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Review on Foot and Mouth Disease: Distribution and Economic Significance

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Abstract: Foot and Mouth Disease (FMD) is extremely contagious, acute viral disease of cloven-hoofed animals. The disease is caused by genus Aphtovirus of the family *picornaviridae* which occurs as seven serotypes O, A, C, SAT1, SAT2, SAT3 and Asia1. It has worldwide distribution and one of the most infectious diseases found in nature. The disease has a wide host range and easily transmitted by ingestion, direct and indirect contact, as well as by aerosols. The virus is distributed throughout the body, to reach best sites of multiplication sites such as the epithelium of oro-pharynx, oral cavity, feet, the udder and heart. It is characterized by fever, loss of appetite, salivation and vesicular eruptions on the feet, mouth and teats. The diagnosis of FMD is based on the clinical signs, together with laboratory examination to establish the serotype of the causal virus. It can cause a high number of deaths among young animals and losses in adult livestock. Losses occur in many ways in which loss of production, prevention, treatment and control. Globally, control of the virus can be made by slaughter of affected and in contact animals together with strict regulation of trade in animal and animal products, or by regular vaccination using appropriate vaccine. In Ethiopia, the disease is endemic and the country is economically less developed, the recommended option for control is vaccination against the circulating serotypes based on the continuous surveillance of the disease.

Key words: Economics Significance · Epidemiology · Foot and Mouth Disease

INTRODUCTION

Foot and Mouth Disease (FMD) is also known *Aphtousfever*. The disease is a major global animal health problem [1]. It ranks first among the notifiable list A infection disease of animals [2]. It is the most contagious transboundary animal disease (TAD) affecting cloven hoofed animals of domesticated and wildlife. Among species of the domesticated animals; cattle, sheep, goats, pigs and buffalo are susceptible. It is caused by Aphthous virus known as foot and mouth disease virus; an RNA virus with seven antigenically different serotypes such as A, O, C, Southern African Territories' (SAT) 1, SAT2, SAT3 and Asia1 as well as over 60 subtypes. Foot and mouth disease is still wide spread throughout the world, particularly in Asia, Africa and the Middle East. Even though the disease can occur in any countries; Japan, New Zealand, Australia and some other countries are FMD free countries [3].

Foot and mouth disease is a severe plaque of animal farming, since it is highly infectious and can be spread by infected animals [4]. The main route of infection in ruminants is through the inhalation of droplets, but ingestion of infected feed, inoculation with contaminated vaccines, insemination with contaminated semen and contact with contaminating clothing, veterinary instruments and so on can all produce infection. In animals infected via the respiratory tract, initial viral replication occurs in the prepharyngeal area and the lungs followed by viremic spread to other tissues and organs before the onset of clinical disease. FMD virus is then distributed throughout the body, to reach best sites of multiplication sites such as the epithelium of oro-pharynx, oral cavity, feet, the udder and heart [5, 6].

Symptomatically, the disease is characterized by fever, loss of appetite and weight, blisters on the mucus membranes, especially those of mouth, feet and udder [7].

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Clinical diagnosis based on lesion identification, in the early stage of infection, FMD virus or viral antigens can be detected using several techniques. However, different serological methods are used to detect antibody against FMD virus and is the main indication that infection has taken place [6].

The degree of control of FMD varies in different area of the world. Routine vaccination is used where the disease is endemic; in contrast, a number of disease-free countries have never vaccinated their livestock but have preferred the use strict movement controls and slaughter of infected and contract animals when outbreaks occur [8]. The risk of introduction of FMD can be reduced but not fully excluded and the cost is high. The global increase in travel, trade and transport will inevitably exacerbate the situation reducing the disease at source, in other words in Foot and mouth disease endemic countries, is therefore shared interest and should be considered a global public good [9].

It is one of the most important livestock diseases in the world in terms of economic impact. The economic importance of the disease is not only due to the ability of the disease to cause loses of production, but to the restriction of trade of animals both locally and internationally [10]. The disease has a high morbidity and low mortality with low occurrence in adult animals. However, myocarditis may occur in young animals resulting to death [11].

The recovered animals remain in poor physical condition over long period of time leading to sustained economic losses for the livestock industry. Currently present in two-third of the OIE member countries where it creates sever economic problems and provides a reservoir of disease ready to spread into disease free areas [8]. Foot and mouth disease is most important livestock disease which is endemic and known for its wider distribution in Ethiopia, where the local economy is heavily dependent on livestock. It has the largest livestock population in Africa possessing about 43.1 million cattle, 23.6 million sheep and 18.4 million goats. Losses incurred due to foot and mouth disease in reduced production and efficiency of livestock may be severe and local food security impaired [12].

Therefore, the objectives of this review paper are important in discussing the available information on the distribution, economic impact of the disease and highlighting the prevention and control measures of foot and mouth disease viruse.

General Situation of Foot and Mouth Disease

Definition: Foot and Mouth Disease (FMD) is the most contagious viral disease of mammals and have a great potential for causing severe economic loss in susceptible cloven-hoofed animals. It is characterized by fever, loss of appetite, salivation and vesicular eruptions on the feet, mouth and teats. It is a list A disease according to OIE disease classifications [8]. The disease was identified for the first time by Friedrich Loefffler in 1898 [13] and has different names in different regions of the world which include: Aphtous fever, Epizotic aphtae, Infectious aphtous stomatitis, Aftosa (Italian and Spanish), fievere aphtheuse (French), Maul and Klavenseuch (German), [14].

Ethiology: Foot and mouth disease is associated with foot-and-mouth disease virus (FMDV), is classified within the Aphthovirus genus as a member of the *Picornaviridae* family, being small, a non-enveloped, single stranded RNA virus, icosahedral and is 26 nm in diameter [15], which occurs as seven major serotypes, over 60 subtypes have been described [16]. There also is extensive genetic heterogeneity within individual serotypes with many distinct virus subtypes occurring within each serotype [1].

Epidemiology: *Host range*- All domestic and wild ungulate species can be infected by the FMD virus but the development of the disease is variable depending on the species and virus strain [13]. Among the domestic species; bovines, water buffalo, pigs. Sheep and goats are the most sensitive with more severe disease in bovine and porcine species [4]. In addition, many species of cloven-hoofed wild life, such as deer, antelope and wild pigs, may become infected and several species of such as African buffalo *(Syncerus caffer)*, Impala *(Aepyceros melampus*), Kudu (*Tragelaphus strepsiceros)* species, Warthog (*Phacochoerus aethiopicus)* and elephants that has a role in epidemiology of the disease [6].

Methods of Transmission: The predominant route of FMD virus infection is respiratory tract, although ingestion of contaminated food or direct inoculation also both highly effective in transmitting infection [1]. Transmission can occur by contact, by aerosols, by mechanical carriage, by humans or vehicles, on fomites and through animal products [17]. Virus may be recovered from all body secretion (tears, nasal, saliva, urine, feces,

milk, vaginal, semen and the placenta of aborted fetus). The survival of virus in such excretions depends up on temperature, PH and humidity [1].

The virus can persist in aerosol form for long periods in temperate or sub tropical climates but not in hot and dry climates. The speed and direction of the wind are important factors in determining the rate of air borne spread. In the most favorable circumstance, it is now estimated that sufficient virus to initiate an infection can be wind borne as far as 250km. Generally, foot and mouth disease can be transmitted in number of ways, including close contact of animal to animal spread, long distance aerosol spread and fomites, or inanimate objects, typically fodder and motor vehicles [5].

In tropics, the most important method of transmission is believed to be direct contact between animals moving freely across state and national boundaries for trade or during nomadic movement [5].

In Ethiopia, it is believed that infected animal's movement is common method of spreads of FMD. The movement of animal health workers and artificial inseminators from one farm to the other without taking into consideration the disease situation suggest that these could have been suspected in a spread of virus. On top of these, poor hygienic conditions on the farms notably the absence of foot bath, management practices like failure to isolate infected animals from the healthy ones and the absence of quarantine for newly introduced animals are also open doors for introduction of the virus to a farm[12, 17].

Risk Factors-Host: The species of animals is important factor for the spread of disease as well as susceptible of animals. Cattle and pigs are more susceptible, but goats, sheep, buffalo and other wildlife such as antelope, deer, hedgehogs, elephants, llama and alpaca are also develop a mild symptomatic disease. Although, cattle, sheep and goats can be carriers, they are not regularly source of infection [19]. Immature animals are relatively more susceptible. The wildlife species also play a great role as reservoirs of infection for domestic animals which is difficult to eradicate the disease as well as important for disease control when an outbreak is occurred [5].

Agent: The virus is resistant to external influences including common disinfectants and the usual storage practices of meat trade. It may persist over one year in infected premises, for 10-12 weeks on clothes and feeds [1]. Foot and mouth disease virus can survive in dry fecal material for 14 days in summer, up to 6 months in slurry in winter, for 30 days in urine and 3 days in summer and 28 days in winter [5].

Environment: Under favorable condition of low temperature, high humidity, moderate wind and comfortable topography, the virus in aerosols may spread to for long distance. Generally, the integrations of these three factors are important for the disease occurrence, of which if one is not available, the disease does not occur [2, 5].

Morbidity and Case-Fatality Rate: The morbidity rate in outbreaks of FMD in susceptible animals can rapidly approach 100% but some strains are limited in their infectivity to particular species. However, the case fatality is generally very low, about 2% in adults and 20% in young stock [5].

Mortality in adult animals is usually low to negligible; up to 50% of calves may die due to cardiac involvement and complications such as secondary infection, exposure or malnutrition [20]. Mortality in suckling pigs and lamps ranges from 20-75% in most extreme cases and it is highly age dependent, infect for animals under 4 weeks of age, mortality is high and decrease rapidly as animals get older (>4weeks). During outbreaks in endemic and developed countries, most deaths are due to a slaughter policy that usually involves all susceptible animals and herds in contact with or within a certain radius of infected herds [21].

Pathogenesis: The respiratory system is the most important portal of infection. After inhalation, the virus can affect the pharynx and primary multiplication of the virus in the mucous membrane is transported by lymphatic and blood circulation to the sites of secondary multiplication in the lymphatic glands, epithelial tissues in and around the mouth, feet and in the mammary glands [13]. Following secondary replication in other glandular tissues, the virus appears in different body fluids such as milk, urine, respiratory secretions and semen, before the appearance of frank clinical signs of FMD. The virus can also persist in oral cavity of infected animals for long periods after the acute infection [1]. In cattle, virus may be detectable for periods up to 2 years after exposure to infection, in sheep for about 6 months [7].

Gross lesions develop only in areas subjected to mechanical trauma or unusual physiological conditions such as the epithelium of the mouth, feet to a less extent, the teats. Bacterial complication generally aggravates the lesions, particularly those of the feet and the teat, leading to severe lameness and mastitis, respectively. In young animals, especially neonates, the virus frequently causes necrotizing myocarditis and this lesion may also be seen in adult infected with some strains of the virus particularly type O [5]. In fatal cases, death is caused either by dehydration or by ventricular fibrillation during cardiac attacks or as a result of bacterial complication [13].

Clinical Signs: When susceptible animals are in contact with clinically infected animals, clinical signs usually develop in 3 to 5 days, although in natural infection, the incubation period may range from 2-14 days. The severity of clinical signs of the disease varies with the strain of the virus, the exposure dose, the age and breed of the animal, the host species and its degree of immunity. The signs can range from a mild or in apparent in sheep and goats to a severe disease occurring in cattle and pig [6].

The disease in cattle is characterized by fever, depression, excessive salivation, lameness and formation of vesicular type lesions on the mucous membrane of the mouth (tongue, dental pad and gums) and the skin of the muzzle, interdigital spaces, udder, teats and coronary band [21, 22]. Lesions on the tongue often heal within a few days, but those on the feet and within the nasal cavities often become infected secondary with bacteria resulting in prolonged lameness and mucopurulent nasal discharge [7]. Young calves, lamps, kids and piglets may die before showing any vesicles because of necrotizing myocarditis. Vesicles also develop in the skin of teats and udders of lactating cows in which milk yield drops dramatically and resulting in mastitis [21].

The sudden onset of severe lameness is the commonest finding in affected pigs, the feet of which are obviously painful. The back may be arched, reluctance to move is common and movement may be accompanied by squealing. Vesicles appear as raised white areas of 0.5-1cm in diameter on the dorsum of the tongue, on the snout and on the teats of the sow and rupture readily to leave small ulcers [5, 23].

In sheep and goats, if the clinical signs occur, it tends to be very mild and may include dullness, fever; and small vesicles or erosions on the dental pad, lips, gums and tongue. In most cases mild lameness is the only sign which occurs with vesicles and erosion of the interdigital space [24]. For further description it has been indicated in Fig. [a1].

Fig. 1a: Ruptured oral and feet blister in diseased cow and pig: Source [24])

Fig. 2a: Tiger heart appearance (Source) [24]

Necropsy Findings: The lesions of foot and mouth disease consist of vesicles and erosions in the mouth, on the feet and udder. The erosions become ulcers especially if secondary bacterial infection has occurred. Grossly, the ventricular walls appear streaked with patches of yellow tissue interspersed with apparently normal myocardium giving the typical “tiger heart” appearance as shown within Fig. [a2] below as foci of progressive swelling, necrosis and lysis of keratinocytes in the deeper layers of the epidermis and accumulation of fluid in the space [5].

Tissues to be submitted for histopathology should include oral mucosa and skin containing vesicles or fresh erosions. The heart, mammary gland and pancreas should also include. Most animals infected with foot and mouth disease will not die and since it is important to make prompt diagnosis from clinical cases, histopathology of necropsy of material is often secondary [5].

Diagnosis: The diagnosis of foot and mouth disease is based on the clinical signs, together with laboratory examination to establish the serotype of the causal virus [25]. Due to highly contagious nature and economic importance of FMD, the laboratory diagnosis and serotype identification of the virus should be done in a laboratory. For laboratory diagnosis, the tissue of choice is epithelium or vesicular fluid. Laboratory diagnosis of FMD is achieved by a combination of virus isolation, serological tests and nucleic acid recognition method [8].

Virus Isolation: The isolation and characterization of the virus is the "golden standard" for the diagnosis of viral diseases. The suspensions of field samples suspected to contain FMD virus are inoculated into cell cultures (primary pig kidney cells), incubated at 37°C and examined for cytopathic effect (CPE), 24 to 48 hours post infection. If there is no CPE, it confirms the absence of FMDV in the samples [19].

Serological Tests: The virus infection can be diagnosed by the detection of specific antibody response. The tests generally used are CFT, VN, solid phase ELISA, liquid phase ELISA and non-structural protein antibody tests such as ELISA, enzyme linked immune electro transfer blot assay [24]. The preferred procedure for the detection of FMD viral antigen and identification of viral serotype is the ELISA [9].

Nucleic Acid Recognition Methods: The polymerase chain reaction (PCR) techniques are increasingly used for rapid identification of FMD virus and sequence analysis of any PCR positive. The reverse-transcription PCR (RT-PCR) can be used to amplify the genome fragment of FMD virus in diagnostic material. Specific primers have been designed between each of the seven serotypes [8, 9].

Treatment: No treatment exists for foot and mouth disease [17]. However, proper animal husbandry practices and treatment of secondary bacterial infection and dressing to inflamed areas to prevent secondary infection is recommended in endemic countries where slaughter policy is not enforced [5, 21]. Sick animals may be treated topically with mild disinfectants but also by applying broad-spectrum antibiotics parentally, tetracycline in particular, in order to control the consequences of secondary bacterial infections [5].

Control and Prevention: Foot and mouth disease is subject to national and international control and the measures taken depend on whether the country is free from the disease, is subject to sporadic outbreaks or has endemic infection [25]. Countries free of FMD impose strict import regulation on animals, animal products and potentially contaminated materials from FMD countries. Quarantine and vaccination programs are also used to control outbreaks and to prevent spread of the disease [1]. In countries where the disease is endemic, efforts are generally directed at protecting high yielding dairy cattle by a combination of vaccination and control of animal movement [17].

Preventive measures in the absence of disease should be implemented as follows: Control of national borders to regulate or prevent significant movement of animals and livestock products from non-free neighbors or trade partners. For officially free countries, prohibition of imports of animals and livestock products from non-free countries in accordance with the OIE standards, prohibition to distribute untreated catering waste (human food) to pigs. Emergency measures in the event of outbreaks through: Rapid slaughter of infected animals, in contact animals and herds considered to have received infection by contact, to reduce the quantity of virus released policy of “stamping-out” [13].

Followed by cleaning and disinfection to reduce the risk of re-infection, strict movement controls, extending to movement on and off farms of livestock products. Intensive investigations to determine if infection is likely to have spread to additional locations within or outside of the protection and surveillance zones and containment measures for such herds or villages, depending on the risk identified. And also possible emergency vaccination is important [3, 5].

In Ethiopia context the control of FMD is practiced by involvement of quarantine, restriction of animal movement, isolation of infected animals, vaccination programs, proper disposal of infected carcass and other methods which are feasible to Ethiopian economy [26]. Currently there is no country-wide vaccination program aimed to control FMD and a ring vaccination is carried out around an infected area. Considering the wide prevalence of serotypes O and A, the National Veterinary Institute (NVI) is producing an inactivated vaccine [27].

The procedures commonly used are; control by eradication and control by vaccination or a combination of the two [5].

Eradication: It is policies and actions designed to eliminate completely FMD virus following an outbreak of disease. This includes both 'stamping out', defined by OIE as the slaughter of all infected and in-contact animals, together with cleaning and disinfection and all the other measures that are necessary in the event of an outbreak in an FMD-free country, region or zone. Stamping out involves: slaughter and disposal, cleaning and disinfection, movement controls, zoo sanitary measures and epidemiological monitoring [28].

Vaccination: Killed trivalent (containing O, A and C strains) vaccines are in general use, but because of the increasing occurrence of antigenically dissimilar substrains the production of vaccines from locally isolated virus is becoming a more common practice [5].

The current foot and mouth disease vaccine confers protection for 6 months and hence at least two vaccinations are recommended for prophylactive protection in endemic areas. In vaccinated animals the peak antibody response is attained in 21-28 days and protection can be achieved with in one to two weeks post vaccination. Vaccination can be used to reduce the spread of foot and mouth disease or protect specific animals [21].

The Distribution and Economic Impacts of Foot and Mouth Disease: The distribution and prevalence of FMD in the world: Foot and mouth disease affects all cloven-footed animals and is endemic in Asia, Africa, South America and parts of Europe, North America, Central America and Australia and currently free of the disease [4]. Many countries in Europe are now free of the disease, but out breaks occur from time to time in Britain and in the Channels of Island. United States, Canada and Mexico eradicate foot and mouth disease at different times by test and slaughter programs [29].

A devastating epidemic occurred in Taipei, China, in1997 and over 4 million pigs died or were slaughtered within a few months [11]. The virus was believed to have been introduced from neighboring countries, through mingling of animal products. Spread with in the country and to the other countries was mostly through the movements of livestock not showing obvious clinical signs [20]. Due to poor reporting from the African continent, FMD is considered endemic in most of the African Countries with only Morocco (based on serological survey), Swaziland, Lesotho, Zimbabwe, Namibia, Botswana and the Republic of south Africa being considered free of the disease by the OIE in 1999 [6].

There are no reliable figures for the prevalence of foot and mouth disease in different countries. The general occurs in the forms of outbreak, that rapidly spreads from herd to herd before it is controlled, of the seven standard serotypes A, O and C are prevalent in all continents where the disease occur, SAT1 is found in Africa and Asia and SAT2 and SAT3 are limited to Africa, where as Asia1 occurs only in Asia. This limitation is more due to the pattern of meat trade than to any inherent properties of serotypes. Overall, outbreaks of type O and A occur more frequently than the others [5]. The general geographical distribution of different serotypes of foot and mouth disease virus are indicated by Table 1 and Fig. [a3] for further explicitly of the information about the disease globally.

Table 1: Geographical distribution of foot and mouth disease serotypes

Region	Virus
South America	O,A,C
Europe	O,A,C
Africa	O,A,C,SAT1,SAT2,SAT3
Asia	O,A,Asia1
North and Central America	Virus free
Caribbean	Virus free
Oceania	Virus free

Source: Knipe and Howley [7]

The Distribution and Prevalence of the Disease in Ethiopia: The disease in cattle in Ethiopia was first recorded by food and Agricultural organization and world reference laboratory FAO/WRL, which indicated that FMD serotypes O, A and C where responsible for FMD out breaks during the period of 1957 to 1979 [6]. FMD is endemic and known for its wider distribution in Ethiopia, although its level of prevalence may have significant variations across the different farming systems and agro-ecological zones of the country. The records of the Ministry of Agriculture and Rural Development (MOARD) from 1997 to 2006 showed that FMD outbreak occurred everywhere throughout the country with highest incidence in the central part [30]. The sero-prevalence of FMD among Borana pastoral cattle in 2008 was reported to be 24.6% [2].

Another study that covered broader areas of the country showed sero-positivity of 44.2% with 1.6% and 8.9% mortality and case fatality rates [31]. Serotype O, A, C, SAT1 and SAT2 were identified in Ethiopia [30]. Serotypes O and A are more prevalent and are the major causes of economic losses. FMD impedes export of livestock as well as livestock products [32].

In Ethiopia, factors such as the presence of high numbers of susceptible animals, wild and domestic animals sharing common grazing pastures and watering points in areas where wild life occur, as well as lack of control of animal movement contribute to the frequent occurrence of FMD outbreaks and to the difficulty in controlling the disease [33]. The geographical distribution of FMD virus serotype O and A that has been isolated in Ethiopia and it has been indicated here in below Fig. [a4].

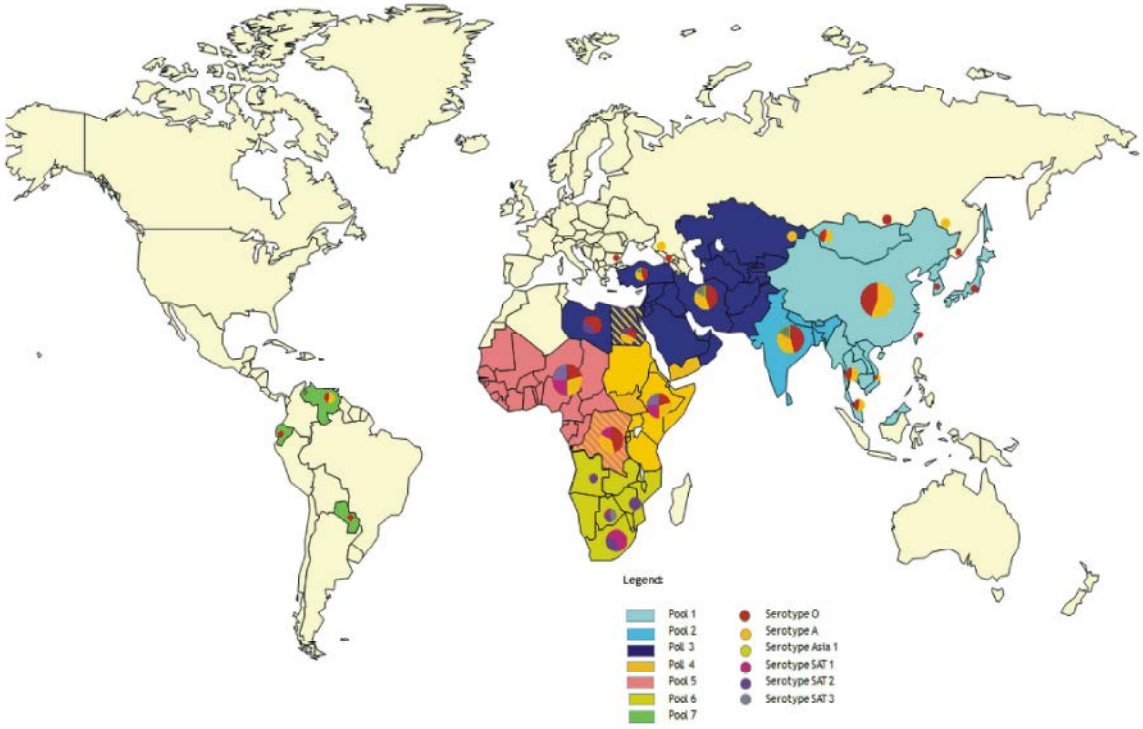

Fig. 3a: Foot-and-mouth disease virus pools distribution, source [36]

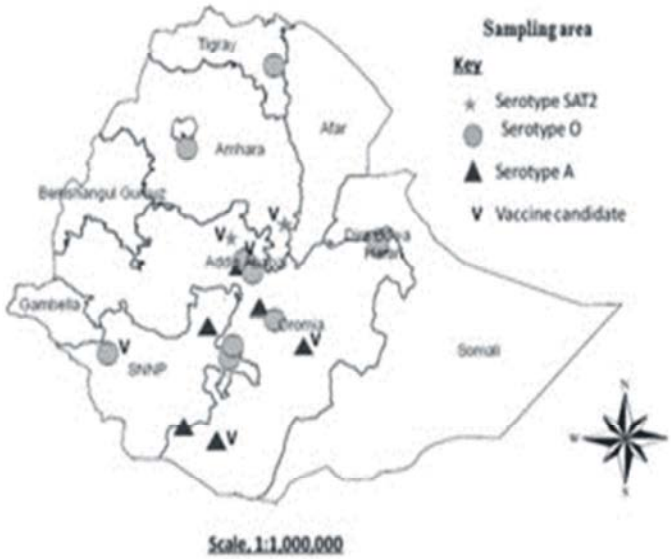

Fig. 4a: Map of Ethiopia showing the distribution of FMD virus serotype O and A isolated in Ethiopia- Source: Ayelet *et al*. [33]

The Economic Importance of the Disease: It is the most contagious of animal diseases with a great potential for causing heavy economic losses in susceptible live stock [34, 35]. Impact of FMD on farmers or producers was considered interms of cattle productivity that means reduction in milk yield, age specific mortalities weight loss and abortions [36, 37]. This impact can be separated into two components the direct losses due to reduction in production and changes in herd structure and indirect losses that relate to the significant costs of FMD control and management and poor access to markets and limited use of improved production technologies [38, 39].

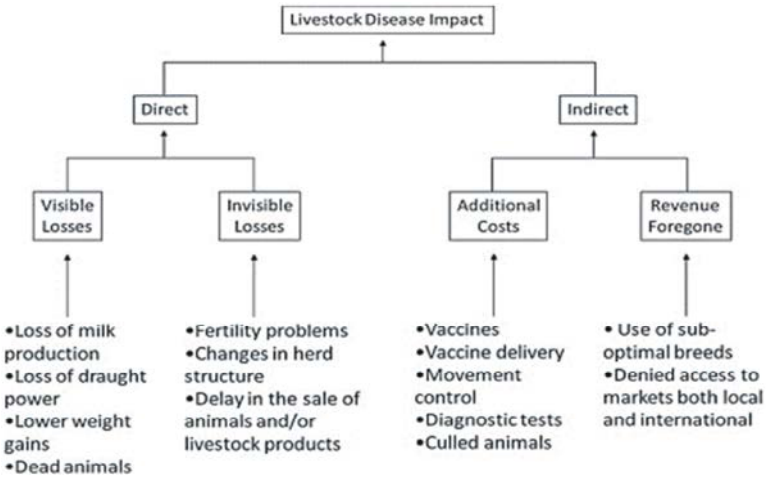

Fig. 5a: The impacts of foot-mouth-disease (Source) [10]

And also there are losses resulting from constraints in international trade in animals and animal products originating from infected countries [40].

The direct production effects in extensive production system include loss of milk due to udder involvement and reduced draught animal power from lesions on the feet. FMD also causes lower rates of live-weight gain in growing animals due to reduced feed intake and reduction in reproductive capacity by increased abortion rates of up to 10% in animals infected during pregnancy; the disease also causes up to 6% mortality in calves. Restrictions on animal movement and international trade can cause much more serious losses [6].

In Ethiopia, where the local economy is heavily dependent on livestock, the burden may be severe and local food security impaired [30]. The impact of reduced productivity of animals can be a long lasting and diseases can have lasting effects on livestock output in a number of "hidden" ways (such as delays in reproduction leading to fewer offspring and the consequences of a reduced population) which often exceed the losses associated with clearly visible illness [18]. At the local level, FMD reduces farmers' income and food availability for consumption. At the national level, FMD slows economic growth by severely limiting trade opportunities [32].

Heavy losses occur in small scale mixed farming system when outbreaks affect draft oxen during the planting season. It causes considerable losses of milk yield and weight gain among dairy and fattening stock [23]. Its role in contributing to the suffering and death of livestock particularly when affected at periods of drought (by limiting their access to feed and water) or at early ages is believed to be significant. The impact of the disease in affecting our export trade has been witnessed by import bans imposed by different countries at different times [27]. And generally the economical loss of FMD disease has been shown properly in the Fig. [a5] here in below.

CONCLUSIONS

FMD is a global disease that is distributed throughout the world, spread through importation of live animals and animal products as well as visitors from infected countries. The economic importance of the disease is not only due to the ability of the disease to cause losses of production, but also related to the reaction of veterinary services to the presence of the disease and to the restrictions on the trade of animals both locally and internationally. Ethiopia is among the countries that are endemic for FMD. The outbreaks of FMD in the country are increasing from time to time. Among the seven serotypes of the virus, the presence of four of them (O, A, C and SAT2) is confirmed in Ethiopia. The presence of foot and mouth disease in the country is a major obstacle to the development of agriculture because of its adverse effects on livestock production and agricultural exports. The current review indicated that transboundary movement of livestock between Ethiopia and the neighboring countries might be the major risk for the distribution of FMD. Based on the above conclusions, the following points are recommended:

- Implementing strict animal movement control both across national and international boundaries to limit the spread of existing serotypes and introduction of new serotypes.

- Priority should be given to well equipped veterinary services and resources to ensure adequate epidemiological surveillance.
- The multivalent vaccine candidates should be formulated containing all serotypes isolated.
- Those areas with highest rate of FMD infection should be considered during control program.
- The importance of wild life in the role of FMD should be studied.
- Rapid diagnosis and information on the epidemiology of each outbreak are key elements of effective disease management.

Conflict of Interests: The authors declare that there is no conflict of interests regarding the publication of this paper.

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