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Research Article

Outbreak Investigation and Economic Impact of Foot and Mouth Disease in Bovine in Western Amhara Regional State, North Western Ethiopia

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Abstract

Foot-and-mouth disease is a highly contagious viral disease that affects cloven-hoofed wild and domestic animals and causes significant economic losses in the livestock industry. This aim of this study was to identify the circulating serotypes and determine it's economic impact on cattle production. A a retrosepective questionnaire survey was conducted with 100 farm owners from six districts to determine the economic losses associated with foot and mouth diseases over one year. During the survy, fourteen active case epithelial tissue samples from three districts, which outbreak occure, were collected from the fourteen cattle. The collected tissue sample detected using real-time reverse transcriptase polymerase chain reaction (RT-PCR). The foot and mouth diseases serotype O, A, SAT1, and SAT2 were identified using a sandwich enzyme-linked immunosorbent assay. In addition questionnaire survey data revealed that the average economic loss was 5553.21ETB (132.21$USA) per herd and 1124.13ETB (26.76$USA) per individual animal. The present investigation indicated that still foot and mouth disease outbreaks occurred in different areas of the northwestern Amhara region, and the economic impact of the disease is extremely severe, resulting in massive economic losses. Therefore, it is recommended that further studies on the epidemiology, vaccine trials, and socioeconomic consequences should be conducted to design appropriate control options.

Keywords

Bovine, Economic Loss, Foot and Mouth Disease, Northwestern Amhara, Serotype

1. Introduction

Ethiopia has one of the world's most extensive livestock resources. However, it has been downgraded owing to animal deaths associated with a higher prevalence of infectious diseases. Many transboundary infectious diseases are prevalent in Ethiopia, and foot-and-mouth disease (FMD) is one of the country's primary animal health challenges [1].

Foot-and-mouth disease (FMD) is a highly contagious and economically important viral disease. It is the most important livestock disease that affects the production and trade of animals, and animal products in the world [2]. The virus has seven serotypes (A, O, C, Asia1, and South African Territories (SAT) 1, 2, 3). Additionally, many subtypes are based on the antigenicity of the capsid-coated proteins [3]. The disease has clinical signs of vesicular formation, and erosions of the epi-

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thelium of the mouth, teats, tongue, lips, and between the hooves [4]. The viruses can be transmitted orally or through the respiratory tract to a new susceptible animal [5]. Treatment and vaccination are the primary means of control in endemic countries such as Ethiopia [6, 3].

The virus affects a wide range of hosts, including domestic and wild ruminants. According to the OIE (World Organization for Animal Health), FMD was the first viral infection of animals recognized and ranks first among the diseases of cattle [7]. The occurrence of FMD in Ethiopia has increased since 1990; outbreaks throughout the country are reported frequently [8].

Foot and mouth diseases spread quickly, infecting a large number of animals in a short period and causing massive economic loss. Quantifying the economic impact of FMD is an important issue because its socioeconomic impact causes significant economic damage by impeding local and international trade. In endemic countries, the most direct economic impact of FMD is the loss or reduced efficiency of production, which lowers farmers' income and incurs huge control costs. At the local level, FMD reduces farmers' income and the amount of food available for consumption. At the national level, FMD slows economic growth by severely limiting trade opportunities. Heavy losses occur in small-scale mixed farming systems when outbreaks affect draught oxen during the cropping season. FMD causes considerable losses in milk yield and weight among dairy and fattening stock, respectively [9, 10]. The economic impact can indirectly delay reproduction, leading to fewer offspring and a reduced livestock population. The economic loss may be visible or invisible, and it varies between endemic and non-endemic areas of the world [3].

Even though, FMD outbreaks in cattle have been reported in Ethiopia, including in the Amhara region. socio economic impact and disturbution of serotypes in each district not known well. For effective control and prevention, an appropriate vaccine containing the serotypes circulating in the area must be developed [7]. A regular study about serotypes circulating in the region, as well as reporting on the disease's economic crisis, is necessary to motivate the government. Unlike other vaccines the cost of FMD vaccine is relativily high. So, the gevermental veterinary clinics not vaccinate FMD vaccine. This leads to to increase outbreaks in Ethiopia. Reports related to the economic impact of FMD in Ethiopia are limited, so it is difficult to make decisions about control and prevention. As a result, research should be conducted on this disease that poses a threat to animal health. Therefore, this study was carried out to identify serotypes of the foot and mouth disease virus circulating in the region and to assess the economic impact of the disease, with an emphasis on farms.

2. Materials and Methods

2.1. Study Area

The study was conducted in the northwestern part of Ethiopia's Amhara regional state. It is located between the latitudes of 8° 45′–13° 45′N and the longitudes of 35° 15′–40 ° 20′E, and it covers an area of 157,127 km^2, as shown in Figure 1.

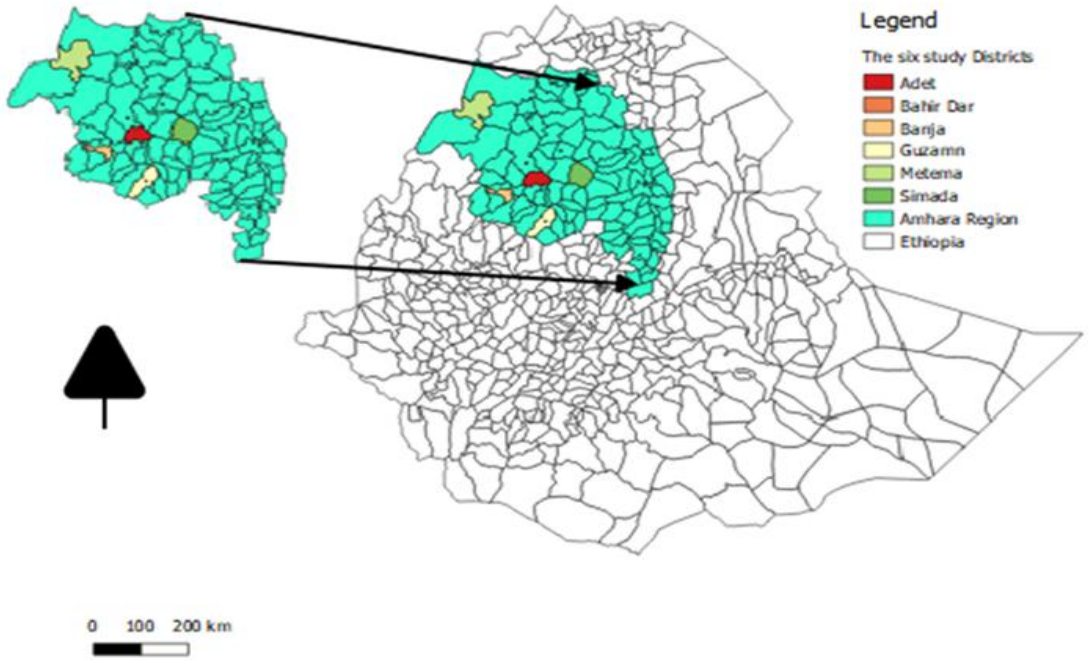

Figure 1. *Map, Study Area, and Source; Adopted by qGIS 2.18.*

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2.2. Study Population

The study consists of cattle under various production systems and farming types. The questionnaire was prepared based on farmers who own small-holder farms, beef farms, and dairy farms. Additionally, outbreak information was another method of determining the study districts.

2.3. Study Designs

A semi-structured retrospective questionnaire survey was conducted with smallholder farm owners, dairy farm owners, and beef farm owners. The questionnaire was prepared based on answers to questions such as how many farmers know about FMDV, how many diseases rank in the region relative to other diseases, the time of incidence of FMDV in the area, information on how farmers control diseases, the challenge of FMD on livestock productivity, and the economic impact of the diseases. Face-to-face interviews with respondents were conducted in the local language, Amharic.

2.4. Sample Size Determination for Tissue Sample

For tissue sample collection, the sample size was not restricted; from all available cases of cattle, the samples were taken.

2.5. Determination of the Number of Respondents for the Survey

The sample size determination for questionnaire data was determined according to the formula $0.25/SE^2$ [11], assuming a standard error (SE) of 5% and maximum variation between farming types. The farmers who volunteered to respond to questions and one animal health technician participated in the interview. One animal health worker was present in each peasant association to support farmer ideas, particularly about vaccination, disease type, and treatment.

2.6. Human Participation in the Survey

There has not been formal ethical approval for this survey because it was a retrospective study and was performed by volunteer respondents. So, only verbal agreement was there between the respondants and the reserarcher. The participants respond with an oral, face-to-face interview, and the interviewer records the data. The survey was conducted from November 1/ 2020 to March 29/ 2021, but for retrospective economic data, the outbreak information was within a one-year period, which was from April 1/ 2020 to March 29/ 2021. Humans who participated in the study were treated with respect; they were not asked without consent, and they had the opportunity to withdraw if they wanted to stop participating in the interview.

2.7. Study Methodology

2.7.1. Epithelial tissue sample collection

Freshly ruptured oral and foot lesions from suspected FMD-infected cattle were collected aseptically. The samples were immediately placed in a sampling tube containing a virus transport medium made up of 50% glycerol and 0.04M phosphate buffer sulfate (PBS) with antibiotics at pH 7.2- 7.4. The parameter species, animal identification number, sex, age, peasant association, and sample type were labeled and immediately placed in an ice box containing ice packs. The sample was kept at -19 ℃ until processed and tested in the laboratory.

2.7.2. Laboratory Examination

The laboratory work was carried out at the National Animal Health Diagnosis and Investigation Center (NADIC) in Sebeta, Ethiopia. In tissue sample preparation, samples were ground with a tissue-grinding device (mortar and pestle) to disrupt viral cells. The sample was ground silica sand with an effective phosphate buffer. For every fourteen samples, the procedure was repeated by cleaning the material for the next procedure and transferring the suspension to the sampling tube. In RNA Extraction, total RNA was extracted from FMDV-infected clinical samples in tissue suspension using the QIAamp® Viral RNA Mini Extraction Kit, catalog, No. 52906, according to the manufacturer's instructions. Master Mix preparation, Twenty microliters of Master Mix were used for one-step RT-PCR. The twenty microliters included 10 microliters of reaction buffer, 2.0 microliters of each forward and reverse primer, 1.5 microliters of the probe, 3.0 microliters of the extracted RNA sample, and 1.5 microliters of RNase-free water.

RNA detection: The viral RNA was detected by real-time reverse transcription polymerase chain reaction (RT-PCR). A 3D pol region forward primer, 5'ACT GGG TTT TAC AAA CCT GTGA-3; a reverse primer, 5'GCG AGT CCT GCC

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ACG GA-3; and a TaqMan probe, 5TCC TTT GCA CGC CGT GGG AC TAMRA-3, were used to screen the samples [12]. Positive and negative controls were added to each and kept in the RT-PCR machine for amplification. The RT-PCR reactions were carried out in a 20-microliter reaction mixture with a 96-microplate well. RT-PCR amplification started with programming at the following temperatures: 50 ℃ for thirty minutes, 95 ℃ for ten minutes, 95 ℃ for fifteen seconds, and 60 ℃ for one minute, for a total of 50 cycles [13, 14]. A threshold cycle (CT) value is used to assign samples as either FMDV-positive or negative. According to the OIE Reference Laboratory, negative test samples and negative controls should have a CT value >50. Positive test samples and positive control samples should have a CT value of <40. Samples with CT values 40–50 are designated borderline, and strong positive FMD samples have a CT value below 20.

2.7.3. Identification of Serotypes by Antigen Detection

FMDV serotypes were identified and detected using FMDV antigen detection and Serotyping sandwich ELISA (IZSLER, Brescia, Italy). The kit was created using carefully chosen combinations of anti-FMDV monoclonal antibodies (MAbs), which were used as coated as well as conjugated antibodies. The kit also includes FMD viruses that may have escaped binding to selected serotype-specific monoclonal antibodies. The cached MAbs were used to detect 10 samples at a time, with one positive and one negative control for each serotype. The test was carried out according to the manufacturer's instructions.

2.7.4. Criteria for the Validity of Antigen Detection ELISA

The positive inactivated controls were expected to give OD values greater or equal to 1.0 units, while the negative controls for serotypes O, A, C, Asia 1, and Pan-FMDV are expected to give OD values less than 0.1 unit, and the negative controls for serotypes SAT1 and SAT2 are expected to give OD values less than or equal to 0.2 unit.

2.8. Assessment of the Economic Loss Associated with FMD

The study focused on direct economic losses such as milk production loss, draft power loss, treatment costs, animal mortality loss, and beef farm refatting costs. It was studied by asking farmers or animal owners, using a semi-structured questionnaire format, about the consequences of the diseases, particularly milk loss, and the measures taken during outbreaks [15].

2.8.1. Milk Loss in Dairy Farms

Milk loss on dairy farms represents the economic loss caused by milk yield. The milk loss was calculated by summing the milk losses from the total number of herds included in the study.

$$Hs = \sum_{100}^{1}(NoDc \times mL \times MPLA \times NoDo)$$

The above formula, which represents 100 (total number of herds), Hs (the sum of the economic loss from hundred herds), NoDc (Number of diseased cows on the herd), mL (milk loss per litter per day per animal), MPLA (Milk price per Litter per Animal), and NoDo (Number of Days outbreak occurred), was used to calculate total economic loss within the infected herd [3].

2.8.2. Economic Loss Due to Dead Cattle

The mortality loss was estimated by the market value of a dead animal. Thus, the economic loss due to mortality per herd was calculated by considering the different age categories of animals that died and their corresponding market prices.

Economic loss due to death of animal with the diseases =

$$Hs = \sum_{100}^{1}((NoDc \times mpdc) + (NoDDc \times mpdc) + (NoDo \times mpdo) + (Nomc \times mpdmc \times NdCm))$$

The above formula, which represents 100 (total number of herds), Hs (the sum of the economic loss from hundred herds), NoDc (Number of dead calves), mpc (market price of dead calves), NoDDc (number of a dead dry cow), mpdc (market price of the dry cow), NoDo (number of died oxen), mpdo (market price of dead oxen), Nomc (number of died milking cows), mpdmc (market price of a dead milking cow), NdCm (Number of days the cow has milked). To calculate the loss per affected herd divided by the number of infected herds. To calculate the loss per herd divided by the total herd in the study [15, 3].

2.8.3. Economic Loss in Beef Farms

$$Hs = \sum_{100}^{1}(Nrfb \times NoD \times \frac{Dcost}{animal})$$

Economic losses estimated on the beef farm were done with the cost used for re-fatting calculated. The above formula, which represents 100 (total number of herds), Hs (the sum of the economic loss from hundred herds), Nrfb (Number of refatting bulls), NoD (number of refatting days), and Dcost/animal (daily cost for refatting per animal), with the farmer for feeding the bull and labor cost per animal as a whole.

2.8.4. Draft Power Loss

$$Hs = \sum_{100}^{1}(NSO \times Ndio \times adj\,factor \times pDppdpa)$$

The above formula represents 100 (total number of herds), Hs (the sum of the economic loss from hundred herds), NSO (number of sick oxen in smallholder farms), Ndio (number of days of illness of the oxen), adj factor (adjustment factor), and pDppdpa (Price of draft power per day per animal). The economic losses caused by draft power loss are calculated as the number of oxen affected multiplied by the length of illness in days of an affected ox in the herd multiplied by the adjustment factor. Draught power for crop production (plowing and threshing) is not required all year due to crop seasonality and cultural beliefs. So the ox can work up to 65 days per year as an adjustment factor (65/365) [10, 15].

2.8.5. Treatment Loss

The cost of FMD treatment was calculated based on the number of animals treated and the average price per head. Also, the average number of working hours lost by the attendant or owner while seeking treatment for sick animals, as well as the average hourly wage, were calculated.

$$\text{Hs} = \sum_{100}^{1}((\text{NTrAni} \times \text{Pt}) + (\text{HLsT} \times \text{PR}))$$

The above formula represents 100 (total number of herds), Hs (the sum of the economic loss from hundred herds), NSO (number of sick oxen in smallholder farms), Ndio (number of days of illness of the oxen), adj factor (adjustment factor), and pDppdpa (Price of draft power per day per animal). n (total number of herds), Hi (the sum of the economic loss of individual herd i), NTrAni (Number of animals treated), PT (Price of Treatment), HLsT (Hours Lost for seeking Treatments), and PR (payment rate) [15].

2.8.6. Total Economic Loss

Total economic loss = (Milk Loss in Dairy Farms+ Economic Loss Due to Dead Cattle+ Economic Loss in Beef Farms + Draft power loss + Treatment Loss [15, 10].

$$\text{Total economic loss} = \sum(\text{Milk Loss in Dairy Farms} + \text{Economic Loss Due to Dead Cattle} + \text{Economic Loss in Beef Farms} + \text{Draft power loss} + \text{Treatment Loss})$$

Limitations: The economic impact estimate does not include most invisible costs, vaccination costs, surveillance costs, and cost losses of national and international trade.

2.9. Data Management and Analysis

The questionnaire survey data was entered into SPSS version 20 software and analyzed using descriptive statistics. Economic data was done by cost determination model using formulas. The count data mortality and morbidity, was transformed into continuous data and entered into Excel, and were analyzed by R software with ANOVA statistical methods for comparison between production and districts.

3. Results

3.1. Field Observation

During sample collection in the field clinical observation was recorded. In these sample collection times, clinical signs like salivation by mouth, fever, loss of appetite, and lesions on the tongue and gums were observed, as shown in Figure 2.

(A) Erosion of the tongue (B) Saliva from the mouth (C) Erosion of gum

Figure 2. *The above images took during sample collection.*

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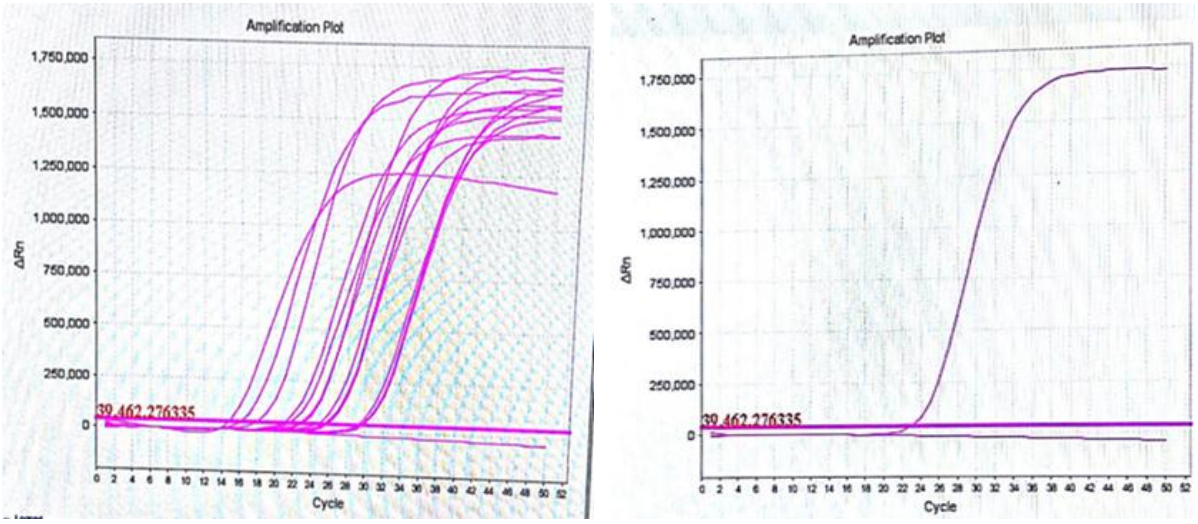
3.2. Laboratory Diagnosis

FMDV was confirmed using the RT-PCR diagnostic method in three districts (Metema, Guzman, and Adet) from fourteen cattle. The serotype, magnitude of amplification and CT value expressed by Figure 3 and Table 1 below. Fourteen epithelial tissue samples were positive, with a minimum CT value of 15.07 and a maximum CT value of 30.08. Six samples had a lower CT value than the positive control. The fourteen samples have been identified serotypically. Four serotypes (O, SAT2, A, and SAT1) were detected. In the Guzman District, serotypes SAT1, SAT2, and O were detected with single and mixed infections. In Adet, O and A were found with one mixed infection. In Metema, only SAT2 was found. Out of all serotypes, 42% were O and 35.7% were SAT2 from total samples, both in single and mixed infections.



A B

In Amplification plot A) 14 samples B) Positive and Negative control

Figure 3. *The CT (Threshold cycle) value and fluorescence produced.*

Table 1. *CT (Threshold Cycle) value and serotypes of epithelial tissue samples.*

Sample No	District	Species	Sex	Breed	CT value results	Serotype result from antigen detection
1	Guzman	Bovine	Female	Cross	30.09	SAT2, SAT1
2	Adet	Bovine	Male	Local	18.34	A, O
3	Metema	Bovine	Male	Local	16.52	SAT2
4	Adet	Bovine	Male	Local	29.57	A
5	Metema	Bovine	Female	Local	30.08	SAT2
6	Adet	Bovine	Male	Local	26.20	O
7	Adet	Bovine	Male	Cross	25.20	O

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Sample No	District	Species	Sex	Breed	CT value results	Serotype result from antigen detection
8	Guzman	Bovine	Female	Cross	21.35	O
9	Guzman	Bovine	Female	Local	15.07	SAT2, O
10	Guzman	Bovine	Female	Cross	23.21	O
11	Guzamn	Bovine	Male	Cross	25.93	O
12	Metema	Bovine	Male	Local	22.04	SAT2
13	Guzman	Bovine	Female	Cross	26.14	SAT1
14	Guzman	Bovine	Female	Cross	30.05	SAT1
+control					23.44	

CT (cycle threshold) value means the number of cycles required for fluorescent signal formation. +control means positive control.

3.3. Farmer's Demography, Knowledge, and Herd Structure

As shown in Table 2 in this study 100 farmers from six districts in the Amhara region participated in interviews. Primarily, most farmers participate in day-to-day activities with mixed crop and livestock production. For some farmers, only livestock provided their livelihood. By their educational background, most participants were illiterate, and some were able to read and write, but very few participants around 6% were higher educators. All farmers with different educational levels have similar concepts about FMD disease. The questionnaire includes sixty-six herds from smallholders, eighteen beef farms, and sixteen dairy farms. There were 27 out of 100 respondents who had a history of disease outbreaks within their farms in the year April 2020 to March 2021. There were 13 smallholder herds, 7 beef farms, and 7 dairy farms among the 27 affected herds. Seventy percent of farm owners were aware of foot and mouth disease. According to the majority of respondents, FMDV is referred to as “maz” in Gondar and Bahirdar Zuria, as well as known as “kortem” in and around Gojjam. Foot and mouth disease was identified as the second leading cause of livestock morbidity. The majority of respondents stated that the time of occurrence for foot and mouth disease was from September to February, but some respondents also stated that it occurred from June to August. Treatment was the primary control method, with the traditional method coming second. The animal-level mortality was calculated by dividing the number of animals that died during the outbreak by the total number of animals at risk for each herd. Morbidity at the herd level is calculated as the number of positive herds divided by the total number of herds observed. Mortality at the herd level was calculated by dividing the number of herds where the animals died by the total number of herds observed. Morbidity and mortality were diagnosed at the herd level and the individual animal level. At the district level, higher morbidity was observed in Simada at 37.14%, and low morbidity was observed in Banja district with a morbidity rate of 2.23%. In a dairy farm production system, higher morbidity was observed, with a morbidity rate of 30.33%. During observed mortality in the district, a higher rate was recorded in Guzamn, with a rate of 5.38%. A lower mortality rate was observed in Metema, with a rate of 1.69%. When comparing mortality rate with farm type, lower mortality was recorded on smallholder farms at a rate of 1.57%. Higher mortality was observed in beef and dairy farms at 3.37% and 3.49%, respectively. The number of animals infected during the outbreak divided by the total number of animals at risk was used to calculate animal-level morbidity for each herd. The morbidity on the beef farm, smallholder farm, and dairy farm was 57.1%, 64.3%, and 78.5%, respectively, as shown in Table 2.

Table 2. *Herd structure, morbidity, and mortality.*

Risk factor	Categories	No+ herd	No herd	Total No animals	No of Diseased animals	Ave Herd Size	animals in the diseased herd	Morbidity in Affected Herds	Morbidity	mortality
District	Adet	6	17	76	22	5	30	73.3%	28.9 %	1(1.3%)
	Banja	1	19	89	2	5	5	40.0%	2.2 %	---

Risk factor	Categories	No+ herd	No herd	Total No animals	No of Diseased animals	Ave Herd Size	animals in the diseased herd	Morbidity in Affected Herds	Morbidity	mortality
	Simada	7	15	70	26	5	35	74.3%	37.1 %	2(2.8%)
	Guzamn	7	23	130	30	6	42	71.4%	23.1 %	7(5.4%)
	Metema	4	11	59	10	5	20	50.0%	16.9 %	1(1.7%)
	Tanahyk	2	15	70	8	5	10	80.0%	11.4 %	----
	Smallholder	13	66	319	51	5	65	78.5%	15.9 %	5(1.57%)
Farm type	Dairy farm	7	16	89	27	6	42	64.3%	30.3 %	3(3.4%)
	Beef farm	7	18	86	20	5	35	57.1%	23.2 %	3(3.5%)
Total		27	100	494	98	5	135	72.6%	19.8%	2.2%)

No+ (herds mean the number of the positive herd), Ave Herd size means (Average herd size), and No (Number)

3.4. Morbidity and Mortality

There was a significant difference in morbidity between District Guzman (19.1%, p = 0.038), Simada (25.0%, p = 0.015), and Adet (21.8%, p = 0.028) compared with Banja. There were no significant differences in morbidity between Banja and Tanahyk (7.4%, p = 0.47). Compared with Banja, there was a significant difference in mortality between District Guzman and Banja (2.3%, p = 0.047). There were no significant differences among Metema (0.2%, P = 0.845), Simada (1.5%, p = 0.240), Tanahyk (1.6%, P = 0.278), and Adet (0.4%, p = 0.700) compared with Banja. By production, the morbidity between beef farms and dairy farms was 1.4%, P = 0.27, and between smallholder farms and beef farms was 1.0%, P = 0.338, with a significance level of p = 0.002.

3.5. The Economic Impact of FMD on Livestock Production

3.5.1. Milk Loss

The total milk loss calculated, the whole milk loss during the observation, was 22322 ETB (531.47 USD). The milk loss per individual animal in the affected herd was calculated by dividing the total cost loss due to milk by the number of diseased animals. The milk loss per affected herd was determined by dividing the total milk loss due to disease by the total number of diseased herds. Milk loss was calculated for each herd by dividing the total cost loss due to milk by the total number of observed herds, as shown in Table 3.

Table 3. *Economic loss due to milk loss.*

Variables	Estimated milk loss
Amount of milk loss per animal in the affected herd	227.78ETB (5.42USA)
Amount of milk loss per animal within any herd	45.19ETB (1.1USA)
Amount of milk loss per affected herd	826.7ETB (19USA)
Amount of milk loss per herd	223.22 ETB (18USA)

3.5.2. Mortality

The total number of milking cows, calves, oxen, and dry cows that died during the study period was 2, 5, 3, and 1, respectively. The total economic loss during the examination period was 368,000 ETB (8761.9 USD). In general, the economic loss was around 13629.63 ETB (324.5 USD) per affected herd and around 3680 ETB (87.6 USD) with any herd. The economic loss due to mortality was 3755.1 ETB (89.4 USD) for each affected animal and 744.94 ETB (17.74 USD) for any individual animal.

3.5.3. Economic Loss on the Beef Farm

Economic losses were estimated as a result of bulls being retained from the market. The total number of bulls retained on each beef farm is due to FMDVs. Refatting costs per day per animal and owner labor costs were included in the refatting. On the beef farm, 20 were diseased and required refatting days (convalesce and again fatten). On the beef farm under consideration, the total economic loss was 154000 ETB (3666.67 USD). The total economic loss per affected herd was calculated by dividing the number of infected herds by 5703.7 ETB (135.8 USD) and per herd by 1540 ETB (36.67 USD). The cost per individual animal level with an infected animal was 1571.43 ETB (37.41 USD) and 311.74 ETB (7.42 USD) for any animal.

3.5.4. Draft Power Loss

The total cost loss in birr due to draft power was 4277.32 ETB (101.846 ETB). The cost per affected herd was 158.41.36 ETB (3.77 USD), while the cost per affected individual animal was 43.65 ETB (1.04 USD). Economic loss per herd and loss per individual animal in any herd were approximately 42.77 ETB (1.02 USD) and 8.66 ETB (0.206 USD), respectively.

3.5.5. Treatment Cost

The cost of treatment and extra labor costs for seeking treatment for sick animals were considered. The owner's labor rate was 50 ETB (1.19 USD) per 12 hours, with a two-day payment of 50 ETB (1.19 USD). Generally, 21 farm owners were treating their animals, including 6, 8, and 7 from dairy, smallholder, and beef farms, respectively. The total cost during the observation was 6722 ETB (160.045 USD). The total loss per affected herd was 248.96 ETB (5.93 USD), and within individual affected animals, it was 68.59 ETB (1.633 USD). The total loss per herd was 67.22 ETB (1.6 USD), and the total loss for any animal was 13.61 ETB (0.324 USD).

3.5.6. Total Cost

During the study period, the total economic loss was 555321 ETB (13221.928 USD) as a result of the summation of milk loss, mortality, draft power, refatting cost, and treatment cost. The total loss per affected herd was 20567.44 ETB (489.69 USD), with a loss of 5666.54 ETB (134.91 USD) per individual animal. The total economic loss due to foot and mouth disease was 5553.21 ETB (132.21 USA) per herd, and the loss per individual animal was 1124.13 ETB (26.76 USA). For each calculation (1 USD = 42 ETB; data from the Commercial Bank of Ethiopia),

4. Discussion

4.1. Molecular and Antigenic Detection

In this study, RT-PCR detected the presence of genetic material (targeting the 3D pol regions). In the previous study, [6, 16] real-time RT-PCR targeting the 3D region of the viral genome detected the FMDV powerfully, which is now a recent and reliable diagnostic method. In the previous study [17], Serotype O was recorded throughout the country where outbreaks occurred. The previous study [18] found serotype O to be the most prevalent and dominant serotype in Adet, causing the majority of outbreaks in the Amhara region. Similar to the previous study, Serotype O was also identified in Adet and Guzamn in our study. Serotype O was considered the most widely studied and common FMD serotype in the world [19], similar to that in this study, 42% of the serotypes were O. In other studies (13, [8], serotype O was the most prevalent in central Ethiopia. In this study, the next most prevalent serotype was SAT2 which was 35.7%. In a previous study [20], SAT2 was the cause of the outbreak in the Afar region. In a previous study [21], serotypes O, A, and SAT2 were found in Debre Birhan, Debrezyiet, and Addis Abeba, whereas in this study, serotypes O, A, SAT1, and SAT2 were found in Adet, Metema, and Guzman. The results show that the most common serotype in the Amhara region was serotype O, but all serotypes SAT1, SAT2, and A were found in this study district at different study times. In another study [22], the three serotypes O, A, and SAT2 were found to be circulating in the Adea Berga district of the western Shewa zone.

4.2. Questionnaire Survey

In this study, 70% of farmers are aware of foot and mouth diseases, whereas, in previous studies in other districts in the Amhara region, approximately 85% of farmers were aware of the diseases, indicating that disease experience in the study area may vary among districts [23]. According to this study, FMD was ranked one through three in terms of occurrence and economic impact. In another study [24], most cases occurred during the dry season (from November to March), except in the Central Highlands. Another study [25] found that the fourth most important disease was other cattle diseases. The highest outbreaks of the disease were observed during the extremely long dry seasons of the year, which were from December to May. Similarly, in this study, most of the outbreaks occurred in the dry season of the year, when animal movement increased. This might be because most of Ethiopia's crops are harvested during the dry seasons of the year and animals move freely from place to place. In this study, FMDV has more frequently occurred on smallholder and semi-intensive farms. This may be due to animals' density and overcrowding. which was not getting sufficient ventilation. In the study [26], the majority of cattle and herds were moved during the dry season to access grazing and water, and more transmission occurred across animals during this time. Individual animal morbidity from the affected herd was 72.6% in this study. Another study [27] found that morbidity rates of FMD at the animal level were 74.3% in the affected herds in

the crop-livestock mixed system. Similarly, morbidity in beef farms, smallholder farms, and dairy farms was 57.1%, 78.5%, and 64.3%, respectively, in this study. In another study, [28] almost similar results were found in a serosurvey study that the herd level seroprevalence was 58.6%. The total annual costs of FMD under the current status of production and control cost is estimated at 1,354 million birr ETB and the major cost was due to production losses [29]. In this study, the total economic loss due to FMD per herd was 5553.21ETB (132.21$USA), and per any individual animal total loss was 1124.13ETB (26.76$USA). In this study, economic loss is associated with production loss and the most visible costs, including FMDV treatment. The cost of trade, the cost of reproduction, and invisible costs were not included in this study.

5. Conclusion

FMD is an economically important and endemic disease in Ethiopia, including the Amhara region. The free movement of livestock in different regions and the absence of effective control measures cause the occurrence of foot and mouth diseases. Due to the frequent occurrence of FMDV in Ethiopia, most animal owners know about foot and mouth diseases and use different control options by themselves. The impact of this disease is very high, with a huge economic loss, so awareness-raising concerning the clinical and economic consequences of FMD should be done among livestock owners. Work more on serotypes, molecular epidemiology, and vaccine trials for each serotype circulating in the different parts of Ethiopia. Detailed epidemiological investigations and more cost-benefit analyses should be conducted, including all types of economic loss.

Abbreviations

ANOVA	Analysis of Variance
RTPCR	Real Time Polymerize Chin Reaction
SAT1	South Africa Terterie 1
SAT2	South Africa Terterie 2
ETB	Ethiopian Birr
ELISA	Enzym Linked Immino Sorbent Assay
FMD	Foot and Mouth Disease
USD	United State Dollar

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Author Contributions

Betelihem Yirdaw is the sole author. The author read and approved the final manuscript.

Conflicts of Interest

The author declares no conflicts of interest.

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Research Fields

Betelihem Yirdaw: Veterinary Epidemiology, Veterinary Clinical medicine, Veterinary Microbiology, Veterinary Parasitology