

A Retrospective Study of Foot and Mouth Disease Outbreaks from 2017 to 2023 and vaccination activities in North Shewa Zone Amhara Region, Ethiopia

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ABSTRACT: Foot-and-mouth disease (FMD) is an acute, highly contagious viral disease affecting cloven-hoofed animals and is responsible for significant production losses. A retrospective study was conducted to describe FMD outbreaks in terms of animal species affected, geographic distribution, and temporal patterns in the North Shewa Zone of the Amhara region from 2017 to 2023. Data on FMD incidence were obtained from the DOVAR Report, compiled by the Animal Health Team in the North Shewa Zone. The data were analyzed and presented using tables and figures. During the period, 162 outbreaks of FMD were recorded in 373 (43.4%) of the 24 districts in the zone. The highest number of outbreaks occurred in 2023 (n=50; 39.9%), and the lowest in 2020 (n=2; 1.2%). This trend highlights the increasing prevalence of FMD in the region, raising concerns among local farmers and veterinarians about the potential economic impact and the need for improved vaccination and control measures. Seasonal trends were observed in the occurrence of outbreaks, the highest number of outbreaks occurring during the dry season (December to February, n = 70; 43%), whereas the lowest (n = 11; 6.8%) occurred in the heavy rain season (June to August). The majority of the outbreaks were reported from mid- and highland parts of the zone, with the highest number of outbreaks from the Bassona Worena District (n=27; 16.6%), while the least (only one outbreak) was from the Shewarobit and Gishi District. The morbidity rate and CFR (case fatality rate) were highest in 2023 and 2017, respectively, in relation to the other years; the least was 2020. However, the mortality rate was generally very low. Cattle were the only species affected with FMD in all of DOVAR (100 %). 33,155 doses of FMD vaccine were given during the 7-year period to control the disease. **In conclusion,** Foot-and-Mouth Disease (FMD) is endemic in the NS zone, with an increasing incidence over time. To effectively prevent the disease, regular vaccination of cattle prior to the anticipated outbreak season is recommended. **However,** it is essential to identify the circulating FMD serotypes through continuous surveillance before implementing any vaccination program.

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Key words: Foot and Mouth Disease; North Shewa; Outbreaks; Retrospective; Vaccination

1. INTRODUCTION

1.1. Background and Justification

Ethiopia owns the largest livestock population in Africa with an estimated cattle population of 70 million (CSA, 2021). Amhara region has a large cattle population, accounting for 16.4 million (CSA, 2016); also, North Showa Zone has 1.7 million cattle (North Showa Livestock Office, 2022/23). Livestock not only contributes to the agricultural GDP (45%) and the overall GDP (19%), but also plays a significant role in foreign exchange earnings, accounting for 16-19% (Statista, 2022). In addition to being a crucial part of the agricultural sector, livestock is a source of industrial raw materials (milk, meat, hides, and skin) and high-value proteins for potential consumers in Ethiopia (Aman and Diribi, 2024). Transboundary livestock diseases are a major problem that hinders the transportation of animals and animal products to the international market, despite the tremendous demand for live animals and animal products worldwide (Shapiro *et al.*, 2015; Jemberu, 2016). Foot-and-mouth disease (FMD) is the most major transboundary animal disease that significantly affects Ethiopia's socioeconomic situation.

Foot and mouth disease (FMD), caused by the FMD virus (FMDV), is important from an economic point of view. Virus (Chen *et al.*, 2020) as seven immunologically distinct serotypes, specifically, O, A, C, South Africa Territories (SAT-1), SAT-2, SAT-3, and Asia-1 (Balemual A.2018). FMDV occurs in most parts of the world and is very endemic in most sub-Saharan African countries which exacerbate the farming socioeconomic issues. (Baluka, 2014) disease is also characterized by low mortality in adult animals and sometimes high mortality among young animals and is

attributed to acute myocarditis. (Kandeil, 2013) Formerly, five of the seven serotypes of FMDV (O, A, C, SAT 2, and SAT 1) were endemic in Ethiopia.

FMD impacts animal productivity directly by decreasing milk production, leading to a high mortality rate among young livestock and causing fertility problem, reflected in an increased rate of abortions (Admassu *et al.*, 2015). The morbidity rate for FMD in susceptible animals can rapidly approach about 100%; however, the mortality rate in adult animals is quite low, around 2%, compared to 20% in younger animals. The majority of calf fatalities occur due to cardiac problem and complications such as secondary infections, environmental exposure, or inadequate nutrition (Balemual, 2018).

Transmission can occur by contact, by aerosols, by mechanical carriage, by humans or vehicles, on fomites and through animal products (Admassu *et al.*, 2015). Virus may be recovered from all body secretion (tears, nasal, saliva, urine, feces, milk, vaginal, semen and the placenta of aborted fetus).

Diagnosis primarily relies on clinical signs, supplemented by laboratory examination to identify the serotypes of the responsible virus (Admassu *et al.*, 2015). Although there is no specific treatment, the use of mild disinfectants and protective dressings on inflamed areas is recommended in endemic regions where a slaughter policy is not implemented, to prevent secondary infections (Radostits, 2007). Disease control measures include quarantine, restrictions on animal movement, isolation of infected animals, vaccination programs, and proper disposal of contaminated carcasses, all of which are considered feasible within the Ethiopian economy (Lombard, 2012).

Foot-and-mouth disease is widely distributed and endemic in Africa, Asia, South America, and parts of Europe. The disease can occur in any country, but Japan, New Zealand, and Australia are disease-free (FAO, 2004; Yalew, 2019). In Ethiopia, FMDV is endemic in all production systems, and a large number of outbreaks were reported every year (Ayelet *et al.*, 2012; Jemberu *et al.*, 2016). The majority of the outbreaks were caused by serotypes O, A, SAT 2, and SAT 1 (Jemberu *et al.*, 2016; Yalew, 2019). Studies of FMD undertaken in different parts of the country so far revealed the existence of the disease and reported seroprevalence ranging from 5.6% to 44.2% (Jenbere *et al.*, 2011).

FMD is a well-established endemic disease in North Shewa. The study area is characterized by free grazing, unrestricted animal movement (including markets), limited vaccination efforts, common shared watering sources, and a high animal population, all of which increase the risk of disease spread. Understanding the spatial and temporal patterns of FMD distribution is crucial for gaining insight into the disease's natural history in specific locations and time periods. This knowledge helps in budgeting, planning, and making efficient use of resources. It also enables the development of contingency plans for high-risk areas, the creation of targeted vaccination strategies (using disease maps), and the implementation of other control measures. Despite several sero-prevalence studies conducted in various regions of Ethiopia, no research has specifically examined the spatial and temporal distribution of FMD in North Shewa zone. **Therefore**, this study aims to analyze and identify the spatial and temporal distribution of FMD outbreaks in North Shewa from 2017 to 2023 in the Amhara region of Ethiopia.

Specific objectives

- To identifying the spatial and temporal distribution of FMD outbreaks
- To determine the morbidity, mortality, and case fatality rates
- To analyze the trends of FMD outbreaks over various Area, months, seasons, and years
- To assess vaccination coverage.

2. MATERIAL AND METHODS

2.1. Description of the Area

The study was conducted in the North Shewa Zone of Ethiopia's Amhara Region, situated between latitudes 8°38'–10°42' N and longitudes 38°40'–40°03' E. Spanning an area of 16,172.52 km², the zone is bordered by Oromia to the south and west, South Wollo to the north, Oromia Zone to the northeast, and Afar Region to the east. The region encompasses three agro-ecological zones: lowland (<1800 m, 34.2%), mid-altitude (1800–2400 m, 28%), and highland (>2400 m, 37.8%). The annual temperature ranges between 15°C and 20°C, and the rainfall follows a bimodal distribution, typically ranging from 400 to 700 mm annually. The zone experiences three distinct seasons: Kiremt (the main rainy season), Bega (the dry season), and Belg (the short rainy season). The Zone consists of 24 rural districts, including 7 highland, 11 midland, and 4 lowland districts, along with 442 kebeles (387 rural and 55 urban). Debre Berhan serves as the capital. The livestock population in the region is substantial, with approximately 1.7 million cattle, 2.5 million sheep, 0.4 million equines, and 2.3 million poultry. The study found that the free market-based marketing system in these districts plays a significant role in the transmission of diseases (North Shewa Zone Livestock Office, 2022/23).

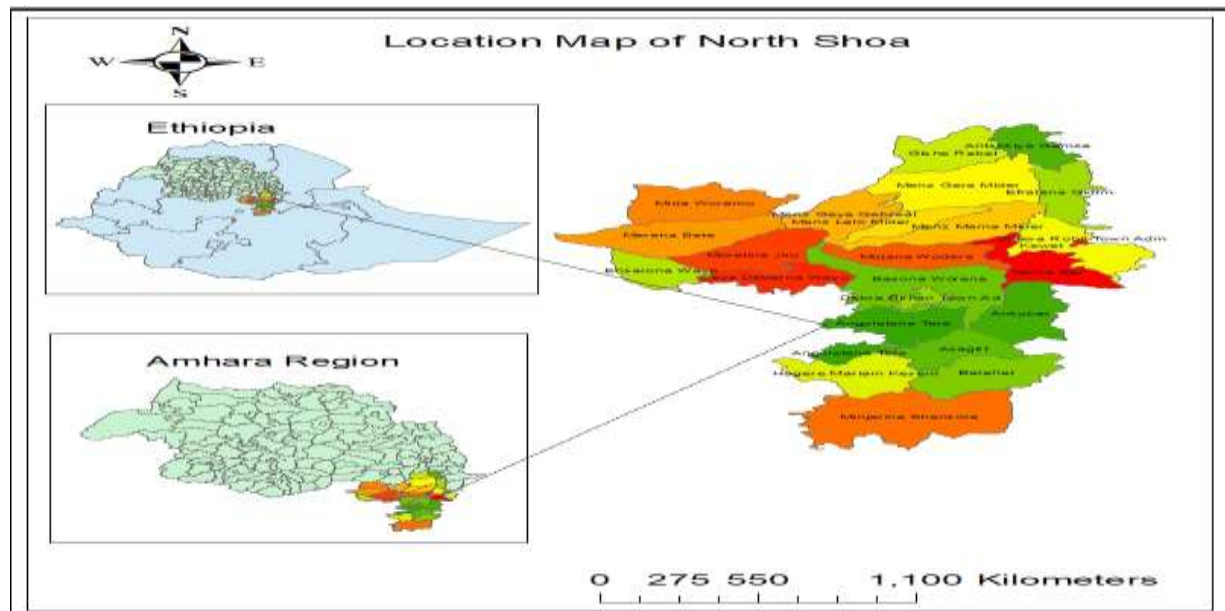


Figure-1 the location of the study area north show a zone wordas/ districts

2.2. Study Population

Due to the absence of disease incidences in small ruminants during the study period, the focus was placed on cattle, with a population of 410,147 found in the study districts. Cattle are raised in an extensive farming system, comprising indigenous, exotic, crossbred, and local breeds.

2.3. Study Design

A retrospective study was conducted to review temporal and spatial occurrence of Foot and Mouth Disease outbreaks and vaccination activities in North Showa Zone in Amhara region, Ethiopia.

2.4. Source of the data

Data on foot and mouth disease (FMD) outbreaks were collected from the North Showa Zone Livestock Office's Animal Health Team, which mandated the submission of Disease Outbreak and Vaccination Activity Reports (DOVAR) from 24 districts. This dataset included key variables such as the affected districts and zones, species involved, outbreak dates, case counts, number of outbreaks, fatalities, vaccination records, and the number of animals at risk. For the purpose of this study, an outbreak was defined as the presence of FMD clinical signs in one or more ruminants within a district. The incidence of FMD outbreaks was then calculated at the district level using the comprehensive outbreak data from the period 2017–2023.

2.5. Dataset Management and Analysis

Microsoft Excel spreadsheets (Microsoft Corporation) were used to manage the data and draw graphs. Descriptive methods were used to calculate outbreak incidence. The mean FMD outbreak incidence was calculated by summing all reported FMD outbreaks over the study period in the zone divided by the total number of districts and number of years (district years). The spatial distribution of FMD outbreaks over the study period was drawn by districts using QGIS version. The number of FMD outbreaks reported in the seven-year period was graphed to visualize the temporal trends of the disease. The graph was inspected for the presence of seasonality.

3. RESULTS

3.1. Temporal Distribution of FMD Outbreaks:

A total of 162 FMD outbreaks were reported in North shewa zone of Amhara region between 2017 and 2023 with an average and median of 23 and 19 outbreaks per year respectively. The results of this retrospective study showed those 5,246 cases and 67 deaths and fatality of 1.27%. The record showed that FMD outbreaks occurred every year with the highest in 2023 (30.9%). Likewise, the greatest number of morbidity cases was recorded in 2023 (34.2%) while the least in 2020 (0.3%). On the other hand, highest number of deaths from FMD was recorded in 2023. Cattle were the only domestic animals affected by the outbreaks No recorded data on other Animals in DOVAR. (Table1).

Table 1: FMD outbreaks by year, suspected cases and deaths in North shewa zone from 2017 up to 2023

Year	Number of outbreaks	Proportion OB (%)	Number of suspected case	Number of death	Morbidity (%)	Case Fatality (%)
2017	32	19.8	1374	6	26.2	0.43
2018	9	5.6	157	1	2.9	0.64
2019	14	8.6	242	5	4.6	2.06
2020	2	1.2	17	0	0.3	0
2021	36	22.2	1355	18	25.8	1.33
2022	19	11.7	305	4	5.8	1.31
2023	50	30.9	1796	33	34.2	1.84
Total	162	100	5246	67		1.27

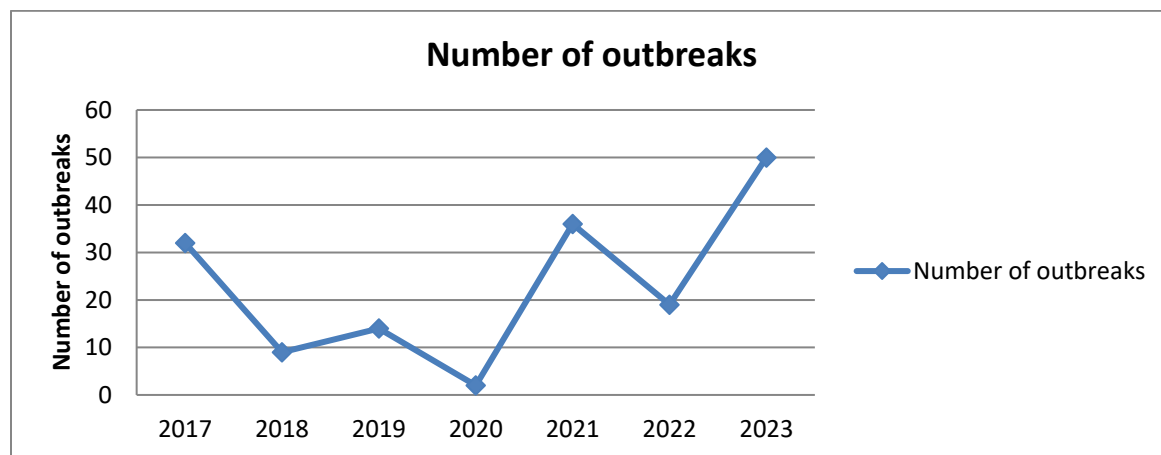


Fig. 2: Number of FMD outbreaks by year (2017-2023) in North Shewa Zone (NSZ)

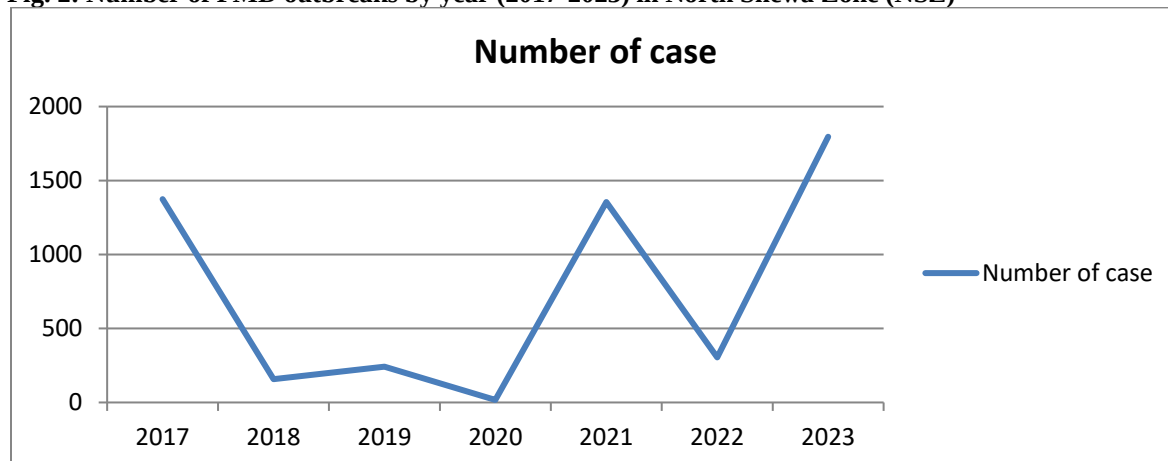


Fig. 3: Number case of FMD by year (2017-2023) in North Shewa Zone

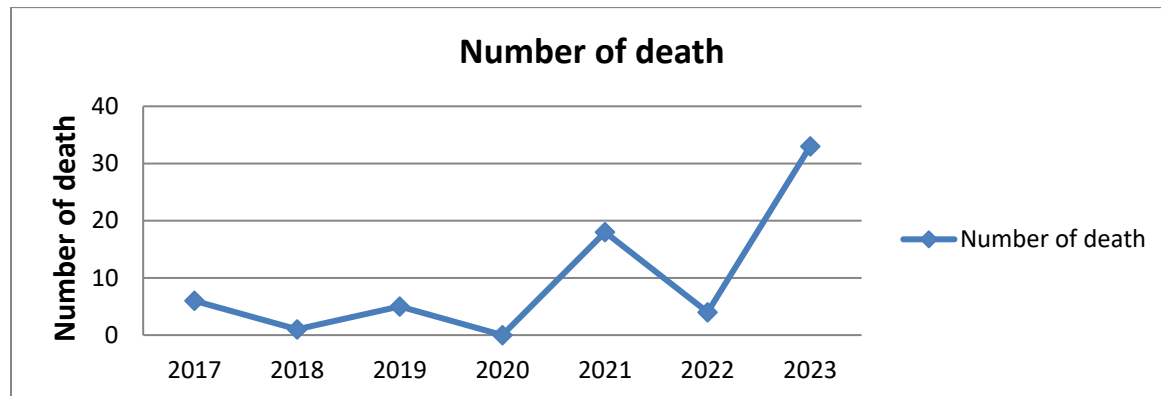


Fig. 4: Number death by year (2017-2023) in North Shewa Zone (NSZ)

During the period, FMD outbreaks were observed all year round showing that the disease is endemic in the Zone. However, there was considerable variation in the number of outbreaks across the months of the year. The highest frequency of outbreaks was reported in December (n = 29) which accounted for 17.9% of all the outbreaks reported and the lowest in April (n=4) and there is no outbreak registered on June and July (n= 0) for each these show the (Table-2).

When the overall data were grouped by season, the highest incidence was reported in the dry season, (December – February, n= 70; 43.2%) followed by early dry season (September - November, n=64; 39.5%) and the short rainy season (March - May, n=17; 10.5%). The lowest incidence was recorded in heavy rainy season (June and July, n=11; 6.8%).

The result indicted, the large number of animal infected by the disease in the month January and August (n= 851) and (n= 846) respectively. Whereas, small number cattle infected month June and July has no outbreak recorded. These show that Table- 2, and figure-1 below:

Table-2: the frequency of FMD disease outbreaks at the time from 2017 to 2023.

Month	Number Outbreak	Proportion (%)	Number of Case	Number of death	Case Fatality (%)	Mortality rate (%)
January	23	14.2	851	9	1.06	0.03
February	18	11.1	581	11	1.89	0.04
March	8	4.9	152	0	0	0.00
April	4	2.5	89	2	2.25	0.03
May	5	3.1	113	1	0.88	0.01
June	0	0	0	0	0	0
July	0	0	0	0	0	0
August	11	6.8	846	3	0.35	0.02
September	23	14.2	626	5	0.80	0.01
October	15	9.3	511	6	1.17	0.03
November	26	16.0	808	24	2.97	0.04
December	29	17.9	669	6	0.90	0.01
Total	162	100	5246	67	1.28	0.02

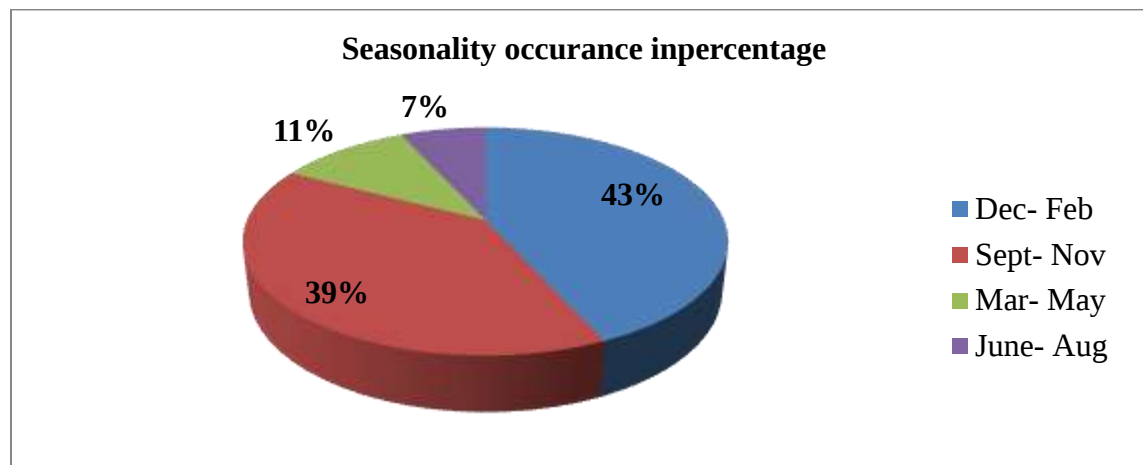


Fig. 1: FMD outbreaks by seasons of the year (2017-2023), NSZ

As shown in **Table 3** below, the morbidity rate and CFR (Case Fatality Rate) was highest in 2023 and 2017 respectively in relation to the other years; the least was 2020. However, the mortality rate was generally very low.

Table 3: FMD Morbidity, Mortality and case fatality by year, North shewa zone, 2017-2023 E.C

Year	Population at risk	Number of Case	Morbidity rate (%)	Number of death	Mortality rate (%)	Case fatality rate (%)
2017	60479	1374	2.27	6	0.01	0.44
2018	15192	157	1.03	1	0.01	0.64
2019	15943	242	1.51	5	0.03	2.07
2020	450	17	3.78	0	0.00	0.00
2021	62500	1355	2.17	18	0.03	1.33
2022	22288	305	1.37	4	0.02	1.31
2023	92852	1796	1.93	33	0.04	1.84
Total	269704	5246	1.95	67	0.024	1.28

3.2. Spatial Distribution of FMD Outbreaks:

FMD was reported from 24 districts in all North Shewa zone between 2017 and 2023. During the study period FMD outbreak has been reported from all districts (n = 24) of North shewa zone. All districts in North shewa zone reported more than one FMD outbreaks during the period. A total of 162 FMD outbreaks were reported during the study period. Most of these outbreaks highest frequency of outbreaks was reported in Bassona worena (n = 27) which accounted for 16.7% of all the outbreaks reported and the lowest in shewarobit and Gishi (n=1) which accounted for 0.62% (Table-3):

Table-3 The number of FMD outbreaks in different Districts from 2017 to 2023

Nameof Woreda	Number of Outbreak	Proportion (%)	Number of Case	Number of Death	Population at risk
D/birhan	6	3.70	128	0	6700
B/worana	27	16.7	416	13	29164
Ankober	4	2.47	47	2	4712
M/wodera	8	4.94	228	4	24686
Taremaber	5	3.09	138	0	15456
Kewot	3	1.85	74	1	15429

Shewarobit	1	0.62	6	0	580
Eferatagidem	3	1.85	51	0	5525
Antsokeya	2	1.23	25	0	5656
Gishia	1	0.62	7	0	1240
Menze qeya	11	6.79	215	7	14787
Menze gera	15	9.26	229	0	27572
Menz lalo	4	2.47	385	7	8006
Menze mama	2	1.23	160	0	3550
Angolela	9	5.56	157	8	29900
Asagiret	5	3.09	280	3	6948
Hagermariam	9	5.56	531	5	11300
Minjare	8	4.94	542	6	10847
Berehet	4	2.47	216	0	9652
Siyadeber	7	4.32	544	2	6005
M/jiru	2	1.23	54	2	3253
Ensaro	7	4.32	91	0	2750
Merhabet	2	1.23	350	3	2050
Midda	17	10.49	372	4	23936
Total	162	100	5246	67	269704

From the above information the highest frequency of outbreaks was reported in Bassona worena (n = 27) which accounted for 16.7% of all the outbreaks reported and the lowest in shewarobit and Gishi (n=1) which accounted for 0.62% (Table-3):

This study result indicted, the large number of animals (cattle) infected FMD outbreaks Minjar (n= 542) and Hageramriam (n=531), followed S/wayu worda. Whereas, small number cattle infected by FMD outbreak Shewarobit (n=6) next to Gishia (n=7) Districts.

3.3. FMD Vaccination utilization:

FMD Vaccination: The result of record analysis revealed that 33,155 doses of vaccine were given during the 7-year period as a control and prevention against FMD. Vaccination coverage of FMD is presented on Table 4 below. Highest number of control vaccination was given in 2017 (11610 doses of vaccine) and are not given vaccination for prophylactic protection in endemic areas.

Table 4: FMD outbreaks by year, number of districts disease occurred and vaccinated animals in North shewa zone from 2017 up to 2023

Year	Number of outbreaks	number of district FMD occurred	vaccinated animals
2017	32	15	11610
2018	9	5	550
2019	14	6	2750
2020	2	2	0
2021	36	15	3180
2022	19	7	4000
2023	50	15	11065
Total	162		33155

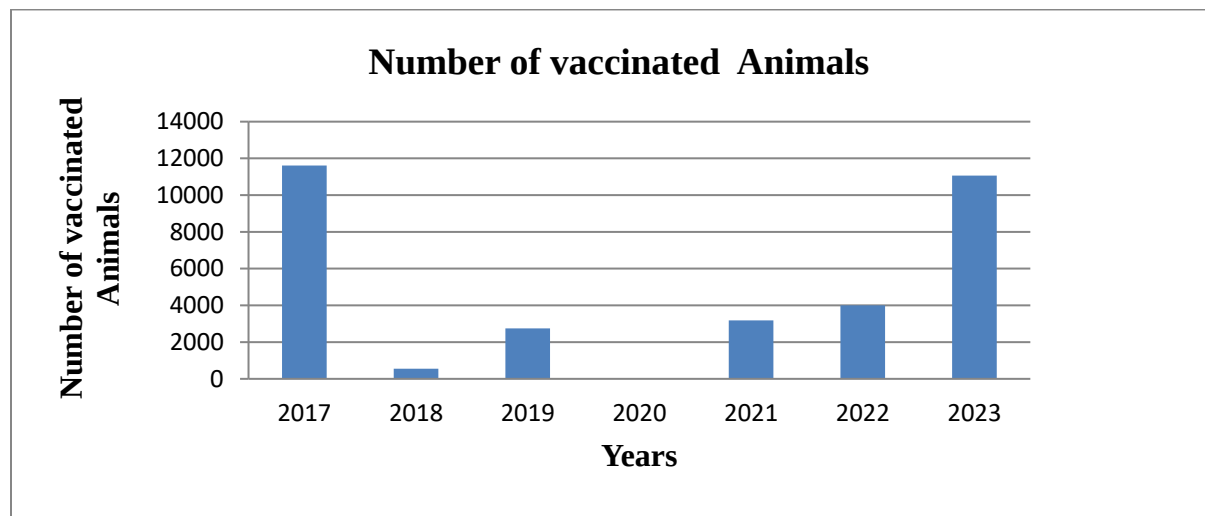


Fig. 7: FMD Number of vaccinated Animals of the year (2017-2023), NS

During the study period from 2017 to 2023, FMD outbreaks were recorded in all woredas of the North Shewa Zone, with the highest incidence reaching up to 162 outbreaks. The retrospective analysis conducted in this study indicates that FMD is endemic in the North Shewa Zone, particularly in the highland regions (indicate percentage). These findings are in agreement with the reports by Ayelet *et al.* (2012), which identified the highest number of outbreaks in the North Shewa Zone, and Jemberu *et al.* (2014), who noted the frequent occurrence of FMD outbreaks in the central part of the country, which includes North Shewa

4. DISCUSSION

The current retrospective study revealed that FMD is endemic in the North Shewa Zone, especially in the highland area. FMD outbreaks were reported from all woreda of zones during the study period, with the highest outbreak incidence of up to 162 outbreaks in the North Shewa zone, which is consistent with Ayelet *et al.* (2012) who had reported the highest outbreak in the North Shewa zones of regions. Another report by Jemberu *et al.* (2014) showed the frequent occurrence of FMD outbreaks in the central (which includes North Shewa) part of the country, which agrees more or less with the present findings.

The Spatial analysis demonstrated that FMD was persistently present in North shewa zones. These five districts (Deber berhan, bassona woreda, M/wodera, Anegollela and Hagermariam) together accounted for **36.16 %** of the total outbreaks. The reasons for this might be the fact that this district share with big livestock market and also where animals travel long distances and can cross national Markets. This can facilitate contact between different herds from different localities, including neighboring district, which are a continuous source of infection.

Temporal patterns of disease outbreaks were decomposed into long-term (secular), cyclical and seasonal trends. In the present study, the highest frequency of FMD outbreaks was reported in the dry season (December to February). More than 40% of the total outbreaks were reported. Various researchers reported that this might be associated with factors such as drought. In agreement to the present finding, (Rufael *et al.* 2007) and (Molla *et al.* 2013) reported that the seasonal incidence of FMD is high during the long dry season (December to February) and lowest in the rainy season (June to July). High FMD incident was associated with the hot season, extending from October to March. The hot season might be scrutinized as the real time for the occurrence of an FMD outbreak. This time is the time of the year where cattle's are allowed to move from one place to another, freely, in search of the pasture & water. Livestock marketing also affects animal mobility (Woldemariam *et al.*, 2022).

This study showed that suspected cases of FMD were recorded more frequently in cattle. A similar observation was also reported by several studies in Ethiopia (Megersa, *et al.* 2009; Mekonen *et al.*, 2011; Sulayman, 2018; Desissa *et al.*, 2014). According to the result of this study, morbidity rate, mortality rate and CFR are low. There is finding by (Mahmoud *et al.* 2017) who states that morbidity rate in susceptible animals can rapidly approach 100% but CFR is generally very low. Moreover, the study conducted by (Jemberu, *et al.* 2014) describes that FMD outbreak in the cattle population of smallholder farmers causes high morbidity and associated economic losses that represent a significant

part of smallholders' income. This variation might be due to the strain of FMDV and the susceptibility of animals (Knight-Jones *et al.*, 2017).

In the current study, vaccination coverage is also described. According to the analysis's findings, more vaccinations were administered for FMD control than for prophylaxis. It matches the findings of Hirsh and Zee (2004), who suggested vaccinations as a preventative measure in endemic areas.

5. CONCLUSION AND RECOMMENDATIONS

A total of 162 FMD outbreaks were reported, widespread and well established in the North Shewa Zone. It occurred in all districts, and more than half of the districts in the zone experienced at least one FMD outbreak in the time between 2017 and 2023. Outbreaks are seasonal and occurred more often in the dry season months. An increased number of outbreaks occur in the zone with an epidemic cycle of two to three years. Recognition of temporal patterns and spatial distribution can indicate particular times and areas when and where attention should be given to control and prevent the disease in cost-effective ways. In line with the above result, the following recommendations are forwarded:

- All districts should implement FMD's strategic routing, surveillance, and control system.
- Strategic prophylactic vaccination of animals should commence at the beginning of the dry season together with restrictions on animal movements during dry season months
- The identification of FMD risk factors is crucial due to the increasing frequency of FMD outbursts.
- The surveillance and reporting system in the zone should be improved to prevent and control FMD.
- Attention must be given to those parts of the zone with highest number of FMD outbreaks. Cattle must be vaccinated to minimize the occurrence of outbreaks.
- Further study on FMD in the zone should be conducted to understand the epidemiology of the disease.

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