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Seroprevalence of bovine foot and mouth disease (FMD) and its associated risk factors in selected districts of Afar region, Ethiopia

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Abstract

Background: A cross-sectional study was conducted from November 2018 to May 2019 to estimate seroprevalence of foot and mouth disease virus for cattle and assess associated risk factors in selected districts of afar region. Simple random sampling technique was employed to select the study areas. A total of 384 bovine sera were collected from 72 herds and seroprevalence of the disease was determined using 3ABC-ELISA technique. Data were recorded and coded using Microsoft Excel spread sheet and analysed using STATA. Potential risk factors of the disease were also assessed using logistic regression analysis.

Results: Out of 384 sera tested at National Veterinary Institute, the overall seroprevalence of foot and mouth disease (FMD) virus was 19.8% (n = 76; 95% CI = 15.8-23.79) at animal level and 56.94% at herd level. The herd level seroprevalence was higher in animals tested from Dubti (85%, n = 17) than Asayita (48.13%, n = 13) and Chifra (44%, n = 11). Among the associated risk factors, age, herd size, district and contact with wild life were statistically associated with foot and mouth disease serostatus ($p < 0.05$). Medium and large herd size animals were 2.49 (95% CI: 1.33-6.63) and 6.05 (95% CI: 2.54-14.43) times more likely to develop the disease as compared to animals from small herd size, respectively.

Conclusions: The current study finding revealed that FMD was more prevalent and economically significant disease in the study districts. Hence, further studies ought to be conducted to estimate the region wise serostatus magnitude of the disease, to assess its economic impact and to identify the circulating serotypes and strains in the areas.

KEYWORDS
3ABC-ELISA, Afar, Bovine, FMD, Risk factor, Seroprevalence

Abbreviations: AOR, Adjusted Odds Ratio; COR, Crude Odds Ratio; CSA, Central Statistical Authority; ELISA, Enzyme Linked Immunosorbant Assay; FAO, Food and Agriculture Organization; FMD, Foot and Mouth Disease; FMDV, Foot and Mouth Disease Virus; GDP, Growth Domestic product; IgG, Immunoglobulin G; NSP, Non-Structural Protein; NVI, National Veterinary Institute; OD, Optical Density; OIE, World Health Organization for Animal Health; PAs, pastoral Associations; SAT, Southern African Territories; TMB, Tetra-methylbenzidine; ^{2}, Chi-Square

1 | BACKGROUND

Ethiopia possesses the most abundant livestock population in Africa with an estimated domestic animal number of 56.71 million cattle, 29.33 million sheep, 29.11 million goats, and 54.5 million chickens (Central Statistical Authority [CSA, 2016]). The agricultural segment constitutes around 45-48% of the gross domestic production (GDP) of the country and livestock sector accounts for an estimated 20% of the total GDP without considering other contribution like traction power, fertilizing, and means of transport (CSA, 2009; Gebreegziabhare, 2010). Ethiopia comprises the largest population of pastoralist from Eastern Africa countries (7-8 million). These pastoralists livelihood depends on livestock production. The main peculiar feature of pastoralist's way of life is that they move from place to place in search of water and pasture for their livestock (Markakis, 2004). Even though the country is resourceful with huge livestock population, production and productivity is by far underneath the expectation due to widespread of livestock diseases and other constraints (Livestock Master Plan, 2015).

Livestock diseases cause great economic losses to the peasant farmers and pastoralists in Ethiopia, accounting for hundreds of millions of birr every year. These diseases are currently widespread in all geographical areas of the country and annual mortality rates due to these diseases is estimated to be 8-10% for cattle herds, 15% and 12% for sheep. and goat flocks, respectively. It is expected that livestock diseases decrease production and productivity of livestock approximately by 50-60% per year (Ganeshkumar, 2012). Foot-and-mouth disease (FMD) is perceived as the most economically important trans-boundary viral disease of cattle both at national, regional and house hold levels because it hampers livestock productivity and limits the country's potential to participate in international trade (Asseged, 2005; Bayissa et al., 2011; OIE, 2010).

FMD is an extremely contagious and acute viral disease of all cloven-hoofed animals. The disease is considered as a bottleneck for livestock production and productivity, and hinders trade embargos for livestock and livestock products (Behnke & Metaferia, 2011). According to the World Organization for Animal Health (OIE), FMD ranks first among the disease of animals (Mahy, 2005). FMD is caused by FMD virus (FMDV) which belongs to the genus Aphthovirus within the family Picornaviridae and the disease is characterized by fever, loss of appetite, salivation, vesicular eruptions in mucosa of the mouth, skin of the inter-digital spaces and coronary bands of the feet and teats, and sudden death of young stock (Ding et al., 2013, OIE, 2010). FMDV exists as seven immunologically distinct serotypes; namely, O, A, C, Asia 1, Southern African Territories (SAT)-1, SAT-2 and SAT-3 (OIE, 2004) and multiple subtypes with distinct immunologic, antigenic and genetic properties due to the high mutational rate of the virus. The seven serotypes FMDV also differ in their distribution across the world (Ayelet et al., 2009; Rufael et al., 2008). Five FMDV serotypes (O, A, C, SAT-1 and SAT-2) have been identified in Ethiopia out of the seven serotypes of the virus (Ayelet et al., 2009,;Negussie et al., 2011). Within each serotype, there are many bio-typical strains and topotypes which can be identified by genetic and immunological tests, and infection with one serotype does not confer immune protection against another (OIE, 2012). Serotype O and A are the dominant serotypes responsible for substantial economic losses in livestock in Ethiopia (Negussie et al., 2011). Generally, studies undertaken on FMD so far showed the presence of the disease in different parts of the country, with seroprevalence varying from 8.18 to 44.2% (Jenbere et al., 2011; Mohamoud et al., 2011).

FMD was more prevalent and economically significant disease in the study districts.

The disease spreads rapidly by movement of infected animals or mechanically via fomites such as clothing, shoes, vehicles, and veterinary instruments (Knight-Jones & Rushton, 2013). The reasons for the rapid spread to fully susceptible population is due to the highly infectious nature of the virus, production of high titer in respiratory secretions and, large volumes of droplets and aerosols of virus shed by infected animals, stability of virus in such droplets, rapid replication cycle with very high virus yields and short incubation period of the virus (Rweyemamu et al., 2008). FMD is the major endemic disease in Ethiopia with abundant socioeconomic importance as a result of reduced production, deaths in new-born animals, huge cost of veterinary services, restricted animal and meat movement locally and between countries (Knight-Jones & Rushton, 2013). Moreover, livestock and livestock product exports to the Middle East and African country has been hampered because of the presence of FMD recently (Bayissa et al., 2011). The Egyptian ban of 2003 on Ethiopia's livestock market alone resulted in market loss of 14.36 million USD and it is a threat to Ethiopia's live animal export and export of animal products (MoARD, 2007, 2009).

In Ethiopia, outbreak of FMD frequently occurs in the pastoral herds of the marginal low land areas of the country (Negussie et al., 2011). Absence of livestock movement control coupled with absence of systematic disease surveillance contributes a lot for outbreak of FMD in the pastoral herds (Sahle, 2004). There is limited information regarding to FMD virus serological status and contributed putative risk factors which may help to generate important baseline information about the disease in the study areas. Hence, the present study was anticipated to estimate the seroprevalence and assess potential risk factors associated with occurrence of FMD virus in selected districts of afar region, Ethiopia.

2 | MATERIALS AND METHODS

2.1 | Description of the study areas

The study was conducted from November, 2018 to May, 2019 in three districts namely (Asayita, Dubti and Chifra), which are located in the administrative zone one of Afar Region, Ethiopia. The Afar Pastoral Region is located in northeast of Ethiopia between 39° 34′ to 42° 28′E longitude and 8° 49′ to 14° 30′ N latitude (Figure 1). The region shares

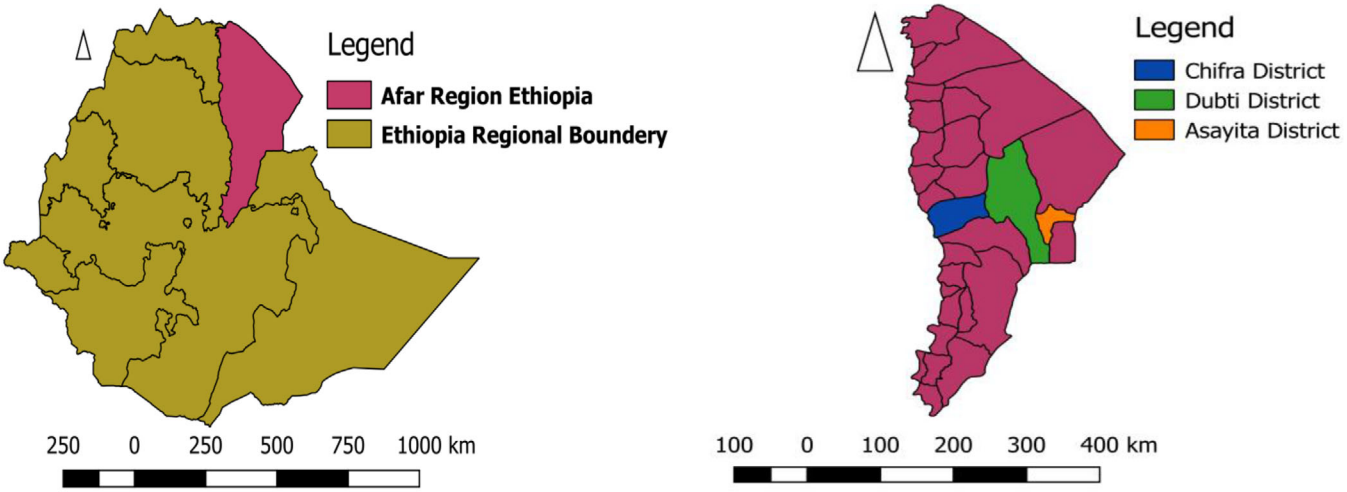

FIGURE 1 Map of Afar Region indicating the study districts (Mamo et al., 2013)

common international boundaries with Eritrea in the northeast and Djibouti in the east and it is characterized by an arid and semi-arid climate with low and erratic rainfall. Rainfall is bi-modal throughout the region, with a mean annual rainfall below 500 mm in the semi-arid western escarpments and decreasing to 150 mm in the arid zones to the east. The altitude of the Region ranges from 120 m below sea level in Danakil depression to 1500 m above sea level. Temperatures vary from 20°C in higher elevations to 48°C in lower elevations. The human population of Afar region is 1.5 million in which the majority are pastoralists who largely depend on livestock production for their livelihood. There are about 1.9 million Afar breed cattle in Afar Region, of which 90% of the cattle are managed under pastoral production system and the rest 10% in agro-pastoral production system (Afar Pastoral, Agricultural, & Development Bureau, 2006).

2.2 | Study populations

The study populations were Afar indigenous breed of non-vaccinated cattle above the age of 6 months having no clinical symptom of any disease. On the basis of physical examination, sampled animals did not show any suggestive clinical signs of FMD such as vesicular eruptions in mucosa of the mouth, salivation, fever, loss of appetite. According to Pace & Wakeman (2003), the age groups of cattle were categorized as (≤3.5years) Young, (3.5years-5.5years) Adult and (> 5.5years). In addition, herd size was categorized as small (<40 cattle), medium (40-75 cattle) and large (>75 cattle) (Asresie & Zemedu, 2015). These study populations were reared by pastoralists in selected districts of the region and these animals are usually kept mixed with other animal species.

2.3 | Study design

A cross-sectional study was employed to estimate the seroprevalence of FMD and to assess associated risk factors in three selected districts of afar pastoral region and a total of 72 herds were included in our study based on the inclusion criteria. A semi-structured questionnaire was administered to herd owners for the assessments of animal and herd level potential risk factors.

2.4 | Sampling technique and sample size determination

The sampling method employed in this study was simple random sampling to select the study population since the study districts were purposively selected based on higher study population, access to transportation, history of no vaccination for the last six months, absence of outbreak cases and willingness of pastoralists to participate in this research work. The individual animal from each herd was selected randomly to attain the required sample size. Since there was no previous study conducted on FMD in cattle found in the selected areas, the present study considered 50% expected seroprevalence, 95% confidence level and 5% absolute precision or marginal error. Based on these assumptions, the total number of animals to be included in the study was determined using (Thrusfield, 2007) formula.

$$n = \frac{Z_2 \times P_{exp}\left(1 - P_{exp}\right)}{d^2}$$

where n is the required sample size, d is the desired absolute precision (0.05), Z is the Multiplier from normal distribution at 95% Confidence interval (1.96), P_{exp} is expected prevalence (50%), (1-P_{exp}) is= Probability of having no disease 50% (0.5). Accordingly, a total of 384 study populations were sampled from all three districts. Proportionally, a total of 147,97, and 140 serum samples were collected from Asayita, Dubti and Chifra respectively based on density of cattle population in the study districts.

2.5 | Sample collection and transportation

Out of all 384 blood samples each approximately 8-10 mL was collected from jugular vein of cattle using 10 mL non-heparinized vacutainer tube and 21 Gauge needle. Following sample collection, vacutainer tubes were labelled and transported to laboratory and kept overnight at room temperature to allow the blood to clot at slant position. Correspondingly, each sample was identified along with sex, age, herd size and district. Then, serum samples were transferred from vacutainer tubes to cryogenic vials and stored in −20°C refrigerator. Finally, the serum samples were transported using an ice box to the National Veterinary Institute (NVI), upon arrival; the sera was stored at −20°C until further processing took place. The samples were then tested using FMD non-structural protein Enzyme Linked Immunosorbant Assay (ELISA) (FMD 3ABC ELISA kit) to detect if animals in the herd had been infected with FMD virus thereby estimating the seroprevalence in the three selected districts of afar region.

2.6 | Administration of questionnaire survey

Open and closed ended questionnaires were administered to herd owners to assess potential risk factors of the disease alongside with sample collection. Respondents from each district were randomly selected and interviewed. Study populations' sex, age, herd size and district were considered as hypothesized risk factors for the occurrence of FMDV. The questionnaires were interpreted into Afaraf language. Herd owner having cattle were the sampling units for questionnaire survey. Accordingly, herd owners included from three districts in this questionnaire survey were 27 from Asayita, 20 from Dubti and 25 from Chifra, a total of 72 herd owners were interviewed. All necessary epidemiological information were tabulated, coded and analysed using statistical analysis on individual animal bases.

2.7 | Serological analysis of the samples

The collected sera were tested by using commercially available FMDV-3ABC- ELISA kit to detect antibodies against natural infection with FMD virus (using IDEXX kit), which is a useful indicator of past natural FMDV infection regardless of the serotype involved. This ELISA test was used according to the manufacturer's instructions. The test principle is blocking of plate bound non-structural protein (NSP) antigen by antibodies present in the serum samples. Any antibody specific for 3ABC binds to the antigen in the wells and forms an antigen/antibody complex on the plate well surface. Antibody to the assay was performed according to manufacturer's instruction and results were analysed and interpreted using:

$$\text{OD Value} = \frac{\text{OD sample} - \text{OD negative}}{\text{OD positive} - \text{OD negative}} \times 100$$

According to the ELISA test kit manual, the samples were categorized based on their optical density (OD values as negative if OD value <20%, ambiguous if OD value is between 20 and 30 % positive if OD value is >30%).

2.8 | Data management and analysis

Data generated from laboratory analysis and questionnaire survey were recorded and coded using Microsoft Excel spreadsheet (Microsoft Corporation) and analysed using STATA version 14.0 for Windows (Stata Corp. College Station, TX, USA). Descriptive statistics (frequency and percentage) were employed to calculate the proportion of risk factors for FMD. Individual level animal prevalence was calculated by dividing the number of animals with positive ELISA tests by the total number of tested animals, and the herd prevalence was determined by dividing positive herds by the total number of herds. Herds were considered positive if one or more animals in the herd had a positive ELISA test. Associated risk factors for seroprevalence of FMD virus were investigated using univariable and multivariable logistic regression analysis.

The likelihood of ratio (LR) test revealed the goodness of fit for the model to analyse this study finding data. Moreover, goodness of fit for the model was determined (checked) by the generated *p*- value and other statistical parameters. The differences between the observed values and the model's predicted values are small and unbiased so that the goodness fit for the model was well. In all the analyses, confidence levels at 95% were calculated, and a $p < 0.05$ was used for statistical significance level.

2.9 | Operational definition

S*eroprevalence*: defined as is the number of cattle in the study population which have been tested positive for FMD virus based on 3ABE-ELISA test divide by the total number of sampled study animals.

Sensitivity: is the ability of a test to identify those who have preclinical disease and it describes its ability to correctly identify animals who have the characteristic that is being measured. Alternatively, it can be expressed as "If tested in duplicates, the OD of the respective sample or control must be averaged. The OD of the positive control (ODpos) as well as the OD of the samples (ODsample) is corrected by subtracting the OD of the negative control (ODneg)":

$$\text{Formula} = \frac{\text{Posetive control : ODpos} - \text{ODneg}}{\text{Sample : ODsample} - \text{ODneg}}$$

Specificity: is the ability of a test to exclude those that does not have preclinical disease or it is the probability that a test correctly classifies individuals without preclinical disease as negative. It can be also expressed as a percentage; the number of individuals without preclinical disease who test negative is in the numerator, and the total number of individuals without preclinical disease is in the denominator.

TABLE 1 Summary of descriptive statistics of variables

Variable	Levels	Frequency (%)
Sex	Female	312 (81.25)
	Male	72 (18.75)
Age	Young (<3.5 years)	127 (33.07)
	Adult (3.5-5.5 years)	122 (31.77)
	Old (>5.5 years)	135 (35.16)
Herd size	Small (<40 *animals*)	124 (32.29)
	Medium (40-75 animals)	142 (36.99)
	Large (>75 animals)	118 (30.73)
Contact with Wild life	No	119 (30.99)
	Regularly	108 (28.13)
	Occasionally	126 (32.81)
	Occasionally	157 (40.89)
Contact with PA	No	52 (13.54))
	Regularly	206 (53.64)
District	Asayita	147 (38.28)
	Dubti	97 (25.26)
	Chifra	140 (36.46)
Total		384 (100%)

PA, peasant association.

2.10 | Limitation of the study

Limitation of the present study supposed to be small sample size and small geographically area coverage.

3 | RESULTS

3.1 | Descriptive statistics

In the current study result, out of 384 sera collected from the study population and tested using 3ABC-Ab ELISA, 19.8% (n = 76/384) were found to be positive for the presence of non-structural antibodies against FMDV. Descriptive statistics was used to calculate the proportion of risk factors with the respective categories and frequency with proportion of each category has been computed and summarized (Table 1). Majority of study population, 81.25% (n = 312) were females while about 18.75% (n = 72) of them were males.

3.2 | Seroprevalence of foot-and-mouth disease virus (FMDV)

In this study, out of 384 sera sample tested using FMD 3ABC-ELISA test, the overall seroprevalence of FMDV at animal level was found to be 19.8% (n = 76/384) with (95% CI; 15.8-23.79) and at the herd level 56.94% (n = 41/72) in the study districts of the region.

TABLE 2 Herds seroprevalence of FMD in cattle in three districts of Afar region

District	No. of Herd	No. of positive Animals	No. of positive Herd	Herd level seroprevalence (%)
Asayita	27	22	13	48.13
Dubti	20	34	17	85
Chifra	25	20	11	44
Total	72	76	41	56.94

The higher herd level seroprevalence was recorded in Dubti district (85%), which was significant different ($p < 0.05$) from other districts as depicted (Table 2).

3.3 | Analysis of risk factors for FMD seroprevalence

Contributing potential risk factors, such as sex, age, herd size, district, and contact with wildlife and peasant association, were considered as hypothesized risk factors for the occurrence of FMDV. Comparison of FMD seroprevalence between sex groups revealed a highest seroprevalence of females 14.84% (n = 57/384) than male ones 3.90% (n = 15/384) (Table 3). However, this seroprevalence variation was not statistically significant ($p > 0.05$). Seroprevalence of antibodies against FMDV was compared between different age groups of the study populations. An increasing seroprevalence trend was observed with increasing age and the difference was statistically significant. In the current study finding, multivariable logistic regression analysis revealed that age, herd size, study districts and contact with wildlife do have a direct relationship with seropositivity against FMDV. The age groups of cattle was found statistically significant, which means adult cattle were 2.97 times more (Adjusted Odds ratio [AOR] = 2.97, 95% CI: 1.33, 6.63) likely to have a chance of contracting FMD than young cattle. Animals' contact with ungulate wildlife was also considered as contributing risk factor for occurrence of the disease and found to be statistically significant and cattle that contact regularly with ungulate wildlife 8.97 times more (AOR = 8.97, 95% CI: 3.24-24.8) likely to develop the disease as compared to cattle having no contact with wild life by keeping the other risk factors constant.

FMD seroprevalence and herd size seems to have positive association in that an increasing seroprevalence of antibodies against FMDV was observed as herd size increases in aged groups ($p = 0.000$) as depicted (Table 4) and this difference was statistically significant ($p < 0.05$). Moreover, comparison of FMD seroprevalence between study districts revealed statistically significant variation. Animals which were found in medium herd size were 2.49 times more (AOR = 2.49, 95% CI: 1.05, 5.92) likely to develop the disease as compared to cattle found in small herd size. Similarly, cattle found in large herd size were 6.05 time more (AOR = 6.05, 95% CI: 2.54, 14.43) likely to develop FMD as compared to cattle found in small herd size. In addi-

TABLE 3 Summary of univariable and multivariable logistic regression analysis of animal level potential risk factors associated with FMD in selected districts of Afar region

Variables	ELISA test	Result	COR (95% CI)	AOR (95% CI)	*p*-value
	–	+			
Sex					
Female	251	57	1		
Male	61	15	1.08 (0.57-2.04)^{ns}	–	–
Age					
Young	114	13	1	1	1
Adult	89	33	3.25 (1.62- 6.54)*	2.97 (1.33-6.63)*	0.008
Old	105	30	2.51 (1.24- 5.06)*	1.71 (0.78- 3.71)^{ns}	0.176
Contact with wild life					
No	112	7	1	1	1
Occasionally	134	23	2.75 (1.14-6.64)*	2.46 (0.93-6.53)^{ns}	0.070
Regularly	62	46	11.88 (5.1- 27.87)*	8.97 (3.24-24.81)*	0.000
Contact with animals from different peasant associations					
No	49	3	1	1	1
Occasionally	108	18	2.72 (0.76- 9.67)^{ns}	1.92 (0.48-7.64)^{ns}	0.352
Regularly	151	55	5.95 (1.78- 19.87)*	2.28 (0.58- 8.98)^{ns}	0.237

Note: COR, crude odds ratio; AOR, Adjusted odds ratio; CI, confident interval; *, significant; ns, non-significant; 1, Reference factor; -, negative sample; +, positive sample.

TABLE 4 Summary of univariable and multivariable logistic regression analysis of herd level risk factors associated with FMD in Selected districts of afar region

Variables	ELISA test result	COR (95% CI)	AOR (95% CI)	*p*-value
Herd size				
Small	1159	1	1	1
Medium	11527	3 (1.35- 6.66)*	2.49 (1.05- 5.91)*	0.038
Large	7840	6.55 (3.01-14.27)*	6.05 (2.54-14.43)*	0.000
District				
Asayita	12522	1	1	1
Dubti	6334	3.06 (1.65- 5.68)*	2.49 (1.19- 5.17)*	0.015
Chifra	12020	0.94 (0.49-1.82)^{ns}	1.19 (0.54-2.60)^{ns}	0.666

Note: COR, Crude odds ratio; AOR, Adjusted odds ratio; CI, confident interval; *, significant; ns, non-significant; 1, Reference factor; -, negative sample; +, positive sample.

tion, study district was also found to be statistically associated with FMD occurrence in our research finding. Hence, cattle found in Dubti district were 2.49 times more (AOR = 2.49, 95% CI: 1.19, 5.17) likely to develop the disease as compared to cattle found in Asayita district as depicted (Table 4).

4 | DISCUSSION

The present study revealed that FMD is one of the most important cattle diseases in the study areas with an estimated seroprevalence of 19.8% (n = 76/384) at animal level and 56.9% (n = 41/72) at herd level in three selected districts of afar region. In our study finding, the overall seroprevalence of FMDV at individual animal was consistent with previous seroprevalence results of 21% in Borana pastoral area (Rufael et al., 2008), 21% in Borana zone, and Guji zone (World Organisation for Animal Health, 2013), 21% in kellema Wollega zone (Fanta et al., 2014). In contrast to the current study finding, relatively lower seroprevalence of FMD was previously reported with various prevalence magnitude, such as 13%, in selected districts of western Ethiopia (Asresie & Zemedu, 2015), 10.88% in some district of eastern showa zone, Oromia region (Dinaol et al., 2016), 12.05% in the Bench Maji zone,

Southern Ethiopia (Gelaye et al., 2009), 8.8% in South Omo Zone (Molla et al., 2010), 9.5% in indigenous cattle of southern Ethiopia (Megersa et al., 2009), 5.53% on quarantined bulls for export at Nazareth and Dire Dawa stations (Bedru, 2006), and 4.8% in selected districts of western Oromia region (Milkessa et al., 2016). On the other hand, as compared to our study results higher seroprevalence results were reported from previously conducted studies in Borena pastoral and agro-pastoral area with 23% (Berecha et al., 2011), in Borena and Guji Zones with 24.6% (Mekonen et al., 2011), in west Shewa zone, North Shewa zone and Addis Ababa with 30.8% (Beksisa, 2017), 32.7% in Guji zone of Oromia region and 30% in Yeka district city of Addis Ababa as well as eastern zone of Tigray with 41.5% (Ayelet et al., 2012) and 28.3% seropositivity in Akaki-kality sub-city (Negussie et al., 2011). A study finding from neighboring Sudan also revealed that following an active occurrence of the disease, the seroprevalence of FMD was reported with 79% in cattle (OIE, 2012). Moreover, according to (Hafez et al., 2014), FMD seropositivity was reported in Saudi Arabia with 53% seroprevalence and (Namatou et al., 2015) as well as 77% seroprevalence was reported from infected cattle in Uganda. These seropositivity variation of FMD seroprevalence results could be resulted from differences in comparison to the current study finding might attributed to the type of diagnostic tests employed, the sampling method, study areas, the geographic variation and timing of infection, production system, which is characterized by a high level of herd mobility in search of pasture and water, intermingling of animals at watering points, large herd sizes and frequent contact with livestock of neighboring countries through cross-border contact as well as regular contact of livestock with FMD virus reservoirs' of wildlife such as buffalo, wild pigs, kudu and warthog and other factors (Gelaye et al., 2009; Megersa et al., 2009).

The overall herd level seroprevalence in this study was 56.9% (n = 41/72). Our study finding was in line with previous seroprevalence results of (Tesfaye, 2006), who reported the seroprevalence rate of 59% in Borna pastoral area, Berecha et al. (2011) who reported 58.6% in Borna pastoral and agro pastoral area. In this study, the highest herd level seroprevalence (85%) was reported in Dubti as compared to Asayita (48.13%) and Chifra (44%). This might be due to the fact that, Dubti is centres for cattle markets and have high population of small ruminant. This suggests that small ruminants may have an important role in the epidemiology of FMD as they can serve as potential carriers and transmitters of the disease (Jenbere et al., 2011; Mohamoud et al., 2011).

Among the risk factors considered in the current study age, herd size, district and contact with ungulate wild life were found to be statistically significant ($p < 0.05$) in multivariate logistic regression. The seroprevalence of FMD in adult age group was higher than in young group and this age specific seropositivitity of FMD was statistically significant. Thus, Adult cattle were 2.97 times more likely to contract FMD than young cattle. This statistically significant higher seroprevalence of FMDV in old and adult animals than young cattle in this current study finding was in close agreement with previous study reports of Asresie and Zemedu (2015) who reported that adult cattle were 2.7 times more likely to contract the disease than young cattle in western Ethiopia, Berecha et al. (2011) in Borna pastoral and agro-pastoral area, Molla et al. (2010) in south Omo zone and (Megersa et al. (2009) in Gamogofa and Sidama zones, Chepkwony et al. (2012) in Awbere and Babille districts of Jijiga zone. This age correlation with FMD serostatus was also in close agreement with previous study of Ocaido et al. (2009). The possible reasoning for age association with FMD seroprevalence could be due to adult cattle acquiring the infection through frequent exposure over time to multiple serotypes of the virus and could get access to mix with other herds at communal pasture land and market places. Furthermore, it might be due to persistence of antibodies against FMDV for extended periods of time (Tesfaye et al., 2016). Relatively lower seroprevalence in animal groups below 2 years old might be revealing of the existence of passive maternal immunity and low frequency of exposure (Jenbere et al., 2011; Mohamoud et al., 2011). In our study areas, young animals were often managed separately at around homestead so that young cattle have low frequency of exposure to the virus and the prevailing passive maternal immunity can give them protection against the disease. On the contrary, our study result contradicted with (Esayas et al., 2009; Gelaye et al., 2009), who documented no significant association between seropositivity of FMD and age of cattle in Bench Maji zone of southern Ethiopia.

In the present study finding, seroprevalence of FMD was also significantly affected by herd size, which means seroprevalence of antibodies against FMDV increased with increasing herd size. In our study result, those animals from medium herd size and large herd size were 2.49 and 6.05 times more likely to develop the disease as compared to those animals from small herd size, respectively, by keeping the other factors constant. Our research finding was in agreement with (Asresie & Zemedu, 2015; Bayissa et al., 2011; Berecha et al., 2011; Gelaye et al., 2009), who reported that they have positive relationship between FMD seroprevalence and herd size. This direct association might be an indication of contagious nature of the disease and mode of transmission, which is attributed to crowding of animals that can facilitate frequency of direct contact and hence enhance the likelihood chances of transmission.

In our study finding, statistically significant association was found between study districts and FMD seroprevalence of 35.05% (n = 34/97), 14.29% (n = 20/140) and 14.97% (n = 22/147) in Dubti, Chifra and Asayita district, respectively. Thus, cattle found in Dubti district were 2.49 times more likely to develop the disease as compared with those cattle found in Asayita district. Our study finding is consistent with previous reports of (Milkessa et al., 2016), who reports the significant variation of Horro (8.2%) and Gobu-sayo (0.8%) districts of western Oromia regional state (Molla et al., 2010). This might be due to differences in the movement and distribution of livestock, the level of contact between herds and ungulate wildlife and the grazing type in each administrative structure. Moreover, Ekboir (1999) suggested that movements of infected animals are by far the most important dissemination and transmission means for FMDV (Paul et al., 1996) in northern Thiland.

Cattle that contact regularly with ungulate wild life were 8.97 times more likely to develop the disease as compared to cattle having no

contact with wildlife by keeping other factors constant. This study finding was in agreement with previous studies of (Asresie & Zemedu, 2015) in western Ethiopia and (Molla et al., 2010) in South Omo zone who reported that cattle that regularly contact with ungulate wildlife were 3.3 times more likely to develop the disease than cattle having no contact with wildlife. According to (Bronvoort et al., 2008) contact between ungulate wildlife and livestock at watering points and grazing areas is the main risk factor for FMDV circulation and it is a challenge for disease control in East Africa (Lazarus et al., 2012). Although statistical analysis using the chi-square test and univariable logistic regression showed that contact with animals from different peasant association/herds appeared to have a significant effect on seropositivity, multivariable logistic regression showed that contact animals to other herds/peasant association had no statistically significant relationship with the seropositivity of the animals ($p > 0.05$). It was a confounding factor in the relationship between seropositivity and contact with herds/PAs. However, this result contradict with (Asresie & Zemedu, 2015), who reported the herds were 3.4 times more likely to be seropositive for FMD than herds that did not have a history of contact with other herds. The difference from the present study might be because of unequal involvement of differently contact animals' group in our sampling where majority of our study animals were animals that regularly interact with other herds/PAs due to accessibility.

5 | CONCLUSIONS

The current study finding indicated that the overall bovine FMD seroprevalence of 19.8% at individual animal and 56.8% at herd level. Hence, our result revealed that FMD was prevalent in the study areas and herd size, study areas, age and contact with wildlife were found to be the contributing risk factors for occurrence of the disease. Therefore, further studies should be conducted to assess the economic impact of the disease and to implement appropriate control measures in the region. Identification of circulating serotypes (strains) in the areas should be further studied in order to undertake vaccination program.

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AUTHORS' CONTRIBUTIONS

TD: Contributed to conception of the research idea, designing and data collection, data analysis, interpretation of data, writing, editing of the manuscript. WN: Contributed to Sample collection, data analysis and reviewing of the manuscript. All authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Written ethical approval and consent for this study was obtained from Samara University College of Veterinary Medicine of Animal Research Ethics and Review committee (Reference AREC019/2019). Oral consent was also obtained from the farm managers to take samples from their cattle and for further research use of the samples. These written and oral consents were documented.

CONFLICT OF INTEREST

The authors have declared no conflict of interest.

DATA AVAILABILITY STATEMENT

The data sets used and/or analysed during the current study available from the corresponding author on reasonable request.

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