

Review Article

Epidemiological Analysis of Foot and Mouth Disease (FMD) Outbreak in 2014 in Sri Lanka

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Abstract

Sri Lanka faced a massive Foot and Mouth Disease (FMD) outbreak in 2014, which was initiated in Jaffna district in December 2013, and lasted for a period of more than a year, until January 2015. The disease spread throughout the country, affecting 68895 domestic animals, and causing 2007 deaths. The aim of this study was to epidemiologically analyze the data of 2014 FMD outbreak in order to understand the pattern and determinants of the massive disease distribution. Data were collected regarding the number of cases and deaths in relation to the time and location. Data in Disease Outbreak Reports, Follow-up Reports, Disease Investigation Reports and Laboratory Investigation Reports were reviewed, and descriptive and simple statistical analyses were carried out concerning the 57 epidemiological week study period. Disease Incidence, Period Prevalence, Mortality Rate, and Case Fatality Ratio of the disease were determined to be 68895, 6.11%, 0.18% and 2.91%, respectively. Seasonal animal movements and unauthorized livestock transportation appeared to be the main causes for the extensive spreading of the disease, while inadequate vaccination and poor awareness seemingly facilitated the development of three epidemic curves during the outbreak period. Newly identified causative agent, the sub-lineage O/ME-SA/Ind-2001d has led to a more severe FMD outbreak in 2014 compared to the previous outbreaks occurred in Sri Lanka.

Keywords: Disease Distribution; Disease Incidence; Fatality; Mortality; Prevalence

Introduction

Foot and Mouth Disease (FMD) is a highly contagious animal disease caused by the virus Foot and Mouth Disease Virus (FMDV), which belongs to the genus *Aphthovirus* (Family: *Picornaviridae*). It is a non-enveloped, encapsulated, positive sense single-stranded RNA virus with icosahedral symmetry. The virus consists of seven immunologically distinct serotypes, viz. O, A, C, South African Territories (SAT) 1, SAT 2, SAT 3, and Asia 1. Due to its highly contagious nature and the ability to infect both wild and domestic cloven-hoofed mammals, FMD is considered as the most economically important disease of livestock in most of the countries [1].

FMD is an endemic disease to Sri Lanka, since the mid-nineteenth century. According to the history of FMD in the island, epidemics have occurred every 4-6 years [10]. Therefore, FMD has been ranked as a highest-priority livestock disease in Sri Lanka, and had been aimed to control and eradicate by 2020 [12].

In Sri Lanka, FMD outbreaks are mainly controlled by vaccination programs, which include both preventive and ring vaccination [10]. Earlier, preventive vaccination was carried out biannually, and was able to immunize over 70% of the susceptible population in the country. However, currently 'Risk base Vaccination Program' is conducted instead of Mass Vaccination programs. Susceptible animals in and around the identified 'endemic foci' are biannually vaccinated against the disease. Based on the epidemiological data of past FMD outbreaks in Sri Lanka, endemic foci have been identified and considered as risk spots to initiate FMD outbreaks.

Serotype 'O' of FMD virus is the only existing serotype in Sri Lanka. Therefore, a monovalent killed vaccine which is produced locally is used for immunization. Causative agent of FMD in Sri Lanka belongs to the lineage O/ME-SA/Ind-2001 of topotype ME-SA of serotype 'O'. Nevertheless, it was revealed that O/ME-SA/Ind-2001d was the causative agent of the massive

FMD epidemic occurred in 2014, which was identified as a mutated version of the previous lineage. The Ind-2001d virus was circulating in India during 2013, and was introduced to Sri Lanka on two different occasions [1].

The aim of this study was to perform a descriptive epidemiological analysis on the data of 2014 FMD outbreak in Sri Lanka to study the determinants of the spatial and temporal distribution of the outbreak and to estimate the magnitude of the disease outbreak.

Methodology

This observational study was carried out for a period of 57 epidemiological weeks, starting from the 50th (from December 2013 to January 2015). The primary data on the number of infected cases and deaths due to the FMD outbreaks were retrieved from Preliminary Disease Outbreak Reports and Weekly Follow up Reports prepared by field Veterinary Surgeons, and Field Investigation Reports of Department of Animal Production and Health, Sri Lanka. The secondary data were obtained from Livestock Statistical Bulletin of 2014 and Annual Reports of Department of Animal Production and Health (from 2013 to 2014) [2,3].

Descriptive statistics regarding Disease Prevalence, Case Fatality Ratio (CFR) and Mortality Rate of FMD during the study period were used to analyze the pattern of the outbreak. Furthermore, 'Q GIS' computer software was utilized to demonstrate spatial distribution and spreading of the disease.

Samples from the clinical cases in different locations were collected and subjected to Enzyme Linked

Immunosorbent Assay (ELIZA) at the Animal Virology Laboratory of the Department of Animal Production and Health for disease confirmation. Further, virus isolation and characterization were performed by the World Reference Laboratory, Pirbright Institute of United Kingdom by viral genome sequencing and phylogeographical reconstruction.

Period Prevalence: The total number of cases or outbreaks of a disease that have occurred in a population at risk, in a particular geographical area, at a specified point of time or during a given time period.

Mortality Rate: The number of deaths due to a particular cause during a particular period of the time among a particular group

Case Fatality Ratio (CFR): An epidemiological measure of the deadliness or severity of an infectious disease. The CFR is the ratio between the total number of deaths and the total number of officially confirmed (diagnosed) cases over a certain period of time, expressed as a percentage.

Results

The index case of the outbreak was detected from a cattle herd husbanded in a military base in Palali (Thellipalai veterinary range of Jaffna district, Sri Lanka), on the 11th of December, 2013, which spread out of the premises. Initially, two adjoining veterinary ranges (Kopay and Vaddukodai) were affected in Jaffna District. Simultaneously, the disease appeared in Mullathivu district, and Vavuniya North Veterinary Range in Vavuniya district. Around 248 infected cases and 7 deaths in Jaffna district, and 7 infected cases and 1 death in Vavuniya district were reported during December 2013, due to this outbreak.

At the beginning of 2014, the disease started to spread southwards from Vavuniya, affecting Mullathivu, Anuradhapura, Puttalam and Ampara districts (Figure 1). Despite the animal movement restrictions and vaccination programs implemented in and around the infected areas, the disease continued to spread to other districts as well, affecting the whole country. The most likely cause for this havoc seemed to be the uncontrollable movement of animals and animal products, which did not comply with the health measures recommended by the authorities. By the mid-2014, all the districts except Nuwara Eliya became affected, reporting 11808 infected cases and 360 deaths during June. Gradually, the disease incidence declined by October, reporting 1946 affected cases and 20 deaths. However, it was increased again by mid-November. During the one-year period from 2014 January to 2014 December, the entire country was affected, showing three significant epidemic curves (Figure 2).

The total disease incidence for the 57 epidemiological weeks concerned was 68895 with 2007 cattle deaths. According to the temporal distribution, the highest disease incidence was reported in June 2014, as 11808 cases (17.14%) and 360 deaths, constituting the second epidemic curve, which showed the highest intensity. Two more significant epidemic curves were observed in March and November, 2014, with 7990 and 5693 disease incidences respectively (Figure 2). The highest disease incidence values were reported from Anuradhapura (24.49%) and Hambanthota (13.11%) districts, as 16872 and 9036 cases respectively, when considering the whole study period (Figure 3).

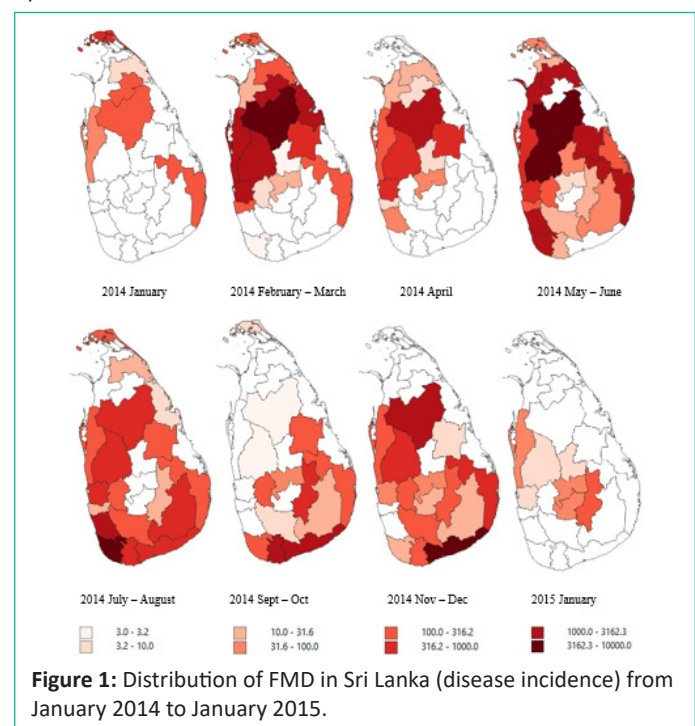


Figure 1: Distribution of FMD in Sri Lanka (disease incidence) from January 2014 to January 2015.

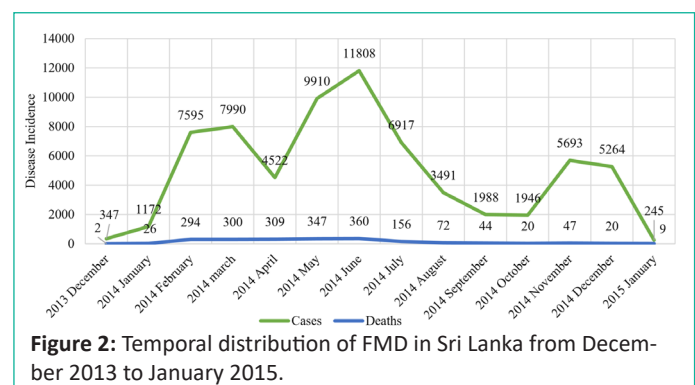


Figure 2: Temporal distribution of FMD in Sri Lanka from December 2013 to January 2015.

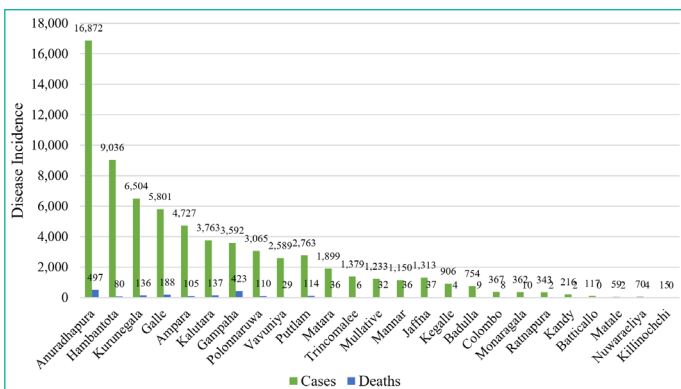


Figure 3: Spatial distribution of FMD in Sri Lanka from December 2013 to January 2015.

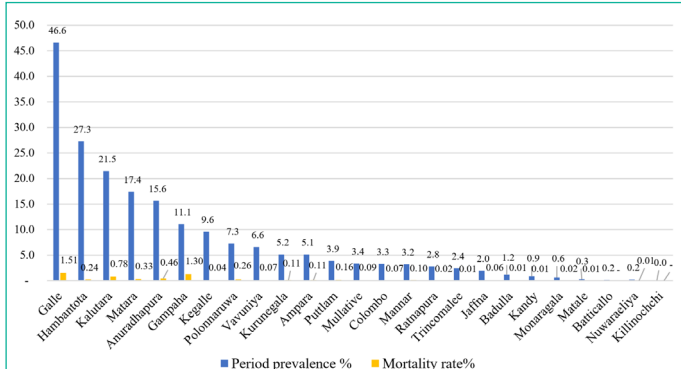


Figure 4: Period Prevalence and Mortality Rate of FMD in Sri Lanka from December 2013 to January 2015.

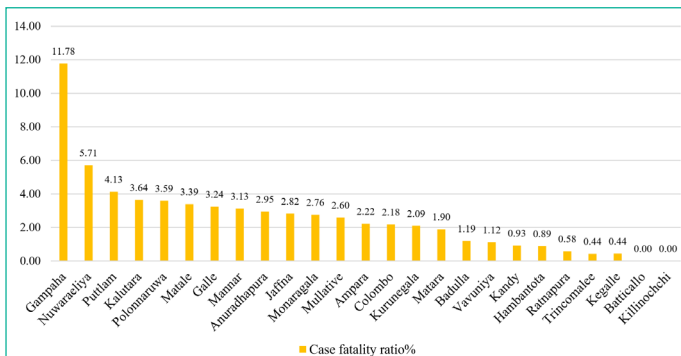


Figure 5: CFR of FMD in Sri Lanka from December 2013 to January 2015.

Period Prevalence of the FMD outbreak for the whole country was 0.0616, and the Mortality Rate was 0.18. Southern and Western Parts of the country showed comparatively higher Disease Prevalence and Mortality Rates. The highest Prevalence and Mortality Rate were both reported from Galle district, as 0.4662 and 1.51 respectively. Although the disease was more severe and retained for a prolonged time in the North Central and North Western Provinces, Disease Prevalence and Mortality Rates of these areas remained at moderate levels (Figure 4). The average CFR of the disease was 2.92%. However, exceptionally high fatalities were reported from Gampaha and Nuwara Eliya districts, as 11.78% and 5.71% respectively (Figure 05). The CFR observed in 2014 (2.92%) turned out to be higher than that in the past few years (0%, 2.02% and 0% in 2011, 2012 and 2013 respectively).

The virus isolation and characterization tests revealed that the 2014 FMD outbreak was caused by the sublineage O/ME-SA/Ind-2001d which had emerged from the lineage O/ME-SA/Ind-2001. The latter had been circulating in the Indian subcontinent since 2006, however, was not recorded in Sri Lanka previously.

Discussion

FMD Epidemic of 2014, initially started as a single outbreak in December 2013 in Jaffna peninsula. However, the route of introduction of the disease is still unknown. As the vaccination program was efficiently implemented in and around the infected veterinary ranges, the outbreak in Jaffna was controlled with convenience.

The second occurrence was reported from Vavuniya South veterinary range of Vavuniya district during the latter part of December 2013. The uncontrollable seasonal movements of cattle crossing the Mullative district through jungle pathways led to the Southward spreading of the disease, affecting districts such as Vavuniya and Anuradhapura. The first case of FMD outside Northern Province was reported in Kebithigollawa veterinary range in January 2014. It is located in the dry zone, and contains large herds of extensively managed livestock utilized for agricultural purposes. These herds have abundant opportunities to mingle with nomadic cattle, especially while sharing grazing grounds and water bodies. This is the likely cause for the transmission of the disease to North Central Province in the beginning of the year 2014.

From Anuradhapura district, the disease spread rapidly and extensively to adjoining districts within few weeks affecting large numbers of animals, resulting in the first minor epidemic curve during the period from February to March, 2014. This epidemic emerged as a result of the returning of cattle to villages during the Northeast monsoon between December to February, as part of extensive livestock management practices [10]. This minor epidemic curve peaked at the middle of March 2014, with 7990 infected cases and 300 deaths. Though it gradually decreased by the end of April as a result of vaccination of susceptible animals, the disease continued to spread towards the Southern regions of the country.

The major epidemic curve occurred in June 2014, resulting in 11808 infected cases with 360 deaths. Movement of livestock and livestock products from affected areas to non-affected regions of the country caused this massive spread of the disease, even into distant districts. As a consequence of the high demand for meat (especially beef) in Western Province, vendors used to purchase cattle from rural areas for very low prices, and transported them to slaughter houses in urban areas. This flow of slaughter cattle into urbanized areas in Western province resulted in introducing and rapid spreading of the disease within the province [10].

Since Sri Lanka is a Buddhist country, cattle salvaging activities are common and play a major role in religious programs, especially during 'Vesak' and 'Poson' festival seasons [10]. As a consequence of releasing salvaged animals to farms in rural areas, the disease was introduced to unaffected districts within Central and Southern Provinces, contributing to the emergence of a major epidemic curve at the end of the second quarter of 2014. Nevertheless, the following four-month period from July to October 2014 showed an exponential decline in disease incidence, as a result of the implementation of successful mass vaccination programs in the affected provinces.

Between the end of October and the end of November 2014, higher disease incidences were reported from Southern Province, particularly from Matara and Hambantota districts. Similarly, Anuradhapura and Kurunegala districts also contributed to create another minor epidemic curve. FMD seemed to have

spread to the Southern Province via cattle transportation, as well as the movement of nomadic cattle from adjacent infected provinces. The spreading of the disease within the province was mainly driven by the direct contact of animals in large managed farms, under free-ranging system.

By the end of January 2015, most of the highly affected areas were recovered, concluding the most significant FMD epidemic of the Sri Lankan history, which lasted for more than a year. Extensive vaccination programs implemented throughout the country played a major role in disease controlling. Development of active immunity by exposure to the disease itself also seems to have contributed to control the epidemic in certain areas of North Central and Eastern provinces, where resources are scarce and accessibility to free ranging large cattle herds is limited.

The study provided a descriptive epidemiological analysis of the FMD outbreak occurred in Sri Lanka in the year of 2014. The highest disease incidences were reported from Anuradhapura, Hambantota, Kurunegala, Galle and Ampara districts, where extensively and semi-extensively managed cattle populations with higher risks of exposure to novel infections are abundant. The disease incidence of 2014 was extremely high compared to that in previous years.

The highest FMD prevalence during the study period was reported from Galle district, as 46.6%, due to the low cattle population (12,442 individuals) compared to other districts with higher disease incidences. Yearly prevalence of FMD during 2014 was 6.80%, which was significantly higher than that in past few years, as they had less than 0% prevalence. Mortality also showed a similar spatial distribution pattern to prevalence in 2014, with a significantly high yearly mortality ratio of 0.17%.

CFR of the outbreak was 2.92%, which was higher than that in 2012 (2.02%), and lower than that in 2010 (4.19%). The highest CFR was reported from Gampaha district (11.75%), corresponding to the high CFR (18.93%) in affected swine population there (408 deaths out of 2155 infected swine). Puttalam and Kalutara districts showed a comparatively high CFR as well, due to the same reason.

The specific causative agent of the 2014 FMD outbreak of Sri Lanka was the sublineage O/ME-SA/Ind-2001d, which was a mutated form of the lineage O/ME-SA/Ind-2001 of ME-SA (Middle East-South Asia) topotype, which belongs to serotype 'O' of the FMD virus. It was speculated that the sublineage Ind-2001d was present in the Indian subcontinent since 2006, co-circulating with Ind-2001e, from where they eventually spread over long distances to the West, East and South. The Ind2001-d sublineage, which circulated in India in 2013, was introduced to Sri Lanka on two different occasions [1].

Conclusion

The observed high intensity of the 2014 FMD epidemic was indicative of high disease susceptibility of animals, or higher infectivity of the causative agent than the previously existed one. High mortality rates during the epidemic revealed the high death risk of the susceptible population. High disease prevalence had resulted in this high mortality rate in 2014 FMD epidemic, when compared with the previous FMD outbreaks of Sri Lanka. CFR, which indicated the severity of the disease, also remained at a higher level compared to previous years, however, within the acceptable range for cattle and swine populations. According to these data, the FMD epidemic caused by the sublineage O/ME-

SA/Ind-2001d in 2014 was more infective and severe than those caused by the previously existed causative agent in Sri Lanka. It is likely that the disease was introduced to Sri Lanka through India, as it was the predominant sublineage there since 2006. However, the route of disease introduction is still inconclusive.

Seasonal movements of susceptible animals, illegal animal transportation, transportation of livestock or livestock products with inadequate health measures, and livestock related activities without proper veterinary consultancy likely resulted in a massive outbreak of FMD all over the country in 2014. While uncontrollable disease spreading, inadequate vaccination processes, and poor awareness on biosecurity and sanitary measures, apparently due to inadequate veterinary extension services seemingly resulted in three epidemic curves during the period of interest.

Author Statements

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