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The epidemiology and socio-economic impact of rift valley fever epidemics in Tanzania: a review

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Abstract: Rift Valley Fever (RVF) is an acute, mosquito-borne viral disease that has a significant global threat to humans and livestock. This review was conducted to provide comprehensive update on Rift Valley Fever (RVF) in Tanzania, with particular attention devoted to trend of occurrence, epidemiological factors, socio-economic impact and measures which were applied to its control. Information presented in this paper was obtained through extensive literature review. RVF occurred for the first time in Tanzania in 1930. This was followed by periodic epidemics of 10-20 years i.e. 1947, 1957, 1977, 1997 and 2007. During the latest disease outbreak in 2007 (the expanded to cover wider area of the country) 52.4% (n=21) of regions in Tanzania mainland were affected and majority (72.7%, n=11) of the regions had concurrent infections in human and animals. Phylogenetic comparison of nucleotide and amimo acid sequences revealed different virus strains between Kenya and Tanzania. Epidemiological factors that were considered responsible for the previous RVF epidemics in Tanzania included farming systems, climatic factors, vector activities and presence of large population of ruminant species, animal movements and food consumption habits. The disease caused serious effects on rural people's food security and household nutrition and on direct and indirect losses to livestock producers in the country. Psycho-social distress that communities went through was enormous, which involved the thinking about the loss of their family members and/or relatives, their livestock and crop production. Socially, the status of most livestock producers was eroded in their communities. Steps taken to combat epidemics included restriction of animal movements, ban of the slaughter of domestic ruminants and vaccination of livestock and health education.

Key words: Rift Valley Fever, Epidemiology, Socio-economic impact, Tanzania

Background

Rift Valley Fever (RVF), caused by RVF virus (RVFV), is an acute, mosquito-borne viral disease that has a significant global threat to humans and livestock (Jouan *et al.,* 1988; Arthur *et al*., 1993; As-Sharif *et al*., 2000; Woods *et al*., 2002). The causative agent belongs to the genus *Phlebovirus* of family *Bunyaviridae,* a group of enveloped RNA-viruses (Flick & Bouloy, 2005). The disease causes a potentially severe disease in both animals and humans (Laughlin *et al*., 1979; Davies *et al*., 1985; Peters & Linthicum, 1994). In ruminant livestock, especially sheep and cattle, the disease is characterised by high mortality (100 % in neonatal animals and 10 % to 20 % among adult animals) and high abortion rates particularly in infected pregnant animals (Coetzer, 1977, 1982). In humans the symptoms of the disease include high fever, strong headaches, body pain, dizziness, nausea, pain within the eyes, loss of weight and bleeding through body cavities (Madani *et al*., 2003; Swanepoel & Coetzer, 2004). The disease is self-limiting, although complications of hemorrhagic fever, retinitis, blindness and encephalitis may occur in 1 – 2 % of affected individuals with a case fatality ratio of approximately 10 – 20 % (Madani *et al*., 2003; Swanepoel & Coetzer, 2004).

RVF is reported as the main cause of the most explosive zoonotic outbreak ever seen recently in Africa (Fredrick, 2008). The number of confirmed cases of RVF in humans is estimated to be 10,000 per year globally (WHO, 2010a). In east Africa, RVF epidemics occur in arid and semi arid areas at intervals of 10 years. The occurrence of RVF epidemics is associated with climatic

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changes with increased rainfall resulting in widespread flooding and resultant swarms of mosquitoes (Davies *et al*., 1985; Linthicum *et al*., 1987, 1999; Anyamba e*t al*., 2002; Woods *et al*., 2002; Martin *et al*., 2007).

Because of its potential to cause severe disease in both animals and man during outbreaks, RVFV is considered a major zoonotic threat which is classified as a category A overlap select agent by the Centre for Disease Control (CDC) and as a high-consequence pathogen with potential for International spread (List A) by the World Organization for Animal Health (Office International des Epizootics) [OIE, 2008]. Furthermore, RVFV is also considered as a potential bio-terrorism tool that could have direct (morbidity and death) and indirect (restriction in international trade) impact in countries that are free from the virus (Bouloy & Flick, 2009). Economic impact attributable to RVF has been found to be substantial (Meegan, 1981; Meegan & Bailey, 1988; FAO, 2003; WHO, 2007b; LaBeaud *et al*., 2008).

The RVFV transmission cycle involves ruminants and mosquitoes. Host susceptibility depends on age and animal species. Humans are dead-end hosts. Research has shown that the life cycle of RVFV has distinct endemic and epidemic cycles (Anyamba *et al*., 2010). During the endemic cycle the virus persists during dry season/inter-epidemic periods through vertical transmission in *Aedes* mosquito eggs. Heavy rainfall and flooding provide an environment for *Aedes* mosquitoes to rapidly multiply and become the predominant mosquito population, which results in extensive livestock transmission and amplification of the virus (Davies & Highton, 1980; Linthicum *et a*l., 1999). Epidemic cycles are driven by the subsequent elevation of various *Culex* mosquito and other biting insect populations, which serve as excellent secondary vectors if immature mosquito habitats remain flooded long enough (Coetzer, 1977, 1982; Turell *et al*., 1984; Logan *et al.,* 1992). Human infections therefore develop either as a result of bites from infected mosquitoes (*Aedes, Culex,* or *Anopheline* spp), exposure to infectious aerosols, handling of aborted foetal materials, or percutaneous injury during slaughtering or necropsy of viraemic animals and ingestion of raw milk (Meegan, 1981; WHO, 2007b). Between epidemics the virus is believed to be maintained through vertical transmission by mosquitoes of the genus *Aedes* and circulates at very low incidence without noticeable clinical manifestation in both humans and animals (FAO, 2003).

Diagnosis of RVF is based on the epidemiological factors including abnormal heavy rains, clinical symptoms and signs, occurrence of storm abortions in small ruminants and serological diagnosis using ELISA. Confirmation of the diagnosis is based on the identification of the organism using RT-PCR techniques. Because propagation of the virus requires strict laboratory guidelines (biosafety level 3 or 4), field diagnosis is mostly done using ELISA technique that has been evaluated in animal and human sera (Paweska *et al*., 2003, 2005, 2007). There is no specific treatment for RVF both in animals as well as in humans and therefore only supportive and symptomatic treatment is provided (WHO, 2007b).

The sustained way of preventing RVF infection in endemic areas is through vaccination of animals. A veterinary vaccine commonly used in Africa is called the Smithburn vaccine. This vaccine was developed (Smithburn, 1949) and confers life long immunity to vaccinated animals. The disadvantage of this vaccine is that it causes abortions and teratogenesis in ewes, cows and goats (Botros *et al*., 2006; Kamal, 2009). There is a risk of transmission from infected blood or tissues for people working with infected animals or people during an outbreak (WHO, 2007b). Protective gears such as gloves and other appropriate protective clothing should be worn and care taken when handling sick animals or their tissues or any other suspected biological materials. Other approaches to the control of disease involve protection from and control of the mosquito vectors. Where appropriate, individuals should wear protective clothing, such as long-sleeve shirts and pair of trousers, use bed nets and insect repellent and avoid outdoor activity at peak biting times of the vector species. Measures to control mosquitoes during outbreaks are effective if conditions allow access to mosquito breeding sites (WHO, 2007b). Dipping of cattle with

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pyrethroid derivatives gets rid not only of ticks but also other biting insects which play an important role in the transmission of RVF (Mlozi & Mtambo, 2008).

This review was conducted in order to provide a comprehensive update on RVF in Tanzania, with particular attention devoted to trend of occurrence, epidemiological factors, socio-economic impact and measures which have been applied to control this significant veterinary and public health threat since it was first reported in the country in 1930. Ultimately, the information gathered in this study will help to improve better understanding of epidemiology of disease and areas at higher risk important for contingency plans for outbreak management, proper allocation of resources to prevent further occurrence and spread of the disease.

Methodology

Information presented in this paper was obtained through extensive literature review. This required identifying and collecting relevant data from journal articles, online books chapters, conference papers, theses and reports so as to evaluate them critically and to synthesize using scientific search engines. We screened articles that described outbreaks and epidemics obtained from the following web sites: Pub Med Google scholar (http:// scholar.google.com), Food and Agriculture Organization of United Nation (FAO) [www.fao.org]. United States Center for Disease Control and Prevention (CDC) [www.cdc.gov]. World Health Organization WHO)[www.who.int] and World Organization of Animal Health(OIE)[www.oie.int]. The search terms used were [Rift Valley Fever] or [Rift Valley Fever Virus] or [Rift Valley Fever Tanzania] or [Rift Valley Fever epidemics or epizootics or outbreaks or occurrence in Tanzania] in all possible combinations with the [trend, history, epidemiology, epidemiological factors, seroprevalence, serology, social impact, economic impact, socio-economic impact, human or animal health, case fatality rates, morbidities, mortalities] and [control measures, prevention, outbreak responses, case management]. Articles or publications included in this study were those published between 1977 (the first outbreak of the disease documented) to 2011, written in English.

Initially, titles and abstracts were screened. Articles identified as possibly relevant were reviewed as full text. The reference lists of included articles were assessed for further relevant publications. Where it was identified that two or more articles presented the same data, only one of those articles was considered in the study. Many publications were available on- line either through open access or via institutional electronic journal subscriptions. Those that were not available on-line were requested using correspondence addresses from respective authors. However, they were such few in the later category. A number of reports on RVF were reviewed at the Tanzanian Ministry of Health and Social Welfare (MoHSW), Ministry of Livestock and Fisheries Development (MoLFD), National Institute for Medical Research (NIMR) and Central Veterinary Laboratory (CVL). Others included Tanzania Floods, Tanzania Food Security Watch, Bank of Tanzania, World Health Organization (WHO) RVF fact sheet, Food and Agriculture Organization (FAO) RVF Contingency Plan, Centers for Disease Control and Prevention (CDC) RVF report, East African Community (EAC), EMPRESS and Central Emergency Response Fund (CERF). In addition personal communications were made with some key stakeholders at the MoLFD and MoHSW.

Publications describing epidemiology, socio-economic impact and trend of RVF in Tanzania were found to be limited. Initial searching gave out 82 articles of which 38 were considered relevant. Upon systematic review, 17 (44.7%, n=38) articles met the inclusion criteria and were included in the study. Of the included articles only one described in detail the socio-economic impact of RVF during the latest epidemic in Tanzania. A total of 20 reports on RVF in Tanzania were collected of which 18 (90%) met the inclusion criteria and were included in the study. Most studies and reports described epidemiology of RVF during the latest 2007 epidemic and only few were found describing epidemics before the latest one.

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RVF and cost-cutting measure in Tanzania

RVF is associated with the Great Rift Valley system that runs from Zambezi River in Malawi, to Lebanon. Tanzania has two forks of this system with one fork branching at the south-western tip of Tanzania and running through the western, periphery of both Tanzania and Uganda. This is the one in which Lake Tanganyika is found. The other fork runs through the centre of both Kenya and Tanzania dividing each country into two halves. The Eastern and Western Rift Valleys traverse the country forming important internal drainage basins (Kalinga & Shayo, 1998).

Tanzania is amongst the countries of the sub-Saharan Africa that has experienced a number of RVF epidemics mostly affecting the northern zone of the country (FAO, 2002: FAO/OAU/IBAR/UNDP, 2001). The disease seems to occur following heavy rains and floods that are preceded by periods of long droughts. The latest re-emergence (2006/2007) of the disease among humans and livestock, had expanded to cover different geographical regions with central zone of the country been mostly affected (Turell *et al*., 2008). RVF is one of the tranboundary animal diseases. Transboundary Animal Diseases (TADS) section placed under the Director of Veterinary Services of the Ministry Livestock and Fisheries Development (MoLFD) in Tanzania vision is: *"By year 2025, there should be a livestock sector, which to a large extent shall be commercially run, modern and sustainable, using improved and highly productive livestock to ensure food security, improved income for the household and the nation while conserving the environment."* Besides Tanzania having the third largest cattle population in Africa after Ethiopia and Sudan (about 21.3 million cattle, 15.2 million goats and 6.4 million sheep) (NBS, 2011) presence TADs including RVF are of economic importance non tariffs barriers to the export of animals and their products. In addition to disease burden Tanzania is a low-income food deficit country. According to World Bank Report Tanzania population is estimated at 39.6 million inhabitants, life expectancy at birth is 46.3 years, infant mortality rate of 78.4 per 1000 live births, and has a Gross Domestic Product of USD 12.1 billion with agriculture contributing 44.5% of the GDP and has an average per capita GDP of USD 210 per year. This economic status might be one of the biggest limiting factor in managing and controlling disease epidemics (including RVF) and other endemic diseases in the country. A further concern about RVF is its implication on human health and national food security because it affects both the humans as well as animals (TBAs, 2005).

Distribution and trend of RVF in Tanzania

Available records at the MoLFD indicate that RVF occurred for the first time in Tanzania in 1930. This was followed by periodic epidemics of 10-20 years i.e. 1947, 1957, 1977, 1997 and 2007 (MoLFD, 2007). However, previous epidemics were very sporadic with little awareness on the disease that made improper documentation of disease occurrence in the country (MoLFD *personal comm*). Contrary to the latest epidemic in 2007 sporadic cases of RVF during the previous epidemics were confined to mainly livestock and mostly affecting northern parts of Tanzania (Kondela *et al*., 1985; Woods *et al*., 2002; WHO, 2010). The latest disease epidemic expanded to cover wider areas (mostly northern and central zones) of the country involving both human and domestic ruminants (Corso *et al*., 2008). Both the 1997/1998 and 2006/2007 RVF epidemics in Tanzania were characterized by sequential outbreaks that appeared across Kenya, Somalia, and Tanzania (Woods *et al*., 2002; WHOb, 2007a) following heavier than usual rainfall and flooding (Bird *et al*., 2008; Breiman *et al*., 2008). The localized outbreaks started in Kenya, followed by Somalia, before being reported in Tanzania (CDC, 2007; WHO, 2007a; Mohamed *et al*., 2010; Nderitu *et al*., 2011). Initially the disease was concentrated in the northern parts of the country that borders Kenya i.e. Ngorogoro and Monduli in Arusha region. Between February and June 2007, other regions of Tanzania including Manyara, Tanga, Dodoma, Morogoro, Dar es Salaam, Coast, Iringa, Mwanza, and Singida reported cases of RVF. Cases were reported until mid-June

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2007 when rains ended (Nderitu *et al*., 2011). By the end of 2007, the disease had claimed thousands of cases in ruminants and several hundred human fatalities (EMPRESS, 2008).

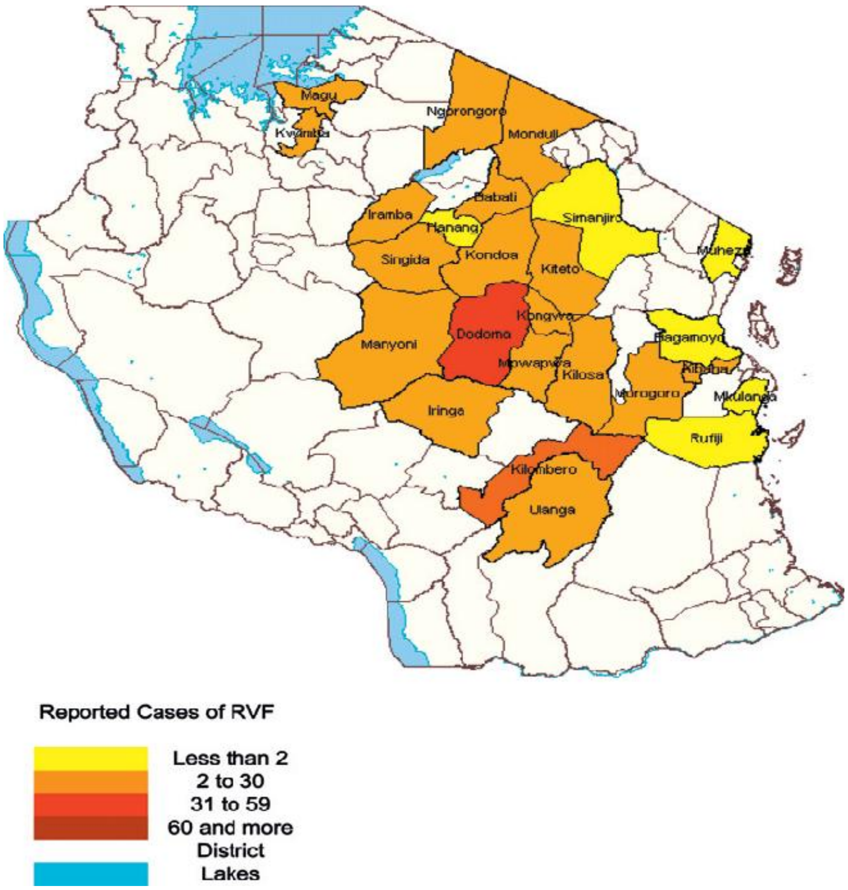

Figure 1: Map of Tanzania showing spread of human RVF cases by Districts during the 2007 outbreak (Source: CERF, 2007)

During the latest disease outbreak 52.4% (n=21) of regions in Tanzania mainland were affected and majority (72.7%, n=11) of the regions had concurrent infections in human and animals. With exception of Magu and Kwimba districts in Mwanza region all other districts that were affected by RVF during the latest epidemic are located in the eastern wing of Rift Valley (Figure 2 and 3). This could be probably due to geo-morphological/dambo like features and climatic conditions present in the eastern wing of Rift Valley that favours survival of *Aedes* eggs during drought periods and are subjected to flooding during heavy rains which results in the lager population of mosquitoes that eventually transmit RVFV to animals and humans. In addition to flooding livestock movements between Mwanza and Kenya (MoLFD personal comm.) might be the contributing factor for disease occurrence in this region.

Besides previous RVF epidemics few studies have been conducted in Tanzania during inter-epidemic periods (IEP) that reported the presence of IgG antibodies against RVFV in Tanga region, North-East at the prevalence of 4 % (Swai *et al*., 2009) and in Mbeya region Southern highlands at the prevalence of 24% (NIMR, 2010). However, the situation on the RVFV activity/circulation during IEP in most of the areas of the country with/without history of epidemics is not known probably because of lack of systematic surveillance activities (FAO/ WHO, 2009).

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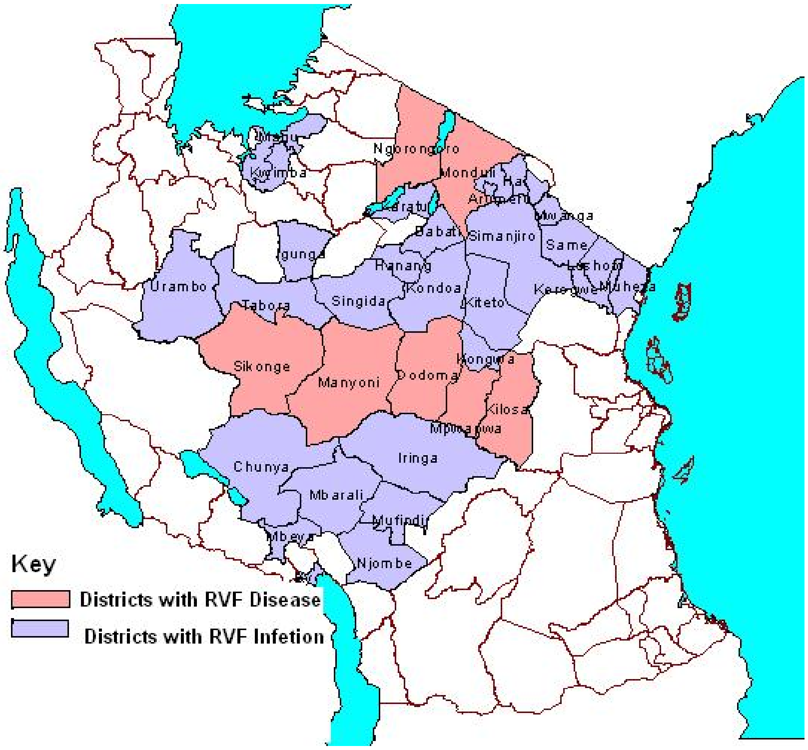

Figure 2: Map of Tanzania showing the distribution of domestic ruminant RVF cases by District during 2007 outbreak (Source: MoLFD, 2007)

During latest epidemic Dodoma was the mostly affected region (Figure 3) having more than 50% of all human cases probably due to lack of awareness on RVF in the community and habit of consuming uninspected carcass and carcass of dead animals (L.E.G. Mboera *et al*., unpubl).

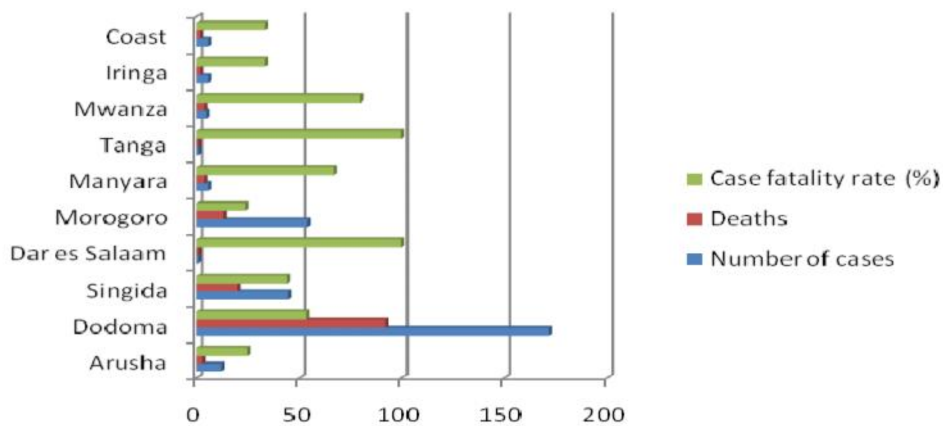

Figure 3: Number of human RVF cases, deaths and case fatality rate in the affected regions in Tanzania 2007

Clinical manifestation of RVF in animals and humans during latest epidemic in the country

The main clinical signs in ruminants reported during the latest epidemic were abortions of pregnant goats and sheep and high mortalities in young lambs and kids (Mlozi & Mtambo, 2008). In all 11 regions that had experienced the latest epidemic of RVF a proportion of 0.4% (n=12,175,115) cattle, 0.6% (n=9,212, 579) goats and 1% (n=3,146, 518) sheep were affected. Of the affected

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ruminants similar proportion of 34% (n=46,680 cattle; n=56,990 goats and n=32,900 sheep) were reported to have aborted. On the other hand a case fatality rate (CFR) of 37% was observed in cattle, goats and sheep. The observed similar trend of abortion and mortalities suggests that once infected by RVFV the clinical manifestation and prognosis of the disease remains more or less similar across these ruminant species.

The main clinical signs in human were high fever, headache, muscle pain, and nausea. Others included abdominal swelling, vomiting, chest pain, bleeding from the nose, ears, and the rectum and loss of consciousness (Mohamed *et al*. 2010). During the 2006/2007 outbreak, 309 human cases with 142 deaths (46% case fatality rate) were reported in the country whereby Dodoma region experienced the highest death rate of 64% (n=144). The clinical signs observed in Tanzania were similar to those reported elsewhere by Swanepoel & Coetzer (2004). However the case fatality rate was higher than previously documented (Balkhy & Memish, 2003; Swanepoel & Coetzer, 2004). For every one human death there were 120 cattle, 147 goats and 85 sheep that died of RVF. Factors that might have contributed to this higher CFR include misdiagnosis/late confirmation of the disease and poor case management (L.E.G. Mboera et al., unpubl).

While fears had been expressed that the virus was becoming more virulent during subsequent epidemics (Nguku *et al*., 2010; Mohamed *et al*., 2010), presence of co-infections might be yet another factor for the observed high CFR in the country. For instance the CFR for RVF plus HIV infection (75%, n=20) was found to be significantly higher contrary to CFR of the RVF-positive but HIV negative cases (13.4%, n=52) (Mohamed *et al*., 2010). In addition, for all 73 patients whose HIV status was known a higher rate of encephalopathy (88.9%) was documented (Mohamed *et al*., 2010) a factor that might contributed to the observed high CFR.

In the latest disease outbreak males (61.8%, n=309), with the highest proportions of cases were observed in the 21-50 years of age group (Mohamed *et al.,* 2010). This young to middle-aged males accounted for a disproportionate number of infections, most likely caused by direct handling of animals and practices such as slaughtering that put males within these age ranges at higher risk of direct contact with bodily fluids from infected animals.

RVF virus strains in Tanzania

Spatial mapping of previous epidemics (before the 2006/2007 epidemic) in the country and molecular analysis of viruses involved were not performed due to late confirmation and response to the epidemic. The relatively early detection of the latest (2006/2007) epidemic enabled performance of spatial mapping and comparison of the sequential outbreaks that occurred in Tanzania and Kenya, isolation and genetically characterization of RVFV strains. Phylogenetic comparison of nucleotide and amimo acid sequences revealed three distinct lineages of RVF virus isolates involved in the 2006–2007 epidemic in eastern Africa (Mohamed *et al*., 2010). Human isolates from distinct foci had identical amino acid substitution patterns, suggesting local spread of a single virus lineage. For example, the isolates from Tanzania, TAN/Tan-001/07 (Tanga) and TAN/Dod-002/07 (Dodoma), had 6 of 7 consecutive amino acid substitutions between positions 419 and 428 of the G1 protein, which were not present in any of the Kenya isolates (Mohamed *et al*., 2010). Although phylogenetic comparison was not conducted in animal and mosquito samples in Tanzania, this homologous substitution in human sera among viruses from different foci in the country i.e. TAN/Tan-001/07 from Tanga and TAN/Dod-002/07 from Dodoma, suggests that amplification and spread of a single virus lineage across regions in the country might have occurred and that during latest epidemic RVFV might have not been introduced into the country from Kenya as it was earlier on suspected. However, the Tanzania 1 lineage virus might have independently emerged in both Tanga and Dodoma. The means of occurrence and/or spread of this similar RVFV strain in the country have not yet been established.

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Risk factors associated with RVF epidemics

Several epidemiological factors were responsible for the previous RVF epidemics in Tanzania. These included farming systems, climatic factors (heavy rains similar to El Niño), vector activities, presence of large population of ruminant species and meat consumption habits (Anyamba *et al*., 2001; Tanzania floods, 2007; EMPRES, 2008; Mlozi & Mtambo, 2008; Nderitu *et al*., 2011). Majority of the RVF positive cases in the latest epidemic were livestock under pastoral and agro pastoral farming systems (Mlozi & Mtambo, 2008). The eastern coastal plain of mainland Tanzania has a tropical hot and humid climate with rainfall varying from 1,016 to 1,930 mm. The inland plateau that was heavily affected by the RVF outbreak is usually hot and dry, with rainfall averaging from 508 to 762 mm (Anyamba *et al*., 2009). During the period between January and June 2007, there was excessive rainfall of an average of 1,720 mm (2- to 3-fold higher than usual) that led to flooding in most parts of the plateau of Tanzania. This above-normal precipitation with subsequent changes in vegetation can be captured by mapping ecological conditions using satellite imagery and developing a normalized difference vegetation index (NDVI). The NDVI for February 2007 showed a significant increase in vegetative cover in the northern central region of Tanzania (the epicenter of the outbreak) indicative of increased rainfall when compared with maps of the same region from October 2006. This anomalous rainfall flooded mosquito-breeding habitats most likely leading to mass hatching of *Aedes* mosquitoes capable of transmitting RVF virus acquired from transovarial infection or by biting infected vertebrates and/or humans.

Basing on the MoLD, livestock statistics for 2006/2007 included 17 million cattle, 11 million goats, and 3.6 million sheep, most of which were located in the north and central regions of the country (MoLD, 2007). It is plausible that heavy rainfall, accompanied by flooding within an area of high density of livestock, created the permissive environment for an RVF outbreak. The areas that were affected by RVF in the country had been identified by FAO (2007) as high risk flood zones. Few months before the latest disease epidemic several lakes and rivers in the country over-spilled, inundating large territories in the south, north, central, western and eastern regions and such floods were associated with RVF occurrence (Tanzania floods, 2007). Previous studies have suggested a close association between climate variability and RVF epidemics (Anyamba *et al*., 2001).

Apart from heavy rainfall, other factors that were responsible for the localized occurrence of RVF outbreaks included flat topology of the area and water retaining soil types that support flooding, dense bush cover, high mosquito populations and high livestock populations (WHO, 1998; 2007a). Other exposure risk factors included contact with animal products including meat and milk from sick animals (Mohamed *et al*., 2010). Consumption habits were important epidemiological factors in the spread of RVF in the pastoral communities (MoLFD, 2007). Majority of the confirmed RVF cases in humans had a history of consumption of meat from sick animals. The two first cases in Manyara and Arusha regions had a history of consumption of meat from a dead sheep; similar incidence was reported in Tanga region (MoLFD, 2007). Some of the inhabitants of Dodoma had a reputation of consumption of condemned meat even from known or unknown diseases (Mlozi & Mtambo, 2008).

Another factor for RVF occurrence and spread was animal movement. Over 90% of the livestock species in Tanzania are of indigenous type with low genetic potential and mostly kept under the extensive system characterized by unregulated mobility of animals because of dependence on seasonal availability of water and pasture (Mlozi & Mtambo, 2008). The largest population of livestock affected in the recent RVF outbreak was the indigenous cattle, sheep and goats under the extensive farming system. No reports of mortalities or abortions were associated RVF in the intensively kept animals (Mlozi & Mtambo, 2008). Apparently, such movements may contribute to acquiring and spread of diseases such as RVF. In addition lack of appropriate slaughter facilities might have contributed to the spread of RVF in the country. In the

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absence of slaughter facilities ante mortem and post mortem meat inspection is usually not properly done.

Socio-economic impact associated with RVF epidemics

Social impacts
Previous RVF outbreaks in Tanzania had severe negative social impacts to people's livelihoods in the country. The disease caused serious effects on rural household livelihoods, food security and nutrition and on direct and indirect losses to livestock producers in the country. Owning livestock is a source of great pride, prestige and possible influence for livestock producers. However, during the RVF outbreak all these aspects were temporarily lost as cattle had no monetary, social or nutritional value. For instance the price of a mature male bull was on average TShs. 285,000 (US$ 238) before the RVF outbreak. However, the price dropped to TShs. 190,000 (US$ 158) during the outbreak period (Mlozi & Mtambo, 2008).

The RVF outbreak resulted in a significant reduction in the consumption of red meat in the affected regions and surrounding areas. Incomes of livestock dependent communities dwindled as a result (MoLD, 2007). The social impacts, caused by morbidity and mortality of livestock and disruption of livelihoods, markets, and the meat industry that resulted from a ban on livestock slaughter, were considerable (Rich & Wanyioke, 2010). Despite improved pasture and animal conditions in pastoral areas of Tanzania following good rains, the disease damaged pastoralist livelihoods through livestock deaths and abortions. In addition to pastoralists, the disease threatened the livelihoods of those who were depending on livestock products and related activities for labour opportunities (Tanzania Food Security Watch, 2007). As a result a class of unemployed/jobless individuals was expanded during epidemics.

RVF was considered by the communities to be a serious disease than HIV/AIDS due to the fact that the RVF outbreak had made them poor as they could not sell their animals, and they went hungry as they could not drink milk and eat meat (Mlozi & Mtambo, 2008). In addition patients were hospitalized within an average of 5 days after onset of illness and they remained ill with RVF-associated symptoms for an average of 28 days (range of 2 to 120 days) before death or discharge (Mohamed *et al*., 2010). Such long-term illnesses, disability and suffering in the patients impaired them to resume their normal economic ventures. On public health aspect, RVF was confirmed in 309 patients of whom 144 died (case fatality rate was 46.6%) of the disease (FAO, 2007; WHO, 2007a).

Psycho-social distress that communities went through was enormous. This involved thinking about the loss of their family members and/or relatives, their livestock and crop production (Mlozi & Mtambo, 2008). It should also be noted that the loss incurred when mourning for a bereaved or attending a sick person, was significant. Socially, the status of most livestock producers was eroded in their communities. Other rural people looked at them as having nothing to brag of as they had lost respect, dignity and experienced low morale, aspects which were exaggerated by their loss of money from selling livestock and their products (Mlozi & Mtambo, 2008).

Economic impacts
The previous RVF epidemics in Tanzania were followed by cessation of the lucrative trade in ruminants. This resulted in serious economic losses to the populations who were totally dependent upon this income (EAC, 2007). An economic impact assessment study on RVF that was carried out in Tanzania by Mlozi & Mtambo (2008) found that livestock internal market flows drastically dropped from February 2007 reaching lowest levels in March 2007. Taking the case of cattle in the Northern zone, a slope of decreasing trend was observed starting in February 2007 in which 4,251 cattle were marketed and dropped to 2,679 cattle in March 2007, a 37% drop.

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Furthermore the data from the same study showed dramatic impact of RVF outbreak on the international animal trade. In 2006 a total of 2,594 cattle were exported to Comoro Islands, while in 2007 the figure dropped to 1,183, a 54% decline in exports. Assuming that the average cost for cattle was TShs. 300,000 (US$ 250) the loss due to 1,411 cattle that were not exported as a result of RVF epidemic accounts to a total sum of TShs. 423.3 million (US$ 352,750) which was substantial. Furthermore, this loss was more if cattle transporters, handlers, city animal fees, inspectors' fees, and rural livestock producers' incomes were to be considered. In addition the number of domestic ruminants that died of RVF during the latest epidemic included 16,973 cattle, 20,913 goats and 12,124 sheep (MoLFD, 2007). The estimate of loss as a result of deaths for cattle was TShs. 5,091,900,000 (US$ 4,243,250) whereas that of goats and sheep was TShs. 2,642,960,000 (US$ 2,202,467).

In the latest outbreak the government spent about US$3.84 million to bring the disease under control, with most of the money going on imported vaccines (MoLFD, 2007). Tanzania been a low-income food deficit country this was a considerable amount of money.

Although few studies have been conducted to assess the economic impact attributable to RVF, in Tanzania it is thought to be substantial (Meegan, 1981; FAO, 2003, Davies, 2006, Clements *et al*., 2007).

Response to RVF

Various measures were taken by the Government in order to control the spread of the disease in the country. RVF was considered under the National disaster category and the National Disaster Preparedness and Response Unit that deals with disasters including avian influenza and others, hence the Unit was tasked to handle RVF preparedness and response plans. The Prime Minister tasked 3 Cabinet Ministers from the Ministry of Livestock Development, Ministry of Health and Social Welfare and Minister of State, Prime Minister's Office, Local Governments to deliberate on the disease. During the 2006/2007, three Deputy Ministers responsible for Local Government, Livestock Development and Health spent weeks in Dodoma participating fully in assessing the situation and conduct of public education on RVF. At the regional levels, Disaster Preparedness Committees were established, members of which included Assistant Administrative Secretary (Economic Development cluster), Assistant Administrative Secretary (Social Services), Regional Livestock Adviser (RLA), Regional Medical officer (RMO) and Regional Health Officer (RHO). The main objective of the committee was to receive and evaluate reports from the Districts on the status of RVF on a daily basis. (Mlozi & Mtambo, 2008)

The steps taken by the MoLFD included RVF surveillance, training of personnel and public awareness, restriction of animal movements to and from the suspected areas, reinforcement of abattoir regulations, ban of the slaughter of cattle and vaccination of livestock (MoLFD, 2007). During the latest disease outbreak 2006/2007, about 4.6 million animals were vaccinated that included a total of 2,668,068 cattle, 1,353,103 goats and 570,862 sheep (MoLFD, 2007). Although vaccination activities were targeting animals in areas without the disease (MoLFD personal comm), the chances of vaccinating already exposed animals might have not been avoided as a result of uncontrolled animal movements, traceability difficulties due to lack of common animal identification mechanism in place and lack of pre-evaluation programme for status of infection in animals before vaccinating. Even though the Smithburn vaccine that was used confers life-long protection in animals its main disadvantage is its residual pathogenic effect and may induce foetal abnormalities and/or abortion in ruminants ((Botros *et al*., 2006; Kamal, 2009). Up to 30 percent of ewes may abort and others develop hydrops amnii towards the end of the term (FAO, 2003). Young lambs may suffer neurological effects. Vaccination in outbreak areas is not recommended at time when there is evidence of RVFV infection (FAO, 2003). A mass vaccination campaign in the RVF epizootic areas should be seriously considered when and where climatic and epidemiological

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evaluations suggest that there is a high probability of outbreaks of RVF (FAO, 2003). The earlier this is done, the greater the chances of success in preventing the more serious consequences of the disease. An early warning of at least two to four months would be required to mount an effective campaign. However, the use of single syringe and needle during mass vaccination programmes may exacerbate transmission especially during time of epidemics.

The MoH&SW strategies to control RVF included formation of a Technical Committee on RVF. A rapid response team was formed and headed by the epidemiology unit of the MoH&SW. Specimens were collected from RVF human suspects and sent to Nairobi, Kenya for confirmation. Health education messages using various media such as radio, television, newspapers, posters and leaflets were prepared and distributed for public use (WER, 2007). However, the absence of operational emergency preparedness plans in the country was a major constraint to responding satisfactorily to the situation and to containing the disease in a timely manner. It is nevertheless laudable that the veterinary and medical authorities responded quickly though with poor coordination and that, despite very limited funding, key control activities were implemented with the support of international organizations and research institutions (CERF, 2007)).

Other control measures included improved safe management of infected animals and humans, rumour investigations in order to save the lives of both humans and animals, encouraging use of insecticide treated nets to reduce human contact to mosquito, advocate behavioural changes for farmers and the general public through targeted public awareness campaigns at national and community levels as the majority of human cases were found to be due to behaviour and practices favouring transmission of the disease, coordination of activities within frontline institutions in-charge of animal and human health to prevent further RVF contaminations (CERF, 2007). It was estimated that approximately ten million people were reached through the various activities at national, district and community level (CERF, 2007). A total of 1.2 million posters and one million leaflets were designed, printed and distributed in the target districts. Implementation of control measures contributed to shorten the duration and the geographical expansion of the outbreaks. The Government declared end of RVF epidemic at the end of June 2007, having had no new cases for one month (CERF, 2007).

Challenges

From past epidemics, it has been observed that each subsequent outbreak had expanded to cover wider areas of the country. The disease had dramatic socio-economic impacts both at community and nation at large. The main challenges related to the control of RVF outbreaks included lack of preparedness plan for RVF, poor coordination and information transmission, limited facilities and manpower for RVF outbreak intervention.

Although there was an early warning on RVF by the end of 2006, the government was not adequately prepared for the disaster. The possibility of RVF outbreak in Tanzania was known well before the end of 2006. However, there were no prior arrangements for vaccination of animals in the risky. Most of the items for outbreak response or services such as test kits, protective gears and vaccines were not available or in stock (CERF, 2007). Even when vaccines were made available time did not allow for pre-assessment of levels of infection in animals before vaccinating. As a result possibility of vaccinating exposed population of animals might not have been avoided.

During RVF epidemics it was difficult to control animal movements even in areas with quarantines. The main problem was tracing the origin of the animals due to lack of appropriate animal identification system. Poor enforcement of the laws and by-laws was also a weakness in part of disease intervention. Probably the Acts and by-laws are not well known to pastoral communities and the general public.

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Though significant delays occurred, in part because mechanisms to support interventions, including financing and logistics of laboratory testing of samples, control of the 2007 RVF epidemic was largely the result of animal and human health agencies working in an integrated manner (Coker *et al*., 2011). Indeed, the outbreak was classified as a national disaster, thus falling under the authority of an inter-ministerial unit, the National Disaster Preparedness and Response Unit, which reported directly to the Prime Minister. A question is how best to harness political support such that prevention through the targeted vaccination of at-risk livestock occurs before the detection of clinical disease in animals and/or humans. All these immensely affected RVF control strategies and therefore should be revised to achieve the best results. However, National RVF contingency plan is being developed by the ministries responsible for livestock development and human health of both Tanzania Mainland and Zanzibar and good progress has been made (JP, 2010).

Other challenges included lack of reliable power back up system, lack or poor equipment and other diagnostic facilities. These might be amongst the limiting factors when there is a need to further analyze the stored samples to better characterize the virus lineages within and between epidemics. In addition there is no clear policy on the storage, accessibility and sharing of the samples.

Conclusion and the way forward

From the review made on studies that had been conducted in Tanzania and available reports focusing on the epidemiology, socio-economic impact and control of RVF, it is obvious that the country had encountered subsequently expanded RVF epidemics with dramatic negative socio-economic impacts. The latest outbreak had the largest case fatality rate than other countries that concurrently faced RVF outbreaks. The fact that northern zone of the country had been involved in each of the previous outbreaks suggests that once introduced into certain permissive ecologies, the RVF virus becomes enzootic, making an area vulnerable to periodic epidemics that are probably precipitated by amplification of resident virus associated with heavy rainfall and flooding. The latest RVF epidemic did not spread from Kenya as it was suspected since RVFV strains involved were different in the two countries.

A number of measures were implemented to control the disease. However, it remains questionable as to which measure(s) was/were most effective as the disease ended when rains had stopped. Measures to control mosquitoes during outbreaks, including the use of insecticides, are effective if conditions allow access to mosquito breeding sites because *Aedes* mosquitoes that are most often responsible for the epicentre for epidemic initiation rarely bites beyond 18:00 hours. This would imply that the use of insecticide treated bed nets (ITNs) might not be an effective means to prevent occurrence of RVF other than probably controlling its amplification when people are covered with bed nets when they would have gone to bed during the night. Outbreaks of RVF have been found predictable; it has inter-epidemic periods that would allow preparations to prevent its reoccurrence.

There is a need for the Regional and District leaders to assist in enhancing awareness in controlling transmission of the disease from livestock to humans stressing on proper boiling of milk, thorough roasting and cooking of meat, as well as avoiding the consumption of non-inspected meat and incinerating any carcass unfit for human consumption. The emergency preparedness plan and early warning systems under development should be implemented by all sectors known to be directly or indirectly associated with RVF management and should be regularly revised.

The Government through MoLFD should ensure availability of vaccine stock and that vaccination of young animals is regular and maintained. Inoculation during outbreaks is usually too late to confer adequate immunity and is fraught with problems such as possible needle

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transmission of the disease from infected animals. Post vaccination evaluation should be scientifically made to ensure animals benefit from the activity. Since it is not known if necessarily vaccinating all animals in the country there is a need to establish what proportion of animals should be vaccinated in order to confer protection in all animal populations in a given area at risky.

The MoLFD should advocate and monitor the use of established system for animal identification and traceability. Movement of livestock from one part of the country to another should conform to the Presidential circular No. 1 of 2002 and Animal Diseases Control Act of 2003. Biosecurity measures to be observed include restricted entry of animals that have recently been purchased or returned to the farm. Such animals should be quarantined for 30 days. Quarantine allows time for a disease to develop in the animal, without exposing the entire herd to the disease agent.

Deliberate efforts should be made to use integrated vector control measures that should be placed under vector control units in the respective ministries. There should be a policy of using broad-spectrum compounds when the animals are dipped. Such compounds like synthetic pyrethroids would act against a wider spectrum of biting insects/flies including mosquitoes which are vectors for RVF, malaria and lymphatic filariasis.

On the diagnostic capacity, test kits including protective gears should be made available in stock and the Government should advocate use of available local laboratories to avoid unnecessary delays and costs for confirmation of RVF suspects. The government should consider providing alternative food to victims during disease epidemics.

Prediction of RVF can be improved by having a good national disease surveillance system, considering and following alert messages from international organisations and strengthening use of climate data. To better understand the nature of the disease in the country additional studies should be conducted on the epidemiology and ecology to establish the means of occurrence and spread of RVF in the country.

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