Sci. Technol. Arts Res. J., April-June 2023, 12(2), 13-26
DOI: https://doi.org/10.20372/star.v12i2.02
ISSN: 2226-7522 (Print) and 2305-3372 (Online)
Science, Technology and Arts Research Journal
Sci. Technol. Arts Res. J., April - June 2023, 12(2), 13-26
Journal Homepage: https://journals.wgu.edu.et

Original Research

Study on financial impact of clinical foot and mouth disease in three selected Districts of Western Ethiopia

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Abstract

Semi-structured questionnaires were administered to 135 households to investigate the financial impact of clinical Foot and Mouth Disease (FMD) and the benefit of control through vaccination. Clinical FMD occurrence in the study group showed that the annual cumulative incidence was estimated to be 38.7% (95% CI, 34.7–42.7%), cumulative mortality 3.2% (95% CI, 2.0–4.0), and case fatality 8.4% (95% CI, 6.9–9.9). The financial impact assessment revealed that the disease caused 6.12%, 11.6%, and 3.1% annual losses in milk production, draft power losses, and beef off-take reductions, respectively. On average, the financial losses due to clinical FMD incurred a total of 10,919.84 USD for the herd owners of the study group and 11.78 USD per head annually. The benefit-cost ratio of controlling FMD through vaccination was estimated to be 1.36, and the net benefit per head was 0.34 USD. In conclusion, FMD causes substantial financial losses to households. Hence, subsequent cross-checking of the viral serotype for an effective vaccination program and the voluntary, cost-shared participation of the herd owners in FMD vaccination would be beneficial for the farmers to sustain their production and livelihood.

Article Information

Article History:
Received: 08-04-2023
Revised: 26-05-2023
Accepted: 29-06-2023

Keywords:
Cattle, Beneshangul Gumz, Financial Impact, Foot And Mouth Disease, Western Ethiopia, West Wollega

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INTRODUCTION

The livelihood of about 600 million smallholder farmers in developing countries depends on livestock and livestock products (Lamy et al., 2012). In Ethiopia, livestock contributes 30–40% of agricultural growth domestic product (GDP), 16–20% of national GDP, and 14–16% of foreign currency earnings. However, out of the 51.83 million cattle population in Ethiopia, 7–10% of cattle die per year due to diseases, which implies significant economic loss (Gebreegziabhier, 2010).

Foot and mouth disease (FMD) is the most contagious transboundary viral disease affecting cloven-hoofed animals (FAO, 2007). The disease is caused by an aphthovirus of the family Picornaviridae, which occurs in seven major serotypes, namely A, O, C, and South African Territories named SAT1, SAT2, SAT3, and Asia1 (Radostits et al., 2008; MacLachlan & Dubovi, 2011). The disease has an indirect economic effect through trade restrictions on the export of animals and their products to the international market, which results in a vital loss of foreign earnings from exports (Murphy et al., 1999; Radostits et al., 2008; Barasa, 2008). The cost-benefit analyses of different countries showed that the economic impact of FMD due to a lack of access to international markets was tremendous; however, the awareness of individual farmers about the financial effects of FMD is not well organized (Forman et al., 2009).

In Ethiopia, studies have reported the occurrence of FMD and its associated risk factors for the spread of the viruses (Rufael et al., 2008; Megersa et al., 2009; Jenbere et al., 2011). In dairy herds, the introduction of FMD infection causes significant milk production loss for the duration of the lactation period, and mastitis usually results in a permanent loss of more than 25% of milk production per lactation. In beef cattle, it causes a reduced growth rate, death in calves up to 6 months of age, and abortion due to fever (MacLachlan & Dubovi, 2011). A study conducted in the Borana zone of Ethiopia showed that acute infection of FMD causes low daily milk yield for the duration of an average of 25.5 days, a long calving interval, heat intolerance in dry, hot weather, the inability to plow for one season in diseased oxen, and abortion of pregnant animals (Bayisa et al., 2011). During the year 2005/2006, an FMD outbreak occurrence in Egypt that was suspected to be from the Horn of Africa resulted in the ban of live animal exports from Ethiopia, which incurred a financial loss of 12.36 million USD, which amounted to 36% of the total market for the Middle East and North Africa (USAID, 2008).

The study areas, Western Wollega and Beneshangul Gumuz, are located in western Ethiopia, bordering Sudan, where cross-border animal movement is a common feature in the pastoral production system. FMD outbreaks were reported repeatedly from these study areas in the past few years. However, there was no study done on the epidemiological and economic impact of the disease in the western part of Ethiopia. Therefore, the objective of this study was to estimate the financial losses due to clinical FMD and to evaluate the benefit of control through vaccination.

MATERIALS AND METHODS

Description of Study Area

The study was conducted in two neighboring districts of western Wallega, Oromia, and one district from Beneshangul Gumuz Regional States. Begi district of western Wallega has a livestock population of 48,462 cattle, 8721 sheep, and 11,483 goats, whereas Gidami district has 47,512 cattle, 7448 sheep, and 4609 goats (CSA, 2011). Bambasi district of Beneshangul Gumuz has a livestock population of 38,830 cattle, 14,253 sheep, and 12,374 goats (CSA, 2011). Districts were selected based on the history of outbreak reports in the past three years. The livelihood of the society in the study area mainly depends on a mixed crop-livestock production system. Livestock production was an extensive production system. Cattle production plays a major role in the livelihood of the smallholders through the provision of milk for family consumption, income from milk, milk products, and live animals sold on the local market, draft power, beef sources during different festivals, and as a capital asset (Figure 1).

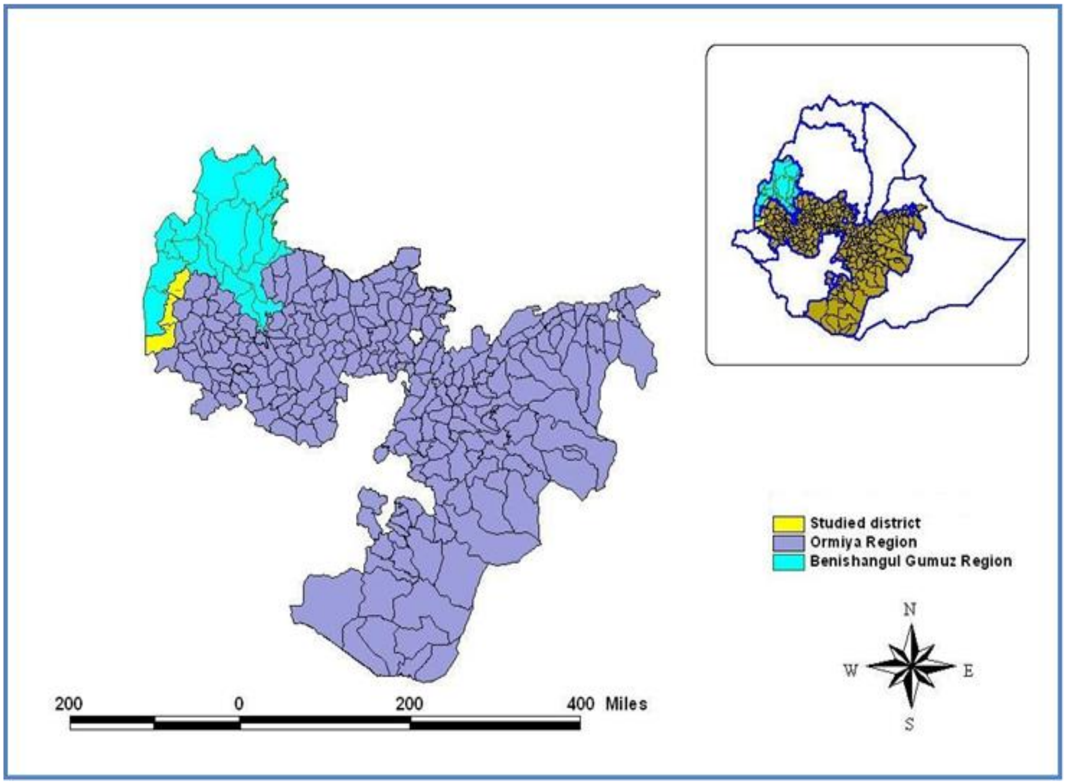

Figure 1. *Map of the study area*

Study Population

The cattle population in Begi, Gidami, and Bambasi districts was considered the target population. Herd owners who experienced the clinical FMD infection in their cattle were considered the study groups. In this study, cattle owned by households were considered a herd. The questionnaire interviews were collected from 135 households, which comprised a total of 927 cattle heads. The herd structure of the study group was composed of 360 draft power oxen, 233 dry cows, 118 lactating cows, 141 bulls or heifers, and 75 calves at the beginning of the FMD outbreak.

Data Collection Questionnaire

Questionnaires were developed at Jimma University College of Agriculture and Veterinary Medicine by the authors. It was pretested by interviewing focal groups like farmers, animal health assistants, and development agent workers in the Asosa district and Tongo special districts, which are neighboring the study districts, before undertaking the actual data collection. A questionnaire was administered to the households in face-to-face interviews by the authors. Veterinary personnel in each district kindly supported the study by facilitating the interview and translating the questionnaire into Bertha and Arabic in the Asosa zone and into Afan Oromo in districts found in Oromia Regional State.

Three to four peasant associations (the lowest administrative structure of the government) were selected in each district. Peasant associations were selected purposefully based on the occurrence of the FMD outbreak, and those herd owners who declared the occurrence of FMD in their herd were selected based on their willingness to participate in the study and their ability to differentiate the clinical signs of FMD from other foot and mouth lesions included in the study. However, those herd owners who did not experience FMD in their herd were dropped out of the interview (Andrews et al., 2004; Radostits *et al*., 2008). The veterinary officials' knowledge of the differential diagnosis for FMD like vesicular stomatitis, vesicular exanthema, foot rot, traumatic stomatitis, and some chemical and thermal burns that affect the digestive system and cause lameness in cattle was taken into consideration to validate the information obtained from the herd owners (CFSPH, 2007). From each peasant association, 12–15 households were selected for interviews, and 135 herd owners were selected who properly explained the clinical signs of the disease. Retrospective data from one year (March 2010–May 2011) was collected to estimate the annual losses due to clinical FMD.

The herd size, age, sex, and number of diseased and dead animals were recorded. Losses due to mortality, milk losses, draft power losses, beef offtake reduction, cost of treatment incurred due to the disease and opportunity labor costs of nursing the sick animals were considered in financial loss estimation (Rushton, 2009). Loss of manure and an increase in calving interval were not included in the estimation of financial losses. The current market price of cattle/heads, milk/lt, and draft power/day was collected from the monthly livestock market record data of the district agriculture and rural development office.

The treatment cost for secondary bacterial infection was obtained from the veterinary clinics, and the numbers of treated animals out of clinically sick cases were collected from herd owners (Table 1). The average milk production per day in the local breed under extensive production was 1.857 L, excluding the milk consumed by calf, and the average lactation period of six months was used to estimate the annual milk losses of lactating cows (CSA, 2011). The national annual beef off-take rate of 8% for cattle was used as baseline data to calculate the annual beef off-take reduction as a consequence of the FMD outbreak (MoARD, 2007).

Data Management and Analysis

The data was entered into an Excel spreadsheet. Descriptive statistics and percentages were computed in an Excel spreadsheet. A statistical package for social science (SPSS, 2007, version 16, USA) was used for the analysis. The annual cumulative incidence and cumulative mortality percentage of FMD during one year of the study period were estimated based on Thrusfield (2007). Case fatality was calculated as the number of dead animals due to FMD divided by the number of clinically sick animals (Thrusfield, 2007; Dohoo et al., 2009). In all cases, a 95% confidence interval with a 5% level of significance was used to reject the null hypothesis. The annual financial loss estimation took into account the losses incurred by the house in terms of monetary value. The model to calculate financial loss estimation was as follows: (Putt*et al*., 1998; Rushton, 2009).

$$C = M_d + (B + M + W_{op}) + O_c + C_t$$

Where, C=total financial losses; Md= losses due to mortality

B=Beef production losses due to off-take rate reduction; M=milk losses

Wop= draught power work output losses; Oc=Opportunistic costs

Ct= Treatment cost

The percentage of annual Production losses was calculated as the total annual production losses due to FMD divided by the total annual production without FMD;

$$Percentage\ of\ annual\ losses = \frac{(Total\ annual\ production\ losses\ due\ to\ FMD)}{Total\ annual\ production\ without\ FMD} \times 100$$

Milk and draught power losses were calculated for FMD-infected and survived animals, but milk of dead lactating cows and draught power losses of died oxen were not included to prevent double counting. The average annual loss of draught power was analyzed based on a previous study report indicating 60 working days for draught power per year in Ethiopia (Tegegne, 1998). Based on the current study result, the average draft power loss in days for sick oxen both during the active and less active cropping seasons was estimated at 15 days/head (Table 3). The annual draft power loss percentage was calculated from the average number of work output losses annually due to FMD divided by the total expected annual output in the study population. Thus, the total draft output loss in the study population was the product of the annual amount of draft power (in days) in the study group and the percentage of annual draft power losses due to FMD.

Percentage of annual draught power work output losses due to

$$FMD = \frac{(CI \times 15\ days)}{60\ days} \times 100$$

Where, CI= annual cumulative incidence

The annual percentage of Milk production losses were calculated from the average amount of milk production losses due to FMD divided by the total expected annual milk production in the lactating cows. The total milk production losses in the study population is the product of the total milk produced, the cumulative incidence of FMD in lactating cow, and the percentage of annual milk losses due to FMD. In this study, FMD could cause milk production losses for the duration of 26 days in the affected population (Table 3). Therefore:

$$Percentage\ of\ annual\ milk\ losses = \frac{(Number\ of\ diseased\ lactating\ cows \times 26 days)100}{Number\ of\ total\ lactating\ cows \times 180 days}$$

The percentage of annual beef off-take reduction was calculated as the annual off-take rate multiplied by cumulative incidence.

The beef off-take reduction assumed and took into account that those infected and survived animals would take a more prolonged duration to finish for beef off-take.

$$Percentage\ of\ annual\ beef\ off\ take\ reduction = (Annual\ beef\ off\ take\ rate \times CI)100$$

Where, CI=cumulative incidence

The opportunistic labor costs were calculated only for 120 owners who declared that they had brought their animals to a veterinary clinic. The study assumed 0.86USD/day for daily casual labor and the opportunity labor cost of the household for three nursing days was considered on conservative estimation.

$$Opportunistic\ labor\ costs = 0.86 \times Number\ of\ days\ (3days) \times 120$$

Where 0.86 USD = opportunistic labor cost/day;120= herd owners' who treated their animals at the veterinary clinic.

Production losses due to FMD in monitory value were estimated as the product of physical product losses multiplied by their value based on the current market price for draught power/ox per day, the weighted average price of live cattle, and the price of milk in liter during 2011/12 (Table 1) (Putt et al., 1998).

Table1

Current Market price of Items in the year 2011(USD)

Parameters	Minimum costs	Average costs	Maximum Cost
Average cattle value/head Age &sex			
Calves	20.79	32.99	45.89
Heifers	48.76	91.79	137.68
Bulls	48.76	109	172.11
Cow	143.42	189.32	229.47
Oxen	177.84	232.34	315.32
Average Value/heads	86.63	131.14	180.13
Draft power value ox/day	1.15	1.43	2.01
Milk price/ lt	0.46	0.5	0.57
Treatment cost/head	0.57	0.57	0.57
Labor opportunistic cost	0.86/day	1.15/day	1.43/day

Partial Budget Analysis

Partial budget analysis is a technique used to assess small changes in the farming system enterprise based on expected costs and benefit values (Rushton, 2009). It can be applied to an annual budget to guide short-term decisions. It compares the extra costs of introducing new technologies over time with the benefits due to a reduction in the direct losses of diseases and the cost saved as a result of the change in the control policy (Putt et al., 1998). In this study, a partial budget analysis of FMD control through vaccination was considered. FMD prevalence of 8.9% was reported in the cattle population conducted in the same areas of Begi, Bambasi, and Gidami districts (Beyene et al., 2015). Estimated losses of milk, drought power, and beef offtake reduction due to FMD in the affected study group were used in the partial budget analysis to calculate the benefit and cost of FMD control through vaccination.

A partial budget analysis of controlling FMD assumed that vaccination control of the disease would benefit the household by preventing milk losses, mortality, beef off-take reduction, and draft power work output losses. The cost of treatment could be saved by controlling the disease. The cattle population of the three districts was considered the population at risk, and a single FMD vaccination per year was taken into account. The experience of FMD vaccination in smallholder dairy farms in the peri-urban areas of big cities indicated that a single vaccination per year can protect animals from the clinical infection of FMD (DACA, 2006). During the study period, the market cost of the FMD vaccine in Ethiopia was 0.92 USD per head. Thus, the cost of the FMD vaccine was considered a new cost incurred by households, and vaccination services are considered a public good for transboundary diseases like FMD in Ethiopia.

$$New\ cost = Cost\ of\ vaccine$$

$$Cost\ of\ vaccine = \frac{(Population\ at\ risk \times Cost\ of\ FMD)}{Head}$$

New Revenue= Losses prevented in (milk off-take/lactation + draught power work output/year + beef off-take per year + mortality losses)

The parameter for FMD prevalence in the target population was obtained from previous data.

$$Saved\ cost = Treatment\ cost\ (population\ at\ risk \times prevalence\ of\ FMD \times \%\ FMD\ treated\ cases \times average\ cost\ of\ treatment/head$$

(Gari *et al*., 2011).

$$Net\ benefit = (Saved\ cost + New\ Revenue) - Cost\ of\ vacine$$

A standard econometric model was applied to assess the financial benefit and to indicate decision support values should one be necessary to invest. The benefit/cost ratio (BCR) was calculated and an investment is worth considering if the BCR is greater than 1 (Rushton, 2009).

RESULTS

The interview result showed that 88% of the herd owners declared that livestock diseases were the biggest constraints for livestock production, and subsequently, they prioritized the top three livestock diseases occurring in the area as trypanosomosis (locally named Gandi) at 100%, CBPP (Somba) at 100%, and FMD (kotte baqaqsa fi gororsa or Maz) at 80%. FMD has different names in the two regions: The local name around Bambasi was Maz, whereas in Western Wollega it is called Kote baqaqsa fi gororsa. In FMD-affected herds, the average time duration for milk loss was about 26 days per head in affected lactating cows and 15 days for draught power (Table 2).

Table 2

The major constraints of livestock production as declared by the herd-owners in West Wollega and parts of Beneshangul Gumuz

Variables	No of Respondent	Percentage of response
Common constraints of livestock production		
Feed shortage (dry season)	16	11.90%
Livestock disease	119	88.1% (n=119)
Top 5 livestock disease		
Trypsanosoma (gandi)	1st (n=135)	1st 100%
CBPP(somba)	2nd (n=135)	2nd 100%
FMD(kotte baqaqsa f gororsa or Maz)	3rd (n=108)	80%
LSD (xaxesa)	4th (n=108)	80%
Pasturellosis(gororsa)	5th (n=135)	100%
How did you rank FMD		
Sever	(n=118)	87.40%
Moderate	(n=17)	12.60%

Out of the draught power oxen, 49.17% (n=177) were claimed sick by FMD whereas 1.94 %(n=7) were declared dead. A total of 57 lactating cows, (48.3%) were claimed sick, out of which 7 lactating cows died. Milk losses were calculated for 50 cows that were diseased and survived FMD infection. The total death recorded in the study group was 30 animals (Table 3).

Table 3

Herd structure, number of sick, died, and effect of production due to FMD in selected districts in infected herds

Category	Number of examined	Number of apparent health	Number of diseased	Number of died	Average days of production effect
Lactating	118	61	57	7	26
Dry cow	233	172	61	8	
Draught	360	183	177	7	15
Bulls/Hei	141	103	38	2	-
Calves	75	48	27	6	-
Total	927	568	359	30	-

Estimated cumulative incidence and cumulative mortality of FMD in the study group were 38.7% (CI 95%= 36.21%-41.19%) and 3.2% (CI 95%= 2.99%-3.41%)

respectively (Table 5). Higher cumulative incidence of FMD was observed in adults 41% (n=294, 95% CI= 36.6-41.1) and calves 36% (n=27, 95% CI=22.4-49.6) than in bulls/heifers 27% (95% CI=36.6-41.1). Therefore, there was a statistically significant difference between age groups (P<0.05). The cumulative incidence and mortality of FMD occurrence in males and females was not statistically significant. The overall case fatality of FMD was 8.4% (95% CI =5-11) in the study group. Case fatality in calves 22.2% (95% CI =4-40) was significantly higher than in bulls/ heifers 5.3% (95% CI=0-13) and in adults 7.5% (95% CI=4-11) with (χ^2=7.26, P<0.05) (Table 4).

Table 4

Annual Cumulative Incidence, Cumulative Mortality and Case Fatality of FMD in three districts

Variable	Total	Cumulative Incidence	95% CI	$\chi2$	P-Value
Age				10.5	0.005
Calves	75	36	22.4-49.6		
Bulls/Heifers	141	27	18.4-35.5		
Adult	711	41	36.6-41.1		
Sex				3.2	0.072
Male	451	41.7	35.7-47.6		
Female	476	35.9	30.5-41.3		
Total	927	38.7	34.7-42.7		
Variable		Cumulative Mortality			
Age				7.7	0.021
Calves	75	8	1.6-14.4		
Bulls/Heifers	141	1.4	0-3.4		
Adult	711	3.1	1.8-4.4		
Sex				0.39	0.53
Male	451	2.7	1.0-4.0		
Female	476	3.8	2.0-6.0		
Total	927	3.2	2.0-4.0		
Variable		Case Fatality			
Age				7.26	0.026
Calves	27	22.2	16.4-28		
Bulls/Heifers	38	5.3	1.3-9.3		
Adult	294	7.5	5.9-9.1		
Sex				2	0.157
Male	188	6.4	4.5-8.3		
Female	171	10.5	8.3-12.7		
Total	359	8.4	6.9-9.9		

The annual financial loss estimation by the FMD outbreak caused 6.12% losses in milk production, 11.6% losses were caused by draught power, and 3.1% beef off-take reduction (Table 5).

Table 5

Physical production losses due to FMD in the study population (in USD)

Parameters	Losses	Average	Minimum	Maximum
Milk	1166.03	581.97	535.15	668.93
draught power	1231.92	2120.20	1766.83	2473.56
Beef off-take	29(3.1%)	3764.81	2487.91	5173.53
Treatment	124.573	107.20	71.47	143.00
Mortality	30(3.2%)	3,932.60	2598.79	5404.10
Opportunistic labor	360days	413.05	206.53	619.58
Total		10919.84	7666.67	14482.60
Loss per head		11.78	8.27	15.62
loss per household		80.89	56.79	107.28

The average monetary value of production loss due to FMD in the study group was estimated to be 10, 919.84USD which means that annual production loss per head was 11.78 USD and per household was 80.89 USD. Annual financial losses in the order of hierarchy indicated that; loss due to mortality was estimated to be 36.01%, due to a reduction in beef off-take rate 34.47%, draught power losses 19.41%, milk production loss 5.3%, opportunity labor cost 3.78% and 1% treatment costs in the order of descending (Table 5).

The sensitivity analysis of the financial cost estimation also showed that mortality loss was the most contributing variable to the model variability and could significantly affect the overall estimation. In the presence of an effective vaccine to control FMD through vaccination, the partial budget analysis showed that disease control through annual vaccination would benefit the households in the target population. The net benefit in the target population was 0.34 USD/ head of the animal with a benefit-cost ratio of 1.36 (Table 6).

Table 6

Financial benefit of FMD control through vaccination in three districts using partial budget analysis (In USD)

Parameter	Value (In USD)
I. New cost	
Vaccination cost	139,790.72
II New Revenue	
Draught power	21,409.62
Milk losses	23,169.89
Beef production	142,142.70
III Cost saved	
Treatment	4,047.28
IV Subtotal benefit (III+II)	190,769.48
Net benefit= IV-I	50,978.76
Net benefit per head	0.34/head

DISCUSSION

Foot and Mouth Disease causes a severe economic impact on milk production loss due to starvation caused by oral lesions and affects draught power as a result of a lack of mobility caused by foot lesions (Dukpa et al., 2011). In developing countries, the disease severely affects the livelihood of households (Forman et al., 2009). Habela et al. *(*2010) reported that 86.4% of livestock owners in Sudan claimed FMD caused 70%–100% morbidity during an outbreak. In this study, 87% (n = 118) of the respondents expressed severe health damage to their cattle, while 12.6% (n = 17) responded as moderate damage, which is in agreement with the finding of Habela et al. *(*2010). The severity of the disease might be due to virulent viral strains, uncontrolled cattle movement in extensive production, and the endemic occurrence of trypanosomiasis and CBPP, which are well established in western Ethiopia and could have a synergistic contribution to the severity of FMD as a result of immunosuppression (Radostits *et al*., 2008; Jemal & Jones, 2000). In North Ethiopia, the incidence of FMD was reported to be more severe in extensive livestock husbandry systems than in semi-intensive husbandry systems because of cattle movement, which supports the spread of the virus over a long distance (Mazengia et al., 2010). The study in Khartoum State, Sudan, also recently reported 36% cumulative incidence and 7.3% cumulative mortality, which were in agreement with the current finding of 38.7% cumulative incidence (Hussein & Daboura, 2012). The mortality of FMD in East Africa under an extensive production system was reported in the range of 2.9%–5.3% (Barasa et al., 2008; Longjam et al., 2011), which was in agreement with the current cumulative mortality (3.2%). A FMD case fatality rate of 9.3% was reported in the Kingdom of Bhutan in an extensive production system based on farmers' clinical diagnoses, which is in agreement with the current 8.4% (Dukpa *et al*., 2011).

Financial loss due to mortality was estimated at 30.38% of the direct losses, which was less than the mortality of FMD reported at 54.7% of the direct losses (Barasa et al., 2008). Bayisa et al. (2011) reported an average 7.7% milk production losses in lactating cows in the face of the disease outbreak. An outbreak of FMD in Khartoum, Sudan, caused financial losses of 11.78 USD per head for lactating cows in the dairy industry (Hussein & Daboura 2012). Thus, the current 6.12% of total milk loss is consistent with the previous findings. The financial impact of the FMD outbreak on draft power showed that the disease caused a value loss of 19.41% out of the total financial losses. FMD can cause losses in draft power for one season (Bayisa et al., 2011).

A model developed for developing countries showed that FMD has a great economic impact at the household and national levels, indicating that controlling FMD has a positive economic benefit at the national and household levels (Forman et al., 2009). Therefore, the net benefit of controlling FMD through vaccination accounted for 80.89 USD per household and 11.78 USD per head of animal, which showed that farmers under an extensive management system could benefit financially if they voluntarily participated in the cost-shared vaccination control of FMD. At large, the country would benefit significantly from export trade earnings. This study has enlightened smallholder farmers that they could play a role by taking part in voluntary cost-shared vaccination control of FMD, which contributes to the global agenda of progressive control pathways (PCP) currently underway at the national level. FMD is not only a threat to the national livestock and livestock product trade, but it also greatly damages the food security of households.

Conclusion and Recommendation

The current study revealed FMD causes severe economic impacts on households, and control of FMD through voluntary cost-shared vaccination would be beneficial to households.

Therefore, the following recommendations were forwarded:

1. *Creation of community awareness on transmission and control measures of the disease*
2. *Collaboration between farmers and the public veterinary service for the control of the disease through cost-shared vaccination*
3. *Serotyping and strain characterization with cross-matching of the serotypes with the available vaccinal strain*

ACKNOWLEDGMENTS

The authors are greatly indebted to the National Animal Health Diagnostic and Investigation Center (NAHDIC) for field and laboratory support to undertake the study.

DECLARATION

There is no conflict of interest in this work.

DATA AVAILABILITY STATEMENT

All data included in the article are available from the corresponding author upon request.

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