abortion	5,6	1,4	2,9	0,9	1,4	0,7
III-If died after FMD infection	**1.112,2**	**65,0**	**938,3**	**68,8**	**546,8**	**71,1**
1.1. losses due to mortality	1.106,6	99,5	935,3	99,7	545,5	99,7
1.2. Losses due to abortion	5,6	0,5	2,9	0,3	1,4	0,3
Weighted average total financial losses*	**270,7**		**137,5**		**48,3**	

* Weighted by probability of occurrence of each of three states of animals after the infection

Estimated FMD related financial losses in dairy calves

Estimated FMD related financial losses in dairy calves of different breeds in Turkey are presented in Table 6.

Table 6. Estimated FMD related financial losses in dairy calves (US$/infected dairy calf)

	Holstein		Cross		Local	
	US$	**%**	**US$**	**%**	**US$**	**%**
I-If stayed in the herd after FMD Infection	**223,5**	**31,3**	**119,7**	**23,7**	**38,3**	**13,1**
Losses due to delay in Age at First Calving	223,5		119,7		38,3	
II-If culled\slaughtered due to FMD Infection	**113,3**	**15,9**	**88,7**	**17,6**	**58,7**	**20,1**
1.1. Losses due to premature culling	113,3		88,7		58,7	
III-If died after FMD Infection	**377,6**	**52,9**	**295,8**	**58,7**	**195,8**	**66,9**
Weighted average total financial losses*	**243,3**		**143,0**		**55,1**	

* Weighted by probability of occurrence of each of three states of animals after the infection

As seen from the table, the weighted average FMD related financial losses, and contributions of different states of animals after infection in dairy calves were estimated to be similar to those in heifers.

Estimated FMD related financial losses in beef cattle and male calves

Estimated FMD related financial losses in beef cattle and male calves of different breeds in Turkey are presented in Tables 7 and 8.

Table 7. Estimated FMD related financial losses in beef cattle (US$/infected beef cattle)

	Holstein		Cross		Local	
	US$	**%**	**US$**	**%**	**US$**	**%**
I-If stayed in the herd after FMD infection	**242**	**16,7**	**194**	**13,2**	**72**	**10,2**
Decrease in live-weight gain	242		194		72	
If Emergency slaughtered due to FMD infection	**216**	**14,9**	**249**	**17,0**	**126**	**17,8**
1.1. Losses due to premature culling	194	89,5	194	77,9	95	76,0
1.2. Losses in expected profit	23	10,5	55	22,1	30	24,0
III-If died after FMD infection	**991**	**68,4**	**1023**	**69,8**	**507**	**72,0**
1.1. losses due to mortality	968	97,7	968	94,6	477	94,0
1.2. Losses in expected profit	23	2,4	55	5,4	30	6,3
Weighted average total financial losses*	**261**		**216**		**79**	

* Weighted by probability of occurrence of each of three states of animals after the infection

As can be seen from the table, estimated weighted average FMD induced losses in cross and exotic breed cattle were about 3 times higher than that in local cattle. Similar to those for cow

and heifer, losses from death of infected cattle had a major contributor to the weighted average loss (between 68-72% of weighted average loss depending on breeds). Another finding need to be mentioned is that losses in expected profit was negligible particularly in Holstein compared to other loss components.

Table 8. Estimated FMD related financial losses in male calves (US$/infected male calf)

	Holstein		Cross		Local	
	US$	%	US$	%	US$	%
I-If stayed in the herd after FMD infection	**16,4**	**5,2**	**10,4**	**2,9**	**9,5**	**3,2**
Decrease in Live-weigh gain	16,4		10,4		9,5	
If Emergency slaughtered due to FMD infection	**61,7**	**19,6**	**92,8**	**25,7**	**66,2**	**22,3**
1.1. Losses due to premature culling	43,6	70,8	41,5	44,7	38,7	58,5
1.2. Losses in expected profit	18,0	29,2	51,4	55,3	27,5	41,5
III-If died after FMD infection	**236,2**	**75,2**	**258,7**	**71,5**	**221,1**	**74,5**
1.1. losses due to mortality	218,2	92,4	207,3	80,1	193,6	87,6
1.2. Losses in expected profit	18,0	7,6	51,4	19,9	27,5	12,4
Weighted average total financial losses*	**62,6**		**41,8**		**23,0**	

* Weighted by probability of occurrence of each of three states of animals after the infection

In terms of the relationships amongst cost components, findings in male calf was similar to those estimated for fattening cattle. However, the estimated FMD related losses were 4 to 6 time lower in male lambs than those in mature fattening cattle.

Estimated FMD related financial losses in mature small ruminants

Estimated FMD related financial losses in mature sheep and goats in Turkey are presented in Table 9.

Table 9. Estimated FMD related losses in mature small ruminants (US$/infected animal)

	Sheep		Goat	
	US$	%	US$	%
1. If stayed in the herd after FMD infection	**65,7**	**20,1**	**61,8**	**23,9**
Milk yield losses	4,5	6,8	0,8	1,3
Loss due to abortion	48,6	73,9	54,2	87,7
Decrease in live-weight gain.	12,6	19,2	6,8	11,0
2. If emergency slaughtered due to the infection	**86,4**	**26,4**	**74,6**	**28,8**
Loss due to premature culling	37,9	43,8	20,5	27,4
Loss due to abortion	48,6	56,2	54,2	72,6
3. If died after FMD infection	**174,8**	**53,5**	**122,4**	**47,3**
Loss due to mortality	126,2	72,2	68,2	55,7
Loss due to abortion	48,6	27,8	54,2	44,3
Weighted average total losses*	**68,9**		**63,5**	

* Weighted by probability of occurrence of each of three states of animals after the infection

The tables depicts that, the estimated financial value of FMD induced losses in mature small ruminants were close to that in local breed cows. On the other hand, the value of the losses in goats was estimated to be about 9% lower than that in sheep. Other findings to be noted are that: 1) costs due to aborts and mortality were the most important cost components in mature small ruminants, 2) value of milk yield, live-weight losses and cost of mortality in infected goats were much lower than those in infected sheep, and 3) value of milk yield losses was negligible particularly in goat.

Estimated FMD related financial losses in young small ruminants

Estimated FMD related financial losses in young small ruminants in Turkey are presented in Tables 10 and 11.

Table 10. Estimated FMD related financial losses in hogs (US$/infected animal)

	$/per infected hog	**%**
1. If emergency slaughtered due to the infection	34,7	23,1
2. If died after FMD infection	115,7	76,9
Weighted average total losses*	**37,2**	

* Weighted by probability of occurrence of each of three states of animals after the infection

Table 11. Estimated FMD related financial losses in lambs and kids (US$/infected animal)

	Lamb		**Kid**	
	US$	**%**	**US$**	%
1. If emergency slaughtered due to the Infection	**19,7**	**24,3**	**12,1**	**24,9**
Loss due to premature culling	17,8	90,3	10,5	86,5
Losses in expected profit	1,9	9,7	1,6	13,5
2. If died after FMD Infection	**61,3**	**75,7**	**36,6**	**75,1**
Loss due to mortality	59,4	96,9	35,0	95,5
Losses in expected profit	1,9	3,1	1,6	4,7
Weighted average total losses*	**26,0**		**14,6**	

* Weighted by probability of occurrence of each of three states of animals after the infection

As seen from the tables, the values of losses due to death of infected young small ruminants accounted for about between ¾ of the average weighted total losses. Although magnitude of FMD induced losses in kids were half of that in lambs, there were not notable differences in terms of proportion of cost components in the total costs between lambs and kids.

FMD related farm level financial losses at national scale

Estimated FMD induced financial losses at national level and their distributions to different animal species are presented in Tables 12.

Table 12. Estimated FMD induced losses in different animal species in Turkey in 1999.

Animal Species	**Financial value ($)**	**%**
Cattle (overall)	11.500.044	66,7
Cattle (Holstein)	4.907.424	28,4
Cattle (cross)	5.597.100	32,4
Cattle (local)	995.520	5,8
Sheep (overall)	5.064.523	29,4
Goat (overall)	686.509	4,0
Total	**17.251.075**	**100,0**

As seen from the table that, total losses caused by FMD in Turkey in 1999 was estimated to be about US $17.3 of which the losses occurred in cattle, sheep and goat accounted for 67%, 29% and 4% respectively.

Cost of disease control activities at outbreak area and annual vaccination programme

Total cost of FMD in Turkey in 1999 was estimated to be US$51.3 million. The proportion of financial losses, expenditures for outbreak management and annual FMD vaccination programmes in the total cost of FMD accounted for 33.6%, 2.6% and 63.4% respectively. On the other hand, cost of vaccine accounted for only around 11% in the expenditures for both outbreak management and annual vaccination programmes (Table 13).

Table 13. Cost of FMD in Turkey in 1999.

Cost components of FMD	Value (US$)*	%
1. National Level Financial Losses	**$17.251.075**	**33,6**
2. Estimated public expenditure for 770 FMD outbreak in 1999	**$1.312.827**	**2,6**
a) Cost of vaccine	$145.870	11,1
b) Cost of vaccination and disinfections	$656.414	50,0
c) Other costs	$510.544	38,9
3. Estimated expenditure for annual FMD vaccination	**$ 32.720.890**	**63,8**
a) Cost of vaccine	$5.453.482	10,6
b) Cost of vaccination and disinfections	$16.360.445	31,9
c) Other costs	$10.906.963	21,3
Total cost of FMD in Turkey in 1999*	**$51.284.792**	**100,0**

*Financial values were calculated by using 2003 market prices in Turkey.

DISCUSSION

The estimated financial value of FMD induced losses in Holstein was rather high compared to local and cross breeds, because Holstein breed cattle is more susceptible to FMD, prognosis of the infection is more severe and milk production is higher.

On the other hand, the main reason why the estimated financial value of FMD induced losses in female calf was similar to dairy heifer is because FMD infection results in much higher mortality in calves (10-20%) compared to that in heifers (0.2 –0.5%).

The estimated financial value of FMD induced losses in mature small ruminants were close to that in local breed cows because probability of small ruminant being died due to infection (the highest cost occurred in the case of mortality) is twice higher than that of local cow, and the abortion rate due to infection in sheep 2.5 times higher than that of local breed cow.

The studies estimating FMD induced production losses and cost of the disease in wider economic perspective is limited in the literature, and almost lacking in Turkey. Ngategize and Kaneene (1985) argued the difficulties of carrying out economic studies on animal disease and disease control problems, and outlined the main reasons for this as follow:

- Disease are not always obvious and pronounced,
- They are influenced by other factors such as overall management (e.g. nutrition, housing), environment and others,
- often manifest themselves in an integrated complex with other diseases,
- The impacts of disease are complex and far-reaching even at farm level.

Because of these difficulties, it is not a simple task to measure the full economic impact of disease and hence that of alternative disease control options to the disease induced economic losses even at production level. Further to this, estimates at national level require much more complex economic analysis (McInerney et al., 1990).

So far, beside this research, there have been only 3 other studies attempted to estimate FMD induced production losses in Turkish field situations.

Nazlıoglu (1967) and Nazlıoglu and Orun (1969) estimated FMD induced production losses during FMD infection (duration of infection assumed to be 20 days both in cow and sheep) by comparing past yield records of few number of livestock before and after FMD infection in several state livestock farms. They estimated the annual cost of FMD in 1965 as US$43 million. However, the value of estimated FMD induced production loss was not reported in animal basis.

Zog (1992) developed a simulation model to estimate the FMD induced financial losses in Turkey, and costs and benefits of several alternative FMD control/eradication strategies. However, majority of the information, particularly related to production losses due to infection was his guestimates (optimistic and pessimistic expectations), as his main objective was to develop a computerised decision support model to estimate costs and benefits of alternative FMD control/eradication decisions. He reported the estimated cost of FMD (Including outbreak management and prevention expenditures) as US$56 million.

Abıbes 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. They reported the average FMD induced losses in infected dairy cow as US$200/head, in fattening cattle as US$250/head and sheep&goat as between US$15-25/head. They estimated the overall cost of FMD in nation basis as US$6-7million .

As seen from the forgoing paragraphs, some estimates are similar, whereas, considerable deviations can be observed in some other estimates amongst the studies. Proximity of the reported estimates can not be interpreted as they are reliable since there are considerable differences exist amongst these studies in terms of loss components considered and the way that they were estimated. Such methodology problems exist in majority of the studies related to economics of animal disease (Schepers and Dijkhuizen, 1991), and a well defined methodology is needed in this area.

In order to emphasise the importance of FMD in Turkish economy, FMD induced losses at national scale was attempted to estimate by considering number of outbreaks in 1999 and estimated morbidity of FMD together with losses at infected animals. The estimated FMD induced losses at national scale should, however, be interpreted with care, because;

1) Estimated cost of FMD at national scale were quite sensitive to number of reported outbreaks which was the least reliably obtained parameter in the DEOS. Since such information has great impact on the results of economic analyses of FMD at National Scale, more reliable data should be obtained on this parameter for more accurate estimates at national scale.

2) This research was restricted to estimating the impact of FMD on livestock farms and the public expenditure for combating the disease. However, measurements at the national level require much complex economic analyses. It requires estimating cost of disease not only to farmers and/or the public purse, but to the whole society including the entire food chain (producers, wholesalers, processing industry, retailers, consumers), disease implications for consumer demand, markets, trade (loss of export markets and/or export potential), human health, the health and well-being of pet/livestock, wildlife and other externalities (McInerney, 1996). Economic analysis at national level also requires social values and costs that are not captured by market prices if the prices in the market are distorted by government intervention, monopolistic/monopsonistic market structure or other reasons (McInerney, 1990; Bennett, 2003).

Estimation of disease induced losses is important, but not the sole information in management of contagious disease. To use such information as a decision support, it should be linked to available control eradication strategies, and how much of disease induced losses can be avoided under each control strategy should be estimated. Such an economic analysis requires development of simulation based computerised disease control decision support models which necessitate a team work of researchers from diverse discipline such as veterinary science, epidemiology, statistics, mathematics and computer sciences. Such disease management decision support models have been developed in many developed counties and successfully used in the management of contagious disease outbreaks. Developing such

disease control models for contagious animal disease in Turkey can be possible, providing required team and other infrastructure are established.

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