

Social Science in Epidemics: Rift Valley Fever Lessons Learned

This report is the fourth instalment of the 'Social Science in Epidemics' series, commissioned by the USAID Office of U.S. Foreign Disaster Assistance (OFDA). In this series, past outbreaks are reviewed in order to identify social science 'entry points' for emergency interventions and preparedness activities. The aim is to determine tangible ways to address the social, political and economic dynamics of epidemics and to ensure that interventions build on the social and cultural resources of the communities they aim to support. This report explores lessons about the social dimensions of past and recent Rift Valley Fever (RVF) epidemics.



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How to read this report:

this document provides an in-depth review of evidence on different aspects of RVF epizootics. It is organised into the following categories, and readers with a specialist interest can skip to the relevant category:

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In each category, social science lessons learned are highlighted and followed by a series of recommendations. This report will provide the basis for a set of programme-oriented case studies and operational tools that will be published in 2019.

Rift Valley Fever (RVF) is an outbreak-prone and vector-borne viral zoonotic disease affecting multiple species, including livestock and humans. The disease can be spread through multiple mosquito species among animals, and to humans. For most part, humans are infected in occupational settings that bring them in close contact with animal blood, tissues or fluids, such as farms, slaughterhouses and veterinary services.

RVF generally occurs in the form of massive, but infrequent, outbreaks that can affect thousands of animals (epizootics) and can result in hundreds of human fatalities. Because of the potential of RVF to be passed through handling of meat products, outbreaks usually result in restriction in animal movement and trade, which can have a significant economic impact, especially in pastoral, livestock-dependent communities. The disease was first isolated in Rift Valley in Kenya in 1931. However, outbreaks are known to have taken place in many other regions over the last several decades, including Southern Africa, West Africa, Egypt and Arabian Peninsula.

The diversity of vector species which can transmit RVF, coupled with the global trading in livestock produce makes RVF highly likely to spread and persist in other countries (Dar *et al.*, 2013). This is possibly the reason the disease has been included in the Blueprint list of priority diseases that have been targeted by WHO for increased attention in research and preparedness activities (WHO, 2018).

1 Emergence

A brief history of RVF outbreaks

Given its outbreak prone characteristics, the history of RVF is best reported through a timeline of key outbreaks. RVF was first characterised in a 1931 paper by Daubney and colleagues (1931), based out of the Veterinary research Laboratory in Kabete, reporting on an outbreak among sheep in a farm in Naivasha, Kenya that resulted in deaths of 4700 sheep in a 4-week period (Bird and Nichol, 2012). Scientists now believe that the history of RVF in the region goes back further – with a similar disease outbreak having been reported by scientists working in the same institute as Daubney twenty-two years earlier in 1912-13 (Davies, 2010; Murithi *et al.*, 2011).

The devastating nature of the disease was highlighted after an outbreak among sheep farms in South Africa that took place in 1950 and 1951. It caused 'abortion storms' among 500,000 sheep, resulting in 100,000 sheep deaths as well as infecting at least 20,000 humans (Muga *et al.*, 2015, p. 730; Paweska, 2015, p. 375). Since then, RVF outbreaks have taken place at least once every decade and spread to cover most of East Africa, including the Horn of Africa and Madagascar, as well as to West Africa, Egypt and the Middle East.

While other African countries such as Mali, Gabon, Congo, Chad, Botswana, Angola, Ethiopia and Nigeria have not reported epizootics thus far, there is evidence of circulating antibodies within many countries, a sign of possible historic exposure to the disease (Gerdes, 2004; Nyakarahuka *et al.*, 2018). There is also evidence of epizootic RVF outbreaks in Madagascar (2008-9), South Sudan (2008-9), Rwanda (2018, prior to which there was evidence of circulating antibodies).

For most of twentieth century, RVF remained a primarily epizootic-prone disease causing outbreaks in livestock farms and among pastoralists in 4-15-year cycles in affected regions, often following heavy rainfalls in flood-prone habitats (Baba *et al.*, 2016). It was thought to be restricted to sub-Saharan African countries and within livestock until 1977-78, when both the nature of the disease as well as its geographic reach expanded during an outbreak in Egypt that resulted in the more than 18,000 human infections and 598 deaths (CDC, 1998; Laughlin *et al.*, 1979).

This outbreak took place six years following the creation of Aswan dam, which had resulted in large mosquito-filled reservoirs. The disease is thought to have been imported either through infected animals, or even possibly by heavy southerly winds which could have transmitted swarms of mosquitoes (Abd el-Rahim, Abd el-Hakim and Hussein, 1999; Gerdes, 2004).

Another serious outbreak took place in Garissa, Kenya in 1997-98. It resulted in 89,000 human infections and 478 associated deaths– the largest human outbreak so far (Dar *et al.*, 2013, p. 190). The disease then presented an ease in transferring to new geographic locations and as a result devastating economic impacts resulted from simultaneous outbreaks in Saudi Arabia and Yemen in 2000 (CDC, 2000). Despite a then-ban on importing animals from East Africa, it is speculated that animals were smuggled into Saudi Arabia for ritual sacrifice following the annual Haj pilgrimage. This might have contributed to the outbreak which resulted in 20,000 infections and 123 deaths among human populations (Dar *et al.*, 2013, p. 190). While later investigations found that RVF had already been circulating in Saudi Arabia and Yemen at the time, this outbreak highlighted the economic dimensions of RVF as well as the potential for spread of the disease through livestock trade routes (Davies, 2010; Paweska, 2015).

Another major set of outbreaks took place in Kenya, Somalia and Tanzania in 2006-07 and in Sudan in 2007-08 causing tens of thousands of human infections and hundreds of deaths (Dar *et al.*, 2013), all of which helped bring the disease into prominence again. RVF's epidemiological characteristics of expanding footprint and massive economic and (animal and human) health impacts warranted its classification as a potential bioterror agent (Borio *et al.*, 2002) and an inclusion in WHO blueprint of diseases of increased investments and attention (WHO, 2018).

This report focuses on the social science lessons learned from the available literature emerging from these outbreaks. The Social Science and Humanitarian Action platform understands social science evidence as interdisciplinary and engaged. It incorporates knowledge from anthropology (with its focus on cultural logics, beliefs and practices, and embedded social relations) and incorporates perspectives from other social science disciplines (sociology, history, geography, political science, political economy, development studies), and articulates these with biomedical and ecological science, epidemiology and public health. In this report, rather than gathering lessons learned in general from Rift Valley Fever outbreaks and responses, we will focus more heavily on those aspects of the epidemic that are related to social, political, economic and cultural factors shaping the progression of the disease and the effectiveness of the response, and less so on the lessons learned from a 'technical' epidemiological or medical standpoint.

Cycles of emergence

There are multiple pathways to human infections: direct exposure, vector-borne, food-borne and vertical. Direct exposure with blood, fluids and tissues contaminated with RVF often occurs during slaughtering, butchering and cooking. Vector-borne transmission occurs when a mosquito that has fed on an infected animal bites a human. Food-borne transmission occurs when contaminated animal products are ingested without being cooked thoroughly. Lastly, vertical transmission occurs between an infected mother and her foetus, which can lead to congenital deformities and miscarriages. However, in epidemiological terms, the transmission dynamics of RVF should be primarily understood as a vector-borne disease as this appears to be the key transmission pathway reproducing the RVF disease cycle.

Gerdes (2004) goes beyond the traditional species-based conception of disease dynamics and identifies two main socio-ecological drivers of RVF outbreaks – flooding (as in the case of 97-98 outbreak in Kenya) and changing land use patterns (as in the case of irrigation systems in Egypt, Saudi Arabia and Yemen).

It is common knowledge among pastoralists who remember the earlier RVF outbreaks in Kenya, that outbreaks of the disease used to be preceded by the unusually large rainfall (Chengula, Mdegela and Kasanga, 2013). The rainfall, in turn causes flooding and creation of breeding sites in the natural depressions called

dambos found in the grasslands (Fafetine *et al.*, 2013). This allows the mosquito numbers to proliferate and spread the disease in susceptible populations.

However, one aspect of the process still puzzles the scientists – how is RVF circulation maintained in the inter-epizootic period (IEP) and what is the source of the first set of infections in a population? While small levels of infection among livestock do occur even in between epizootics, it doesn't result in outbreaks for unexplained reasons (Paweska, 2015). RVF outbreaks do not occur on a regular timescale, whether annual or seasonal. Instead, the outbreaks are interspersed with long inter-epizootic periods ranging 4-15 years, sometimes even longer (Mariner, 2018, p. 10). Therefore, it is thought that the virus must maintain itself through one of several means. There could be quiet infections taking place in the background involving either a small number of livestock, or an unknown wildlife mammal that we don't know about (Ithondeka *et al.*, 2010; Rostal *et al.*, 2017).

Another explanation could relate to the discovery of *Aedes* eggs in IEP and speculate that a vertical transmission of the virus among certain species of *Aedes*. This would give rise to the first generation of virus in a fresh outbreak when conditions become favourable for mosquitoes to breed and for the virus to spread again. The virus can transfer over to other vectors either from the bloodstreams of the first batch of animals infected by the *Aedes*, or the first cycle of infection (Hanafi *et al.*, 2010; Paweska and van Vuren, 2014; Nakouné *et al.*, 2016). However, this explanation is based on limited observations and has not been adequately verified. Indeed, a modelling exercise which varied the number of *Aedes* showed no effect on the transmission patterns of RVF (Lo Iacono *et al.*, 2018).

Another explanation is based upon the fact that no single animal reservoir has been identified which could prove to be conclusively responsible for maintaining the virus during IEP and that RVF antibodies have been isolated from multiple species. This explanation states that instead of a single animal acting as a reservoir, the virus is in fact, maintained by a reservoir system, consisting of complex connections between vertebrate animal hosts, and vector populations (Rostal *et al.*, 2017).

Once introduced to other zoophilic vectors (which prefer animal blood feeds) the virus is likely transmitted to anthropophilic (human-preferring) mosquitoes, through the means of opportunistic anthropophilic or through shared breeding sites (Hanafi *et al.*, 2010; Tantely *et al.*, 2015). Gerdes (2004, p. 616) states that, 'epidemics do not occur as a result of lateral spread from a single source, but because of the intensification of vector activity due to the simultaneous emergence of a great number of vectors. This would explain why localised heavy rainfall does not produce an epidemic'. While the epizootics in the drylands of eastern and southern Africa are a result of heavy rainfalls, the chief driver of RVF outbreaks in northern Africa and the Middle East is the changing land use patterns. The construction of irrigation canals and dams with large reservoirs in tense regions have resulted in better conditions for vector breeding, as seen in the examples below.

The construction of Aswan dam on the Nile in the 1970's was followed, within a few years, by the first outbreak of RVF in the country (Meegan, Hoogstraal and Moussa, 1979). A year after the construction of Diama dam, Senegal and Mauritania had outbreaks affecting thousands of people and killing hundreds (Gerdes, 2004; Hassan, Ahlm and Evander, 2014). Similarly, the irrigated areas of Tihama region in Saudi Arabia and Yemen, as well as Jizan dam in the region, would have likely contributed to creating the conditions for the first outbreak in the region in 2000 (Jupp *et al.*, 2002; Davies, 2006). This shows the importance of considering the impact of development projects, especially dams and irrigation systems in the emergence of vector-borne diseases such as RVF.

Disease forecasting

There are three conditions that must be present for an outbreak to take place: the presence or introduction of virus in an area; a large population of susceptible ruminants (cattle, sheep, camels or goats); and, finally, a set of climatic or environmental conditions that encourage build-up of vector populations. In the last two decades, with an increasing awareness of the social and economic costs of RVF, greater investments have been made by national and international community into developing predictive models for forecasting the heavy rainfalls

that are usually followed by RVF outbreaks. These models can then feed into a decision support system, and so the thinking goes, allow the government to implement standard protocols for preparedness and response measures well in time (Nanyingi *et al.*, 2015).

Among other factors, the increased rainfall is supposed to be a result of the ENSO (El Niño Southern Oscillation) phenomenon, which regulates temperature variations in global oceans, which are a principal cause of year-to-year difference in weather. Accordingly, this was one of the earliest drivers of RVF to be studied. Early models used satellite vegetation imagery and rainfall data to estimate potential of RVF outbreaks in high risk regions in Kenya (Linthicum *et al.*, 1987). The addition of more parameters such as sea surface temperature, vector surveillance, and a risk framework, provided lead times of 2-4 months in the prediction of outbreaks (Linthicum, 1999; Anyamba *et al.*, 2010).

Despite the advances in forecasting methods, they are still hampered by lack of accuracy, specificity and timeliness (FAO & WHO, 2009). However, even when accurate, many of the forecasting systems remain geographically and culturally distant from the decision-making contexts in the country, leading to several critiques of the forecasting approach and outcomes (Dijkman *et al.*, 2010). Citing Wolmer and Scoones (2006), Millstone *et al.* (2016) make the point that this disconnect is possibly because most of the policy response is often directed towards sanitary regulations in cross border livestock trades rather than farmer interests.

While there was a lead time of three months before the 2007 outbreak in Sudan from disease forecasting models (Anyamba *et al.*, 2010), national decision-makers found the prediction to be too generalised and were able to correctly predict the location of human outbreak in only half the human cases (Hassan, Ahlm and Evander, 2014). Dijkman and colleagues (2010) recall, that in case of the 2006-07 outbreak in Kenya, the US-based modellers cited a low risk of RVF as late as one month before its onset; the disease was actually first spotted by pastoral farmers, who could identify the disease based upon their experience of earlier outbreaks (Muga *et al.*, 2015). This shows the importance of incorporating community surveillance into RVF surveillance systems.

Continuing in the same vein, Himeidan (2016) points to a large gap that exists between model-generated risk warnings and implementation of prevention and control measures. Using examples from 2007 outbreaks in Sudan, South Africa and other countries, he makes the case that even when timely alerts can be generated by the models, they are limited in their effectiveness due to inefficient response systems. In the case of Sudan, where the time between the initial alerts and declaration of outbreak was 18 weeks, he argues, that a timely response in the shape of livestock vaccination and movement restrictions might have decreased the impacts of the first human outbreak in the country.

Competing narratives of RVF

Diseases can also be approached as social constructs which are often a product of competing narratives constructed by different actors who each seek to push a certain limited understanding of the disease based upon their worldviews (Leach and Hewlett, 2010). Over its long history of almost 90 years, or more, RVF can be said to have been framed using three competing narratives – bio-medical health security threat; economic and political challenge; and, bio-social.

The biomedical narrative framed the disease as a scientific problem, requiring technical solutions. The focus was more on the virus as an agent and less on the way the virus manifests itself and interacts with different segments of the society. Tools such as disease forecasting are seen as 'sophisticated methods' for converting less comprehensible uncertainties into quantifiable and manageable risks (Himeidan, 2016, p. 2; Millstone *et al.*, 2016).

Another framing that springs from the same worldview, portrays RVF as a potential bioweapon, and a global health security threat (Dar *et al.*, 2013). Its conceptualisation as an exotic threat to the security of the global North harkens back the early discourse around zoonoses and the critiques it provoked (Leach and Hewlett, 2010; Golnar, Kading and Hamer, 2018).

The second set of framings is a relatively new development, having emerged along with the internationalisation of the livestock trades with pastoral regions in Eastern Africa. In light of growing prosperity of the gulf countries and formalisation of the subsistence farming practices of the pastorals has led to the emergence of new industries and powerful corporate and state actors deeply invested in the livestock export trade to the Middle East and beyond (Peyre *et al.*, 2015). The potential of RVF to infrequently and intensively disrupt national and regional economies means there are powerful interests that are equally concerned with investments in disease preparedness as well as in slowing the declaration of an outbreak once it does come to notice.

The last set of framings is best exemplified by research investigating the links between poverty, livelihoods and disease (Dzingirai, Bett, *et al.*, 2017; Grace *et al.*, 2017). RVF is a disease of the poor and socially marginalised groups, making the case for more socially responsive policy stance that acknowledges the interests, knowledge and social capital among the affected communities. This could include using religious leaders for slaughter practices, engaging herders in community-based surveillance, using traditional knowledge of risks and taboos, etc.

Recommendations for emergence:

- Establish RVF surveillance in enzootic as well as potentially exposed countries (geographic neighbours, trade partners, etc.) to prevent its emergence and spread to newer regions.
- Include RVF in conducting impact assessments of development projects, especially dams and irrigation systems.
- Promote multi-country platforms for sharing surveillance data and coordinating response activities, across animal and human health sectors.
- Monitor disease activity among both animals and humans as a part of sentinel surveillance: the sudden nature of outbreaks coupled with remote locations of disease emergence means that diseases in animals and humans can be missed.
- Enforce biosafety and sanitary regulations uniformly for all levels of livestock value chains, both for internal as well as external markets.

2. Surveillance and identification

The importance of a sufficient lead time for disease forecasting is especially important for RVF response. This is because the disease tends to occur at infrequent, irregular intervals, and due to the relatively quick turnover of smaller ruminants, there are large numbers of susceptible populations which do not have any immunity to the disease every year. And because of reasons to do with vaccine availability, explained below, regularly conducted vaccination campaigns are not feasible in many countries.

Vaccination campaigns are therefore initiated only when there is a high risk of outbreaks. As demonstrated in a decision support tool prepared for country program managers it might take 4-5 months from ordering vaccine supplies to conducting vaccination campaigns for herd immunity to develop (Consultative Group for RVF Decision Support, 2010, p. 76).

Since vaccination cannot be carried out while an outbreak is circulating (because of the live nature of the vaccine there is a possibility of transmission of the disease from animal to animal through vaccination needles), an early warning system that can give 4-6 months warning becomes crucial to controlling the impact of the imminent outbreak.

This also means that instead of supplying early warnings the role of surveillance systems is instead directed towards developing risk maps in the inter-epizootic periods. Surveillance systems can also be used to monitor the course of an outbreaks and inform decision-making in the case of an outbreak, as demonstrated in the example of 2000 outbreak in the Middle East (Hassan, Ahlm and Evander, 2014).

Regular surveillance is useful for identifying high-risk areas and settings as a part of preparedness efforts during the inter-epizootic period (Murithi *et al.*, 2011; Munyua *et al.*, 2016). Sentinel surveillance can help the programme managers keep a close watch on any signs of disease activity in high-risk areas, thus identified. The RVF Decision Support Framework (components of which was incorporated into national RVF Contingency Planning states that the sentinel surveillance, because of the time taken in information processing, is most useful for retrospective data analysis. Towards that end, they suggest closer integration of CAWS and building capacities within the veterinary workforce to recognise signs of RVF, alongside tracking animal movements along the major supply chains (Consultative Group for RVF Decision Support, 2010).

When working with pastoralist communities Deglise, Suggs & Odermatt (2012) noted that mobile phones provide the opportunity of SMS-supported interventions for prevention, surveillance, management and treatment compliance of communicable and non-communicable diseases in developing countries. With increased coverage of mobile service providers and increased ownership and usage of mobile phones, community members can be trained in a participatory way to identify potential RVF outbreaks. Pastoralists can be encouraged to be alert on these indicators at the community level and always report these using the mobile platform. Similarly, information on RVF from the government veterinary/health officials can also be channelled through this platform. Early or pre-diagnostic detection of emerging and endemic infectious disease remains a vital aspect of health surveillance targeted at preventing further transmission and spread (Abakar, 2016). Hence, a community-based syndromic surveillance, coupled with visual mobile phone technology, adapted to the high levels of illiteracy among nomads, could offer an alternative to existing RVF health surveillance systems. Such an approach can be adopted to help contribute to accelerated RVF reporting, which could in turn lead to targeted RVF interventions among mobile pastoralists in sub-Saharan Africa.

Community identification of the disease

As mentioned above, RVF occurs in cycles of 4-15 years (Munyua *et al.*, 2010; Baba *et al.*, 2016). In this regard, since it is not an endemic disease researchers think that people tend to 'forget' about it especially agro-pastoralists (de St. Maurice *et al.*, 2018). However, because the disease has a significant effect through livestock deaths and pastoralists depend largely on livestock, they tend to remember the loss of livestock and the noticeable changes in the environment before the onset of the disease such as flooding and the large numbers of mosquitoes (Jost *et al.*, 2010; Munyua *et al.*, 2010). Hence engaging pastoralists in surveillance can lead to an early detection of the disease.

Agro-pastoralists however, associated increased rains and increased mosquito swarms with foot and mouth disease and not RVF (Jost *et al.*, 2010). The pastoralists in particular had several cultural measures to protect themselves and their livestock from the swarms of mosquitoes. These included using smoke from wood derived from acacia trees to ward off mosquitoes and enclosing their livestock at night to reduce their exposure to mosquitoes (K'Oloo *et al.*, 2015). They also prepared an herbal treatment for their livestock (*ibid.*).

Most of the studies on RVF have focused on pastoralists and agro-pastoralists. Pastoralists have been found to have better knowledge regarding the signs of RVF in livestock as well as its causation (Jost *et al.*, 2010; K'Oloo *et al.*, 2015). The commonest signs of RVF mentioned by pastoralists were nose bleeding, high fever, death of newborn calves and abortions in pregnant females (Jost *et al.*, 2010; Abdi *et al.*, 2015; K'Oloo *et al.*, 2015; Alhaji *et al.*, 2018; de St. Maurice *et al.*, 2018).

However, another study conducted among agro-pastoralists in Tanzania observed that while abortions in pregnant females were one of the biggest signs of RVF in livestock it was the least reported (Shabani *et al.*, 2015). Corresponding to this study, Jost *et al.* (2010) also noted that the Somali pastoralists of Kenya had better knowledge on RVF than their agro-pastoral Maasai counterparts in Tanzania. Potential explanations of this is that Somalis have greater dependence on animals for survival, and they have less access to veterinary services and drugs and hence they are more compelled to closely monitor emergent diseases in their herds.

In general, knowledge of RVF symptoms does not vary significantly by gender. However, more women than men identified bleeding as a sign of RVF in humans. Significantly more men stated that they were familiar with RVF symptoms in animals and significantly more men identified nasal discharge as a symptom in animals. The most common symptom recognised in both humans and animals was bleeding; however, this is a rare symptom of RVF (de St. Maurice *et al.*, 2018).

Recognition of symptoms and signs in animals and humans is imperative to prevent the spread of disease, especially in communities that depend substantially on livestock for their livelihood. During the 2007 RVF outbreak in Sudan, Hassan *et al.* (2011) noted that an RVF outbreak was only recognised after human cases were identified, indicating that improved awareness of the disease in animals should be emphasised. Similarly, when at-risk communities have a heightened awareness of RVF symptoms in animals, they may be able to improve surveillance and identify an early outbreak.

In terms of RVF disease causation, pastoralists reported to note that RVF seemed to be caused by a different type of mosquito variably described as 'dotted' and unique in form and behaviour (Jost *et al.*, 2010). This is similar to the findings of two other studies both conducted in the Ijara region of Kenya which found that majority of the pastoralists believed that RVF was caused by mosquitoes (Abdi *et al.*, 2015; Ng'ang'a, Bukachi and Bett, 2016). The respondents in both of these studies did not think that their practices such as consumption of raw milk and residing with livestock in their houses could place them at the risk of contracting RVF.

This demonstrates the need for further in-depth studies to understand how risk is conceptualised among pastoralists. RVF is usually asymptomatic when it infects humans, therefore it is confusing to people when they are told that there is a risk of infection through animal product consumption, yet they have not experienced it as such. This is compounded by the fact that livestock is the main source of food and livelihood. The need to have an understanding of existing misconceptions about RVF is great because these may prevent people from taking protective action or from fully weighing their personal risk.

Most studies of RVF knowledge among affected pastoral communities appear to be overtly focussed on risks, instead of understanding how 'local communities conceptualised those risk factors' (Ng'ang'a, Bukachi and Bett, 2016). This has resulted in many studies adopting a binary framing of local practices within the farming communities as either contributing to increasing or decreasing disease risks. Indeed, researchers have identified 'inadequate' knowledge of disease risks as a major constraint for RVF prevention and control (Owange *et al.*, 2014).

However, a more nuanced reading of local knowledge and practices is also possible. Jost *et al.* (2010) showed how Somali pastoralists in Northeast Kenya were adept at identifying RVF as *Sandik*, or bloody nose to describe a disease they found matched RVF. They associated *Sandik* with rainfall and mosquito swarms, and included symptoms such as abortion, froth from nose and bloody diarrhoea.

A participative epidemiology study in Niger among Fulani pastoralists by Alhaji *et al.* (2018) described similar findings. The Fulani referred to RVF as Gabi-gabi – a disease associated with high fever, diarrhoea, abortions and sudden death in newborn calves.

The health-seeking practices for human as well as livestock health services are diverse. Due to a range of factors, ranging from social acceptability, availability, accessibility and personal preferences, pastoral communities prefer to go to arrange of health and veterinary professionals, leading some to make the case for a 'pluralistic perspective' in health service planning (K'Oloo *et al.*, 2015; Muga *et al.*, 2015, p. 734; Dzingirai, Bukachi, *et al.*, 2017). Due to the zoonotic nature of the disease and how the environment shapes it, there is a need to integrate animal, human and environmental health in a One Health approach to RVF. In both preparedness and response there has to be an effective and coordinated communication between human and animal health authorities.

Recommendations for surveillance and identification:

- As an entrenched enzootic/endemic disease, RVF control needs a long-term strategy: strengthen the One Health approaches in the RVF contingency planning in all affected and vulnerable countries to ensure all relevant sectors are involved in its prevention, detection, response and recovery phases.
- Community surveillance strategies should incorporate pastoralists to give information on the changes that they are noticing in their immediate environment so that speedy action can be implemented before the actual outbreak begins. Mobile phone technology can be deployed for early detection, coordination and communication with pastoralists. When community-based surveillance finds that the disease is not present, offer vaccination as a means to protect disease free populations.
- Given the longstanding history of the disease in the region, there is likely to be a plethora of local knowledge related to the identification and management of the disease, which needs to be identified and incorporated into developing culturally appropriate intervention strategies. Measures to include these could be:
 - Compile locally grounded definitions of the disease and practices associated with it across different communities and regions.
 - Identify everyday practices that contribute to RVF incidence or control in different communities.
 - Collect and use qualitative data on community knowledge, attitudes and practices on the disease.
 - Use existing community practices to promote personal protection, prevention and health-seeking practices that align with everyday practices of local communities.
 - Include community engagement in preparedness and response efforts.
- Development, service delivery and trust: There is no alternative to basic health systems strengthening, both on animal and human health sides. Supply side interventions need to couple with demand side trust-promoting measures to increase the acceptability of government services. This can take the following form:
 - Engage with pastoralists and other affected communities in the contingency planning process.
 - Acknowledge power and influence in contingency planning and community dialogue to ensure inclusive voice and decision-making of different actors.
 - Examine availability and acceptability of non-formal health providers for humans as well as animals.
 - Monitor usage, quality and trust of formal health services among affected communities.
 - Engage non-formal health service providers in disease surveillance and information campaigns.

3. Transmission

The nature of RVF outbreaks has been changing over the decades. Sindato and colleagues (2014) conducted a multi-decadal review of RVF in Tanzania stretching from 1930 to 2007 in which they describe the principle characteristics of the changing epidemiology of RVF. They found that whenever RVF is introduced to a site, subsequent outbreaks become more likely. This phenomenon, mediated through an interaction of climatic, ecological and host factors, accounts for the gradually increasing footprint of the disease, in terms of number of countries affected, number of districts within each country as well as the severity of individual outbreaks (Nanyingi *et al.*, 2015).

Another analysis of the evolving nature of RVF in East Africa by Baba *et al* (2016) describes the changing nature of the infection. Whereas for the first 50 years most RVF outbreaks were epizootic in nature with minimal human involvement, they contend that most of the outbreaks in the last two decades have a significant

epidemic nature resulting in tens of thousands of human cases in each outbreak. In summary, this means that the nature of RVF spread is creating new vulnerabilities, expanding its geographical footprint to affect more countries and affecting an increasing number of humans in each epizootic.

In order to explain the possible reasons for changing disease dynamics it is important to first discuss the disease cycle of RVF, specifically the role of each of the host species involved – vectors, livestock, wildlife and humans. This will enable a discussion of the importance of different drivers of the disease, including social phenomena, in influencing disease dynamics.

Vectors

Vector-borne transmission is the most important mode of spread of RVF, and thus, can be the starting point for a discussion of its epidemiology. One of the important features of RVF that makes it particularly well-suited for export to new areas, is the wide range of vectors that support its transmission. Entomologists have identified 32 different species of mosquitoes (spread across 5 genera) that are believed to play a role in transmission of RVF (Gerdes, 2004; Tantely *et al.*, 2015). In addition, horseflies, midges and ticks are also known to be vectors of the disease (Lo Iacono *et al.*, 2012; Hartman, 2017).

Another unique feature of RVF is the presence of vertical transmission of the virus among the *Aedes* mosquitoes. Outbreaks of Rift Valley Fever are interspersed by long periods without significant disease activity. In the absence of infected livestock with viremia, scientists speculate that viruses are shed in the eggs of certain *Aedes* mosquitoes. The virus can survive in the eggs deposited in the soil, such as along the Rift Valley ridge, and emerge upon heavy rainfalls to introduce the virus in subsequent generations of vectors and hosts. This, they hypothesise, is one of the ways in which the virus maintains critical levels in between outbreaks, though the exact process still remains a mystery (Ithondeka *et al.*, 2010; Lo Iacono *et al.*, 2018).

Livestock

RVF has traditionally thought to be primarily an epizootic disease, causing outbreaks within animals, with a small zoonotic component. This understanding was grounded in the experience of RVF outbreaks for most of the twentieth century which were primarily confined to animals and had very small epidemic components, as summarised by Baba *et al* (2016). This understanding is possibly also due to the contrasting presentation of the disease in livestock and humans. the presence in susceptible animals is quite stark, resulting in fever, abortions and death. RVF manifests among most humans with non-specific presentation (flu-like fever, joint and muscle pain). Less than 8% experience severe symptoms such as eye lesions, meningo-encephalitis or systemic haemorrhagic fever (Gerdes, 2004).

A wide range of animal species can be infected, but they differ in their degree of susceptibility and the severity of disease they exhibit. Domesticated ruminants, such as sheep, goat and cattle are thought to be the main species affected. These are also likely to be amplifying hosts, allowing the virus to replicate in their bodies and subsequently mosquitoes transmit the infection to other animals. Young animals, especially lamb and kids less than a week old, are highly susceptible to the virus – more than 90% die within two days of the start of the illness. Older sheep and goat are less susceptible- most have sub-clinical infection, which is not noticeable, but around 10% might still die following 2-8 days of illness (Paweska, 2015, p. 380). Infection in indigenous herds are often diagnosed retrospectively following signs of abortion and reduced milk production (Gerdes, 2004; Davies, 2006). Other animals, such as camels, buffaloes and cattle might have abortions even if other signs of illness are absent (Sindato, Karimuribo and Mboera, 2012; Hartman, 2017).

The vulnerabilities of livestock to RVF plays out in different ways across different farming systems with differing impacts on livestock health and individual and national economies. Outbreaks of zoonotic diseases can lead to disruption in local markets and may result in the restriction of movement of animals and affect many rural livelihoods. At a national level, it may result in barriers to export markets which has a multiplier effect

on employment and auxiliary sectors (WHO, 2012). This has enormous implications in how the disease is perceived by people, including pastoralists, ranchers and the public officials. In addition to contributing to the availability of dietary protein, livestock serves many other purposes across many low-income settings. They provide transport, draught power, fuel and clothing.

The impact of the disease and the policies for disease control vary significantly depending on the type of herders affected, and the scale of husbandry involved. Small-scale or traditional pastoral communities keep livestock on a subsistence-orientated extensive system (relying on unmanaged pasturelands and free-range) and mainly use their livestock for meeting socio-cultural and economic needs. Ranchers keep their livestock on an intensive system, using improved breeds confined in private land, and with managed nutrition (pasture and grain) mainly for large-scale sales, often export-oriented.

Ranchers closely monitor disease in their herds using highly mechanized systems. They spend more money to ensure their animals are free from disease since they must adhere to high biosecurity standards to enable their animal products to meet export regulations. If an outbreak is suspected, ranchers are more likely to request veterinary services in order to vaccinate their livestock, and they are able to afford it. Pastoralists have less access to veterinary health services and are less likely to vaccinate their animals. Therefore, the purpose and meaning of livestock is varied across the different livestock management systems and have implications for disease control and management. In terms of vulnerability, it means that pastoralists' livelihoods are more at risk when the disease emerges. This is compounded by the livelihood risk that follows when movement or sales bans are implemented.

Wildlife

High levels of virus circulation are reported in some wildlife, with some evidence pointing towards African wild bulls and rodents (Olive, Goodman and Reynes, 2012). However, evidence remains patchy, in particular multi-species seroprevalence studies that could help shed light on the broader transmission dynamics are lacking (Clark *et al.*, 2018). This is possibly the reason why no single wildlife reservoir host has been implicated for mainlining RVF levels in the inter-epidemic period (IEP). Some epidemiologists advocate a multi-species reservoir systems approach as an explanation for the role of wildlife in maintaining low-level circulation of virus (Haydon *et al.*, 2002; Olive, Goodman and Reynes, 2012; Rostal *et al.*, 2017). This lack of seroprevalence studies concurrently in livestock, wildlife and humans means that it is difficult to gauge the importance of human interaction with wildlife in human transmission vis-à-vis the most known transmission from livestock to humans.

Human

Humans can get infected by RVF through four transmission routes: direct exposure to blood, body fluids or infected tissues of infected animals, vector-borne, food-borne and vertical (causing miscarriages of infected pregnant women). By far, the most significant route is vector-borne, followed by exposure to blood or tissues, and both of these represent two different ecological settings within which most RVF (human) epidemics take place. The last two routes of transmission have not been observed widely, particularly so the vertical transmission routes (with a case in Saudi Arabia and over two dozen in Sudan) (Baudin *et al.*, 2016; Khan and Smith, 2016), but represent potential risks and so contribute to levels of anxiety surrounding RVF. Fears exist about the potential of RVF to spark a Zika-like scenario of epidemic birth defects and infant deaths. Aside from this vertical transmission from mother to foetus, there are no reports of human-to-human transmission of RVF.

Traditionally, when RVF was known more for its epizootics, and reports of it were restricted to sub-Saharan and eastern Africa, the disease was associated with pastoral farming communities or remote sheep farms. Human infections were likely to be caused by direct exposure to infected blood, fluids or tissues, and affected people involved in farming, processing meat or in veterinary services – occupational settings that carried increased exposure (Paweska, 2015).

The second route of spread is the one responsible for amplifying the disease among humans and causing large epidemics in human populations, in parallel to the epizootics among the livestock in recent decades. Mosquitoes and other blood-feeding insects can pass on the infection to humans. Human populations can also serve to amplify infections through producing the virus at sufficiently high levels in their blood stream, for the mosquitoes to transfer it to other humans, as in the case of other human vector-borne diseases, such as malaria and dengue, yet this has never been reported in the case of RVF. There have been isolated reports of vertical mother-child transmission among humans (Arishi, Aqeel and Al Hazmi, 2006; Adam and Karsany, 2008) which have prompted epidemiologists to highlight potential risks to pregnant women from RVF, similar to Zika (Baudin *et al.*, 2016; Khan and Smith, 2016). While the virus is present in animal fluids, making slaughter and butchering risky occupational settings, it is supposed to be easily deactivated by cooking. There is a risk of spread through consumption of raw milk, but this route has not been conclusively established (Gerdes, 2004; Paweska, 2014).

RVF infection can present itself in a variety of ways. The large majority of infected people will show no, or minor flu-like signs. The overall mortality due to RVF is relatively small, ranging from 0.5% – 2%, but appears to be increasing in recent outbreaks, likely due to improved surveillance, as also the changing nature of the disease itself. RVF can also present in the much more serious haemorrhagic or encephalitic forms which are associated with higher mortality rates (around 50%) and residual disabilities, including vision loss (Paweska, 2015, p. 380). As mentioned above, there have recently been reports of miscarriage following RVF outbreaks (Baudin *et al.*, 2016).

Recommendations for transmission:

- Commission interdisciplinary analysis of RVF transmission dynamics, in light of its changing character:
 - In light of the increasing frequency and human character of RVF, what factors are preventing RVF from presenting as a seasonal or urban phenomenon? How can we best understand emerging socio-ecological dynamics?
 - What keeps transmission alive in the inter-epizootic period? How can we best incorporate local insights on disease emergence, identification and transmission?
 - What is the nature of unexplained transmission routes, and wildlife reservoirs?
 - Which are the primary host species and what is the process of secondary hosts acquiring infection, especially in newly exposed geographic areas?
 - What are the transmission dynamics that enable small outbreaks to precipitate large countrywide outbreaks?
 - Investigate the spectrum of RVF presentations in humans, including recent reports of vertical transmission and possibility of foetal anomalies. Use local symptom categories and disease models to ascertain these modes of animal to human transmission.
- Promote public discussion around the impact of natural and man-made changes to environment in disease emergence and spread
- Disease modelling should incorporate practical lessons from their use in local health systems in the following way:
 - Promote multi-species, multifactorial 'systems' approach
 - Improve timeliness, accuracy and specificity
 - Conduct information needs assessment and work closely with local decision-makers and affected stakeholders to better tailor analyses to meet their requirements
 - Learn to work with other means of early warning systems, such as supplementing modelling predictions with community-based reporting systems of weather patterns and mosquito loads

- Use political visibility to develop templates for 'One Health' multisector collaborations
- Use this attention to develop cross-country regional platforms for data sharing and response
- Devise newer models of financing disease control measures, possibly involving livestock traders and importing countries

3. Vulnerability

Marginalised nature of pastoralist settings

Pastoral communities are important to several countries affected by RVF. These include countries around the Horn of Africa and the Middle East. Pastoralism remains an important source of livelihood for large populations in Kenya, Tanzania, Somalia and Yemen, among others. In Kenya, pastoral lands comprise 80% of the country's landmass. Pastoralists comprise about a third of the national population and rear 70% of national livestock (Millstone *et al.*, 2016, p. 15).

Livestock trade is the primary source of livelihood. It represents over 90% of pastoral incomes (Rich and Wanyoike, 2010, p. 52), and contributes about 12 % of GDP to the Kenyan economy, and up to 65% of Somalian GDP. The exports to Middle East alone amount to a trade of more than US\$ 1 billion annually (Peyre *et al.*, 2015, p. 12; Millstone *et al.*, 2016, pp. 15, 98).

However, despite the economic significance of the pastoralists in the country, the regions of northeast Kenya have the highest incidence of poverty within the country, with poverty rates of approximately 70% in 2004 (Rich and Wanyoike, 2010, p. 52). These are possibly because of historical and political reasons affecting the development of the pastoralists who have been ignored at every stage of their country's development, which has profound implications on the emergence and control of RVF in the regions.

Because of their physical and political proximity to newly formed Somali Republic in 1960s, resultant *shifita* wars and the more recent militarisation of bordering forests, both served to marginalise the pastoralists and prevent natural movements in the region. Recent development of large irrigation projects in the regions has reduced pastureland. The government has incentivised the pastoralists to settle using land allocations. However, they are often located at the end of canal networks, where the water tends to be stagnant and provide more breeding grounds for mosquitoes, thus increasing the risks of acquiring the disease among the farmers (Dzingirai, Bett, *et al.*, 2017; Dzingirai, Bukachi, *et al.*, 2017).

The marginalisation of the pastoralists has impacted their interactions with animal and public health agencies in multiple ways, to the detriment of RVF control strategies. Multiple studies have documented the lack of resources within the health services in the pastoral lands. This includes poorly staffed, or absence of veterinary and health professionals (K'Oloo *et al.*, 2015; Dzingirai, Bett, *et al.*, 2017) as well as poor connectivity by roads and electricity resulting in difficulties in delivering essential health services and vaccines to the community (Gerdes, 2004; Dijkman *et al.*, 2010).

Dijkman *et al.* (2010) reported that even when the pastoral herders had reported the first cases of the 2006-07 outbreak, the local veterinarians continued to treat it as Trypanosomiasis, until they were forced to change the diagnoses to RVF. A lack of manpower and vehicles in the field, compounded by poor connectivity of the areas in the rain resulted in further neglect of the communities. In such an environment, it is not difficult to see why communities might feel resistant in reporting diseases in livestock in the absence of compensation, or to allow vaccination when it is associated with adverse effects on the livestock (Millstone *et al.*, 2016).

Pastoralists and agro-pastoralists

There are distinct differences among pastoralists and agro-pastoralists, the former depending solely on livestock for their subsistence, and the latter combining livestock herding with agriculture. Pastoralists are

often more aware of the signs, symptoms and causes of RVF especially in the regions where outbreaks have repeatedly occurred (Jost *et al.*, 2010; K'Oloo *et al.*, 2015; Ng'ang'a, Bukachi and Bett, 2016). This means that community surveillance strategies can incorporate pastoralists to give information on the changes that they are noticing in their immediate environment so that speedy action can be implemented, for example through vaccination, long before the actual outbreak begins. It is possible therefore to utilise the insights that local people have in relation to their environmental and social context to monitor possible RVF outbreaks. Community surveillance using either indigenous knowledge of observations of specific environmental and/or weather changes or changes in animal health can act as an indicator of a possible RVF outbreak in livestock and humans. For the surveillance of the disease in humans, pastoralists can be used in the establishment of an active animal health surveillance system to provide early warning for veterinary and public health authorities given that outbreaks of Rift Valley fever in animals precede human cases. Pastoralists' collaboration in surveillance will depend on their relationship of trust with the response, since they may be adversely affected by the control measures, including livestock movement and sale bans.

Whilst pastoralist indigenous breeds do not show typical signs of illness, they are subject to abortion storms, death of lambs and reduced milk production. The impact of RVF is dramatic in terms of loss of income and food and nutrition security. The loss of animals to RVF and the lack of milk production as a result of abortion, represents a direct medium term impact to nutrition outcomes, as households cannot consume those products, or alternatively have to purchase them in the market. Incomes are also heavily affected by losses, with decreases in production compounded by decreased prices for live animals, decreases in meat consumption and market and travel restrictions. 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" (Chengula *et al* 2013: 9; Mlozi and Mtambo 2008).

Pastoral communities who normally bear the brunt of the RVF outbreaks have their livelihoods tied to livestock. This creates a strong connectedness among their social, economic and political practices, diet and food practices, religious practices, kinship relations, social structure and status, among others. Yet the majority of the RVF studies do not focus on the broader factors that shape people's actions. One example would be the fact that during RVF outbreaks, trade and consumption of livestock and their products are banned as a way of controlling the outbreak yet during RVF outbreaks there is flooding and thus impassable roads. Access to essential services are curtailed hence most of the people cannot therefore access alternative sources of food during an outbreak other than meat and milk from their livestock. The key questions to ask are: 'what alternative do they have?'; 'what alternative food or income provisions are made to help them cope with the bans since they need to eat to survive?' Similarly, preventative measures such as RVF vaccination are not always affordable for pastoralists at market rates or are not available, and uptake is low. These are critical questions and factors that need greater consideration and ought to inform policy and response strategies for appropriate control and management of RVF in different livestock production systems and geographical and socio-cultural contexts.

Social difference and vulnerability

There are very few social science/anthropological studies on RVF (Muga *et al.*, 2015). Most of the studies are KAP surveys and seem to place a lot of emphasis on communication for behaviour change without understanding the underlying rationale of why communities engage in certain practices.

In terms of social difference, herders, mostly from poor households, are especially exposed, followed by women who manage young and sick animals (Dzingirai, Bett, *et al.*, 2017). In terms of occupation, farmers, farm labourers, veterinary surgeons or other personnel who perform veterinary and obstetric procedures are highly at risk of infection while handling the carcasses of animals which are sick or have died of Rift Valley fever (Chambers and Swanepoel, 1980; McIntosh *et al.*, 1980). There is a need for a greater understanding of the gendered and age-related differences in participation in livestock production and in food preparation and processing in the home.

Most of the studies on RVF are conducted over five years after an outbreak. This has been cited as a possible reason for the lack of adequate knowledge on RVF as people might have forgotten about RVF especially agro-pastoralists for whom the impact of RVF is lesser in comparison with the pastoralists (de St. Maurice *et al.*, 2018). It would be necessary to conduct an in-depth study soon or during an RVF outbreak to understand how the disease is experienced by people in real time.

Gender has a strong, but variable role to play in influencing the relationships of individuals with different aspects of livestock rearing, which can result in men and women being exposed in different manners to risks of acquiring RVF infection. Drawing upon anthropological work among the pastoralists, Muga *et al.* (2015) describe the allocation of responsibilities between men and women in animal husbandry. Whereas women tended to adopt the role of 'milk managers' responsible for milking and tending to animals, the role of men was akin to 'managers of herds' responsible for herding and slaughtering. Women, as part of their gendered housework, may be more exposed to unpasteurized milk, raw meat and other contaminated products during cooking; on the other hand, men may be exposed through herding and other work that may be male-dominated. Whereas women tended to spend more time looking after animals and tending to sick animals, men, particularly, herders, spend extended amounts of time leading animals to pastures (Muga *et al.*, 2015).

In a pastoral community in north-eastern Kenya, men and women gave gendered reasons as to why different livestock were preferred. Women in pastoral communities reported that sheep were more preferred because they produced a lot of fat when slaughtered; their fat was useful for cooking and as food for nursing mothers while the raw blood from sheep was useful in replenishing blood lost during child birth (Ng'ang'a, Bukachi and Bett, 2016). In contrast, men mainly gave economic reasons for preferring goats. These reasons situate women closer to RVF infection due to the fact that sheep besides goats are among the most affected species of livestock by RVF (Njenga *et al.*, 2010).

Women, in many communities, look after sick animals, thus increasing their risks of RVF (Dzingirai, Bett, *et al.*, 2017). As most of the milking is done by women, consumption of raw milk is apparently a common practice while milking, many also giving some milk to children to pacify them (Ng'ang'a, Bukachi and Bett, 2016). Women also interact closely with sick animals by virtue of their role as the main caregivers in households. This social role could expose women to RVF infection especially in situations where using some form of personal protections such as gloves may not fit well with the existing community beliefs.

In terms of knowledge dissemination, often the people targeted for awareness campaigns may be men because women are left home with the children and young livestock. Yet most of the herd owners do not actively participate in the day-to-day care of their livestock. On the other hand, the younger men and boys who move with the livestock may be missed out of educational campaigns because most often these education campaigns are centralised.

Food practices

Different communities have their own sets of cultural practices, which they use for minimising disease risks, but these are also influenced by economic and contextual needs. For example, while there were taboos regarding eating meat of dead animals among some social groups, there was also a motivation to salvage animal meat. Similarly, cohabitation with animals can be due to security concerns, due to fear of animal theft, or protecting them against floods, rain, cold and animals of prey (Ng'ang'a *et al.*, 2016). First-hand experience plays a role in people accepting restrictions on consumption of animal products. For example, one study in Ijara, Kenya (Ng'ang'a, Bukachi and Bett, 2016) found that the pastoralists reported to have consumed meat and raw milk during the last RVF outbreak, and they observed that they were not adversely affected. In this case, therefore, the ban on raw milk and meat consumption did not make sense to people. This calls for collection of more localised information about the disease from the community.

While some studies have shown that the pastoralists refrained from consuming meat during an outbreak (de St. Maurice *et al.*, 2018) other studies reveal that the consumption of meat and raw milk continued during

the RVF outbreak season (Ng'ang'a, Bukachi and Bett, 2016). In one study, pastoralists considered RVF to be a disease with greatest impact on their livelihood while agro-pastoralists felt that the disease had a lesser impact on their livelihoods compared to other livestock diseases (Jost *et al.*, 2010).

Among Muslim pastoralists, animals not killed by religious ritual slaughter are considered carrion meat, which is *haram* given that meat quality has both spiritual and conventional components (Farouk *et al.*, 2014). Hence an animal that has died naturally is considered unfit for human consumption. This was observed among pastoral communities in the northeast parts of Kenya. This may explain the difference between pastoral communities and the various motivations that drive their practices. For example, whilst meat from dead animals could be taboo in some situations, meat from sick/dead animals could still be eaten, provided they were cooked properly. Mutua *et al.* (2017) describe several practices used in the local communities to ascertain the safety of the meat. This included curing the meat with herbs from local herbs; restricting its intake only to men; or testing the meat with two local ant species.

Livestock played a central role in organising pastoral communities and consumption of raw milk and blood was supposed to be healthier, and tastier alternatives (Ng'ang'a, Bukachi and Bett, 2016). There were different views on carcass disposal practices. While some buried the carcasses, others did so after skinning and some chose not to treat livestock as humans and thus, did not bury the carcass at all (Mutua *et al.*, 2017).

Religion and ritual slaughter practices

Livestock play a central role in majority of farming communities in eastern and southern Africa with livestock being used in dowry and slaughter of animals conducted in honour of visitors or important social and religious occasions (Ng'ang'a, Bukachi and Bett, 2016). A key religious ritual that is associated with animal trading and RVF, is the Islamic ritual of slaughter, whether conducted individually in the case of Eid-al-Kabeer, or in the case of mass slaughters, such as the annual pilgrimage ritual of Haj in Saudi Arabia (Davies, 2006).

A modelling exercise conducted in Egypt found ritual slaughter conducted at individual level during the festival of Eid-al-Kabir did not affect the risks of RVF either way (Drake, Hassan and Beier, 2013). Nonetheless, mass slaughter at a prayer meeting conducted in Kenya in 2006, in the midst of an RVF epizootic, exposed the attendees to the virus. During the same outbreak, the government convinced the local religious leaders in north-eastern Kenya to issue calls prohibiting slaughter during the Eid, which is reported to have reduced the impact of RVF in the region (Munyua *et al.*, 2010; Muga *et al.*, 2015).

The annual religious pilgrimage of Haj in Mecca provides the venue for mass slaughter of 1-2 million animals a day for a few days every year. The supply of animals for Haj is typically from the pastoral zones of northeast Kenya, Somalia, southeast Ethiopia, western Sudan and Yemen utilising a route developed over decades of trading (Davies, 2006). As discussed earlier, the importation of RVF in Saudi Arabia led to trade bans, crippling national economies in the regions, as well as higher standards for quarantining, vaccination and inspection of imported animals. However, as subsequent research has demonstrated, these norms might not be enforced and large proportion of animals imported for Haj are likely to be unvaccinated (Abdi *et al.*, 2015) which suggests an ever-present risk of RVF from the mass gathering in the region.

Recommendations for vulnerability:

- Emphasise clear messages around food-borne transmission of RVF, in different settings: particularly due to local practices of ingesting raw milk, fat and meat, including advice on alternative sources of food available to them.
- Recognise association of RVF with poverty, livelihoods and exclusion with an explicit mention in Contingency Plans
- Link RVF response programmes with emergency social protection and nutrition interventions in the short and medium term.

- Devise gender responsive strategies that allows for local information campaigns and interventions to address specific gender-associated risks in different communities
- Partner with local influencers, including religious leaders to devise awareness campaigns that can align with or address local religious and cultural values.
- Conduct rapid social research during outbreaks to better understand and characterise the experience of disease by different people and their responses to it.
- Establish the lay knowledge, perceptions and practices in relation to RVF including community management of the disease

4. Prevention and Control

a. Contingency Planning

The first attempt at documenting a systematic approach for containing RVF, or at least the one which was most influential in recent years, was a 2002 FAO Manual on preparation of RVF Contingency plans (Geering, Davies and Martin, 2002; Davies and Martin, 2003). Millstone *et al.* (2016) describe how the plan, with inputs from ILRI and other agencies resulted in the development of a national RVF contingency planning in Kenya and other countries in the region (Consultative Group for RVF Decision Support, 2010; Brett, 2015). The RVF contingency plan is derived from the manual by FAO on RVF contingency planning (Geering *et al.*, 2002) and is organised around the RVF outbreak phases (Table 1) and hence specific activities in the plan are organised around each of the four phases.

Table 1 RVF outbreak phases

Phase	Description
Inter-epidemic phase	When the situation seems normal in-between outbreaks
Pre-outbreak phase	When there is prediction of RVF based on environmental conditions – local and international
Outbreak phase	When there is laboratory confirmation of RVF
Recovery phase	When pre-outbreak or outbreak phase has ended

Source: Ministry of Livestock Development (2010)

The contingency planning borrowed from the strategic framework developed by WHO for management of Ebola and Marburg drawing upon the similarity in chronology of events across most disease outbreaks, and resultant response strategy (de La Rocque and Formenty, 2014). This resulted in the development of a four-stage response plan, as shown in Table 2 below:

Table 2 Stages of RVF response strategy

Outbreak stage	Response
Before (Normal)	Preparedness & Forecasting
Risk Confirmation	Disease Alerts
Outbreak	Operational – control
Post-Epidemic	Step down phase

Source: Based on de La Rocque and Formenty (2014)

The normal disease-free phase of the inter-epidemic period is characterised by building capacities of local health systems and setting in place sentinel surveillance systems by identifying areas and herds at high risks of exposure to the disease as explained in the next section and working with disease modellers to monitor predictors associated with risks of an outbreak.

The second stage of outbreak alerts are supposed to come from disease forecasting models or sentinel surveillance sites. In practice, however, in many instances, such as the 2006-7 the outbreaks in Kenya came to notice only following sudden increases in human deaths, which in effect became the 'sentinels' provoking the government to launch a public health response (Millstone *et al.*, 2016, p. 98).

Recognising the limitations, the contingency plan developed by ILRI in consultation with national government stakeholders includes additional activities in the initial phases, such as reporting heavy rains, mosquito load, etc. (Consultative Group for RVF Decision Support, 2010).

Depending on the nature of the alert (the location, status of outbreak, etc.), appropriate interventions are launched. If there is forecasting of increased risks of an outbreak, livestock vaccination might be stepped up. Alternatively, in the case of impending rains, vector control measures are likely to be launched along with public information campaigns to minimise the intensity of the outbreak and encourage early reporting by the community.

The control strategies are likely to involve a public information campaign targeting those at high risk of contracting disease such as farmers and slaughterhouse workers. This will also include efforts to restrict the spread of the disease through monitoring or restricting of livestock movements. As the 'trans-sectoral One Health' strategy spells out, such a suite of measures is likely to involve both the public health as well as veterinary sectors (de La Rocque and Formenty, 2014).

While the contingency planning is a welcome exercise, and as noted, a result of years of deliberations within international and national agencies, the process is not completely free of the political dynamics operating in the region. Millstone *et al.* (2015; 2016) offer three critiques of the contingency planning process, discussed below, and reflect on the way disease discourse engages with other factors in different countries.

First, RVF has been around for decades, much longer in Kenya than in other countries. Yet, it was only in 2010 that the Kenyan government launched a Contingency Plan. The motivations could have come from several directions – increased frequency and intensity of outbreaks, increasing involvement of humans, and, the economic importance of livestock trading. The burgeoning livestock trade sustains a large part of the pastoral population and is estimated to be worth US\$ 1 billion (Millstone *et al.*, 2016, p. 98).

The Contingency Plan at least initially did not seem to make any reference to the pastoralists, except in an instrumentalised fashion, referring to farming communities who should be targeted for surveillance. Also, surprisingly for a plan seeking multisector engagement, there did not appear to be any contributions from the health sector in the early versions of the plan (Millstone, Odame and Okumu, 2015; Dzingirai, Bukachi, *et al.*, 2017).

Currently, gaps exist in core capacities of health systems (animal and humans), such as lack of standard protocols for response and communication, logistical capacity to transport personnel and samples and vaccines (FAO & WHO, 2009; Himeidan, 2016). Instead of recognising the challenges of carrying out outreach surveillance and response activities in marginalised pastoral settings, the plan makes commitments for vaccination, meat-testing and outreach services that would be not feasible in the current circumstances of lack of trust and under-resourced veterinary and health services (Millstone, Odame and Okumu, 2015; Dzingirai, Bett, *et al.*, 2017).

This leads Millstone *et al.* (2015; 2016) to conclude that the Contingency Plan was essentially developed in a 'top-down' fashion. Based on an FAO template, it was more a statement of intent – what the government should do- than a commitment.

b. Decision-makers' risk-management under uncertainty

Decision-making in complex emergencies, by definition, is never simple. The job of the decision-makers is made even more complicated in the case of RVF owing to the many characteristic so the disease. These include the zoonotic nature of transmission where the disease simultaneously affects the economically productive livestock populations as well as humans. The widespread and the marginalised nature of pastoral settings

affected by the disease makes the detection and response of the disease even more difficult to implement. As if this weren't enough, an additional layer of complexity is added by the infrequent, but widespread, nature of disease outbreaks.

This means that even though RVF outbreaks result in huge losses to animal and human health, the unpredictable and infrequent nature of the outbreaks make these hard to anticipate and prepare for.

As explained earlier in the report there is a big time lag of 4-5 months between ordering for vaccines and in rolling out the interventions (Consultative Group for RVF Decision Support, 2010). On the other hand, the time taken from the first rains to the first mosquito swarm to the first animal cases is often less than six weeks. Maintaining stocks of RVF vaccines with a shelf life of a year, is likely to be seen as a wasteful expenditure in countries with competing resource priorities given the multi-year frequency of disease outbreaks.

The other option available to policy makers is to develop capacities for early prediction that can increase the lead time available to them from a few weeks, to a few months, and thus allow more timely interventions. The current efforts around predictive modelling using weather and ecological inputs are efforts in this direction. However, these efforts, so far, have been impeded due to low specificity, and lack of translation to national policy contexts (Millstone, Odame, Okumu, & Bardosh, 2016).

Mariner *et al.* (2009) use the context of RVF to plot the inverse relationship that exists between securing perfect understanding of the outbreak and the risks of being too late. They describe how every progressive step in the disease cycle increases the probability of an outbreak, and consequently, the justifications for intervening. An obvious flip side to this decision-making trade-off is that if the decision-makers wait for the perfect information to emerge, it is likely going to be too late to intervene effectively.

While this adds on to challenges of decision-making for RVF, an examination of social science literature reveals plentiful insights on decision-making under conditions of uncertainty that could be of relevance to the case of RVF as well.

The sporadic nature of disease outbreaks is also replicated in other biological and social phenomena. This has inspired a suite of analytic methods which are referred to as the Punctuated Equilibrium model (Baumgartner & Jones, 2010). This model postulates periods of stability with minimal or incremental change, disrupted by bursts of rapid transformation. The model assumes bounded rationality to operate in policy environment. This implies that due to lack of complete understanding policymakers cannot consider all problems and their solutions at all times.

For example, government ministers can only pay attention to a tiny proportion of the issues for which they are responsible. They ignore most and promote few to the top of their agenda. This is done through disproportionate attention. The lack of attention to most issues helps explain why most policies may not change. Intense periods of attention to some issues may prompt new ways to understand and seek to solve old problems.

This is where the ideas of *framings*, *agenda setting*, and *powerful actors* come into play. Groups compete to influence how a problem is framed (understood, defined, categorized and measured) and therefore solved by policymakers. For example, it may be framed as a problem that has largely been solved, leaving the technical details of implementation to experts, or a crisis which should generate widespread attention and immediate action. Punctuated equilibrium is said to be especially suited to analysing making around infectious diseases because of overlaps with the frenzied activity accompanying a disease outbreak (Shiffman, 2002).

Policymaking almost always occurs under conditions of bounded rationality- since one can never have complete insights on complex dynamics underlying most social phenomena. Far from being atypical, this is somewhat of a norm in most policy settings. Lindblom (1959) described policy-making as a process of 'muddling through'. Roe (2013, 2016) uses the term 'policy mess' to describe the policy process which according to him consisted of bounded rationality, suboptimization, compromises and the risk of failure that runs through many scenes of policy making (Roe, 2016, p. 352). Making compromises, and finding imperfect solutions, according to him, is the only way policy makers can hope to function.

The use of scientific expertise to inform what are essentially political decisions – should one intervene early and risk loss of credibility, or wait and run risks of loss of lives – have been studied in other cases within the discipline of science and technology studies. Scholars such as Collins & Evans (2007) and Jasanoff (2003). Such scholars argue that instead of depoliticising decision-making using technocrats, it is important to acknowledge the role of politics in making choices.

This stream of thought makes the case that since there cannot be any perfect choices (since there can never be a perfect scientific understanding), political compulsions inevitably creep in. This is important to acknowledge if the process of decision-making is to be discussed or influenced by those affected.

Lastly, some scholars of development studies have tried to unpack the different meanings of risks that underlie how disease outbreaks are understood, and which interventions are chosen to counter these risks. Stirling and Gee (2002, p. 524) identify the different ways in which lack of knowledge, or incertitude, can be categorised, and how decision-makers use technical expertise to ignore the complexities underlying this lack of knowledge, and promote a technical, quantifiable measure like risks. Leach, Scoones and Stirling (2010) apply this argument specifically to the case of outbreaks of avian influenza and haemorrhagic fevers to highlight particular understandings of risks and uncertainty are deployed by decision-makers to convey the appearance of stability without acknowledging the complex social and ecological dynamics underpinning the epidemics.

To summarise, the above discussion demonstrates the uncertainties in the RVF decision-making process, largely arising as a risk of complex social and ecological dynamics influencing disease activity. We then cite examples from other disciplines' understandings of decision-making under uncertainty to make the case that this situation is not unique to RVF alone. Imperfect understandings are a necessary part of decision-making. What is more important perhaps, is not to give in to the temptation to quantify the 'unknowable' in narrow, quantifiable risks that ignores the underlying complex dynamics. Recognition of the political nature of decision-making, including the deployment of scientific expertise, is an important step in increasing transparency of the decision-making process.

A tool like the RVF decision support framework, that recognises the importance of early detection and response, and outlines specific steps for decision makers to follow has the potential to empower them to respond early in the disease cycle (Consultative Group for RVF Decision Support, 2010). The tool, as conceived for the Horn of Africa, consists of four elements:

1. Map of areas at risk from RVF epizootics, identified by veterinary services, drawing on risk factors such as vector habitat, susceptibility to floods, soil types, *dambos* (shallow wetlands), and time of involvement in previous outbreaks.
2. A list of the sequence of events related to the increase of an RVF epizootic: 1. Normal situation between outbreaks ↔ 2. Early warning or alerts of RVF or heavy rain ↔ 3. Localized heavy rains observed by eyewitnesses ↔ 4. Localised flooding reported by eyewitnesses ↔ 5. Localised Mosquito swarms reported by eyewitnesses ↔ 6. Reports of Livestock disease by active searching or rumours from herders ↔ 7. Laboratory confirmation of livestock cases ↔ 8. First rumour or field report of human case ↔ 9. Laboratory confirmation of human RVF case. This phasing is crucial, as it is important not to consider it an all or nothing event. The tool is designed "to help decision-makers lower the risk to themselves, their governments, and citizens by taking action commensurate with the level of risk at the right time." (Consultative Group for RVF Decision Support 2010: 77). The further into the sequence, the more likely the epizootic is to occur, and the justification to take action increases, and the risk to taking unjustified action decreases.

From the point eyewitnesses report localisation of mosquito swarms, one can presume that the epizootic is taking place (Consultative Group for RVF Decision Support, 2010). This should be aligned with:

3. Actions matched with events in this sequence, according to the capacities and specific context of the area. These specific actions are varied, including: Capacity building and training, Communication, Coordination, Early warning systems, Surveillance, Disease control, Vector control, Trade and markets, Funding,

Post-outbreak recovery and reflection, Institutions and policies; and Research, impact assessment and risk assessment. For an example of specific matching of phases with actions please see Consultative Group for RVF Decision Support, 2010. Each context, depending on local capacities and institutional make-up, will have different activities lined up -perhaps by a different set of actors- to respond to the different decision points.

c. Regulating animal movements and international trade

National and international movement of live animals, whether for pasture or trade, remains an important risk factor for introducing the virus in neighbouring areas (Himeidan, 2016). Therefore, regulation of animal movement is one of the main interventions that is enforced during outbreaks.

As RVF outbreaks tend to escalate rapidly, trading bans are put in place for entire countries. This can have devastating impacts for exporting countries that are dependent on livestock trade, and also for importing countries that are faced with price fluctuations, in addition to the countless individuals involved at different parts of the value chain (Millstone, Odame and Okumu, 2015).

While the epidemiologic reasoning for trading bans is quite convincing, given the lack of animal census and tracking abilities within national veterinary services in many countries, the effectiveness of such interventions is not certain.

Indeed, some speculate that the outbreak in Saudi Arabia was caused by an illegal import of infected animals (Himeidan, 2016). Saudi Arabia is the largest importer of live animals, especially during the annual Haj pilgrimage that requires ritual sacrificing (Davies, 2006). Despite quarantine and vaccination norms in place for animal imports, they are not always followed effectively, and many, if not most, animals are not likely to be vaccinated (Abdi *et al.*, 2015).

There is another perspective to regulating animal movements, especially by pastoralists within countries. This argument seeks to make the case that animal mobility is a basic requirement of pastoralism developed to avoid overexploitation of pastures. In addition, animal herders have devised specific herd management strategies to decrease risks of losses to drought, epidemics and raids which can influence RVF risks and need to be incorporated in the development of national response strategies (Muga *et al.*, 2015).

These strategies include – herd division, herd dispersion and herd diversification. Herd division is a drought-management strategy. The herder breaks the herd into smaller groups that can go for grazing in larger areas. Herd dispersion involves regular exchanges of animals with other herders. Herd diversification helps the herders spread their risks by having different types of animals in the herds, thus reducing risks of a single disease and utilising the pastures more efficiently (Muga *et al.*, 2015).

Trading bans are put in place when a country is affected by an outbreak. This is likely to have a major impact on livelihoods of individual farmers as well as national economies involved in livestock trading. Taxation on livestock export is supposed to be the main source of government revenue in countries like Somalia and Tanzania. As Peyre *et al.* (2015) recollect, following RVF outbreaks, bans on livestock import from the country by Saudi Arabia and gulf countries in 1997 and in 2000, respectively, caused a collapse in its national economy.

As 90% of its income used to come from livestock export, the ban resulted in a decline of 36% in its GDP, an economic loss greater than US\$300 million, regional instability and the collapse of an otherwise stable administration (Peyre *et al.*, 2015, p. 12).

A consequence of the economic significance of the livestock trade in the region is the political pressure that can emerge to prevent measures that are seen as harmful to the livestock industry and trade, potentially leading to delayed or weakened response (Himeidan, 2016, p. 5). On the other hand, the internationalisation of livestock trade in the region is also said to have resulted in pooling together of resources by major importing countries to reduce price fluctuations as a result of disease outbreaks in the producer countries (Millstone *et al.*, 2016).

Vaccination, Larvicides and Antivirals

Due to the long history of the disease, there are several vaccines in different stages of readiness, unfortunately, none are available for widespread use among humans. However, the most widely used and readily available vaccine for animals is a live vaccine developed from the Smithburn strain. It is known to cause abortions or developmental anomalies in pregnant livestock. In addition, because of the risks of cross-infection (such as, if needles are not changed within viraemic herds), and its live nature, vaccination is not practised during an outbreak. This means that vaccination as a strategy, can only be effective, if delivered before the outbreak occurs – among non-pregnant livestock (Jost *et al.*, 2010; Munyua *et al.*, 2010; Faburay *et al.*, 2017).

Other challenges of using vaccination as a strategy are related to its short shelf life of less than a year, and the short duration of protective immunity it offers. This means, that in order to achieve protective levels of herd immunity, the vaccine should be given every year before the rainfall. As outbreaks generally took place in decadal cycles, this was not seen a viable strategy till recently because of the costs involved. The other option was to make use of early forecasts, or the presence of outbreaks in nearby regions, to procure vaccines on a short notice and vaccinate all the animals in a country within a short span of time. In addition to the obvious impediment of costs, this strategy presents with other obvious challenges of timelines, procurement and logistics of implementation (Gerdes, 2004; Bird and Nichol, 2012; Millstone *et al.*, 2016).

On a more practical level, the pastoral regions of north-eastern Kenya are marked by poor road connectivity, lack of refrigeration facilities and distrust with the veterinary health services – all of which adds another set of challenges to the vaccination strategy. Moreover, since the vaccines are generally given in the summer before the rains when the animals are at their weakest, and are associated with abortions among animals, the veterinarians often encounter resistance from the farmers (Millstone *et al.*, 2016).

The major goals of veterinary vaccines are to improve the health and welfare of companion animals, increase production of livestock in a cost-effective manner, and prevent animal-to-human transmission of zoonotic diseases from both domestic animals and wildlife (Meeusen *et al.*, 2007). Explosive human population growth and environmental changes have resulted in increased numbers of human-animal interactions which presents a potential zoonotic threat that may cause spillover of infections from wildlife to cattle in areas around national parks (Kansiime *et al.*, 2015). Control of zoonoses is beneficial for developing economies and human health, as it reduces morbidity and mortality, reduces costs for disease management and increases productivity, health and well-being (Mangesho *et al.*, 2017). However, different communities perceive vaccination variously.

Some consider it beneficial while others given their ethnoveterinary practices and limited access to mainstream vaccines prefer the former in the management of their livestock. In relation to outreach and disease management, usually among the communities such as pastoralist communities in northern Africa, there is no distinction between practitioners and lay folk as there are no ethnoveterinary specialists or healers, and everyone is a practitioner managing the health of his own herd (Moritz, Ewing & Garabed, 2013). Divergent cultural perspectives and opinions toward vaccination of livestock and humans, including religious objections, mistrust of the vaccine, as well as issues of accessibility and availability of vaccines and related health information remain key barriers to effective livestock vaccination in the management and control of zoonotic diseases. For example, in north-eastern Kenya, the majority of herders (around 4 out of 5) had positive attitudes towards preventative vaccination, whereas 1 out of 5 had negative attitudes towards it (Abdi *et al.*, 2015). There is a need to identify socio-cultural, economic and technical barriers to uptake of RVF vaccination and other control mechanisms, including gender dynamics in decision-making and uptake of RVF vaccines and other control mechanisms.

Vaccination represents specific challenges in pastoralist communities. For RVF vaccination campaigns to be inclusive and to work in pastoral areas to achieve a good percentage of immunity/herd cover, it is imperative

that the exact locations of pastoralists and their livestock are known. Borrowing/adopting from Abakar *et al.*, (2016) on what has been done before and has worked, vaccination strategies for control RVF can adopt a three-pronged strategy to track nomadic communities: (a) enlisting already known pastoralist groups through local government and partners engaged in animal vaccination, (b) establishing an extensive network of informants at community level that will stay in contact and engage with clan elders, and last (c) cross-notification of the enlisted nomadic groups once they move to a new place, where program stakeholders at district level inform each other of arriving and departing groups. These structures can be used to both plan and help implement RVF vaccination as well as disseminate relevant information.

Integration of animal vaccinations with the activities of the human health sector providers and other health interventions as part of the one health approach has also been hailed as a useful approach (Donadeu *et al.*, 2019). For example, in Chad, joint campaigns in nomadic communities demonstrated the feasibility of combining vaccination programs for people and their livestock (Schelling *et al* 2007). Socio-economic meeting points such as watering points and livestock markets can also form key entry points for vaccination campaigns information especially for mobile livestock given that these are areas where animals congregate for water and for economic reasons, respectively.

Willingness to pay (WTP) studies in pastoralist communities have shown that there are different factors that shape the ability and willingness to pay for interventions such as vaccination. Firstly, poor pastoralists have low elasticity of demand for insurance/preventative interventions (Kairu-Wanyoike *et al* 2014), pastoralists are more likely to pay for emergency vaccinations rather than preventative vaccinations (Railey *et al* 2018), which is problematic with RVF vaccines as affected/suspected areas in an outbreak do not receive vaccination for fear of nosocomial transmission through needles. Pastoralists and agro-pastoralists with off-farm income (e.g. surplus from selling crops) will be more willing to pay for vaccination. Income liquidity also plays an important role, particularly in pastoralist populations that rely solely on livestock (*ibid*).

WTP increases for herders who have improved breed, higher-productivity breeds (Campbell *et al* 2019). Awareness of herders of the disease (and levels of education) is related to WTP, particularly when this awareness comes as a result of extension networks of community animal health workers being present and active in the area (Khainga Dickson *et al* 2018; Railey *et al* 2018). This awareness would incorporate subjective notions of risk and expectations of losses that shape WTP (Kairu-Wanyoike *et al* 2014). According to Railey *et al* (2018) in the case of Foot and Mouth Disease vaccination, households have a good understanding of risk and the role that vaccination could play to mitigate it; however, this does not translate into willingness to pay. This can be explained in terms of income, and health services, but also in terms of understandings of how vaccines work and the population level effect they confer. Interestingly, women have reported higher willingness to pay for high efficacy vaccines compared to men (*ibid*). Note that WTP decreases when people are addressed directly by government veterinarians: this can be explained by doubts on the efficacy of the vaccine (Railey *et al* 2018), and perhaps by people anticipating government free roll-out of vaccines in case of emergency.

In addition to vaccination, other sets of interventions include a suite of vector control measures. Replicating the strategies used in other vector borne diseases, such as malaria, this includes personal protection through insecticide treated nets and protective clothing, as also spraying of larvicides in breeding grounds. Larvicides are effective only after the breeding sites have formed and have been identified. For this reason, these are less suitable to use, despite their efficacy, in remote sparsely populated pastoral settings.

Antivirals have been explored for use in human populations as a treatment option, most notably, Ribavirin, following the 2000 outbreak in Saudi Arabia. However, its use did not prevent the development of encephalitis and was quickly stopped. There are no antivirals indicated for use in human currently (Paweska, 2015; Hartman, 2017).

Recommendations for preparedness and control:

- **Contingency planning**
 - Contingency planning should not only be top-down. Include a bottom-up consultative process that seeks to engage with different stakeholders affected by the disease and its interventions, including farmers, animal handlers as well as frontline health workers in surveillance, preparedness and response efforts.
 - Capacity building of health workforce: Simple interventions like ensuring enough personnel are posted, vehicles are provided, and they are as close to communities as is practically feasible.
- **Multisectorality**
 - As RVF affects human and animal health, and requires engagement across several sectors, including animal husbandry/livestock development, public health, environment, infrastructure development, etc. The success of contingency planning and response will depend on the negotiation of diverse views and interests, and should include consideration of:
 - What are the different sectoral views of RVF and its interventions, including points of convergence and divergence? Can the contingency plan go beyond RVF outcome indicators and address diverse sector needs to enable necessary cooperation?
 - What are the best ways to promote cross sector collaborations at different levels of functioning? Will formal notification process work better, or should more informal personal interactions be encouraged at the field level?
 - Utilise the frameworks for multisectorality, such as pandemic preparedness plans, to encourage information sharing and joint response by multiple sectors, such as publishing a list of nodal officers in each agency for inter-agency collaboration and for media inquiries in case of outbreaks
- **Animal movement, Animal tracking and International trade**
 - Explore the possibility of private sector as well as livestock importing countries in helping support development of interventions such as RVF vaccines
- **Vaccination**
 - Develop strategies to increase acceptability of vaccination programmes by listening to concerns of affected communities and members of the frontline workforce tasked with delivering the intervention.
 - Economic barriers can limit vaccine uptake. To ensure coverage among vulnerable low-income groups (e.g. pastoralists), consider free or subsidized vaccination depending on the context.
 - Identify socially-specific requirements for successful vaccination strategies. For example, in the case of pastoralists, adopt cross-border strategies and mobile units that adapt to their mobility patterns. Identify local reasons and language articulated by those who have positive attitudes to vaccination (e.g. local ideas of strength and immunity) and build on them.
 - Gauge the level of trust in the veterinary and human health services, as well as the historical relationship between these and the herder communities. Learn from other emergency vaccine interventions (e.g. polio) to identify what activities provoke suspicion, and if relevant, ensure that vaccine delivery is not politicised.

6. Health systems & Health-seeking

Health systems context

Knowledge of causative agents, transmission and possible presentation of diseases (including those zoonotic in nature) not only enables diagnosis and reporting, but also enables control of them (John, Kazwala and Mfinanga, 2008). Notably though, health care workers in RVF-affected regions are not fully familiar with these aspects of zoonotic diseases in endemic areas where they work and this limits positive outcomes for disease management and control as in a case study of western Uganda (Benon *et al.*, 2018). Adequate knowledge of causative agents, vectors/animal reservoirs and transmission routes, along with high levels of clinical suspicion about RVF, enables practitioners to focus on key areas related to the disease and hence reach the definitive diagnosis easier and early enough for prompt management of the disease as well as designing of health education packages for the communities to prevent disease spread.

Populations living in marginalised areas, conflict and war zones, internally displaced populations, refugees, as well as those affected by natural disasters face significant challenges to respond effectively to outbreaks of RVF and other zoonoses. In such situations, already weak infrastructures for health and limited resources cannot cope with the increased burden of infectious diseases, even though the pattern of emergence of diseases in these situations is well known (Dzingirai, Bett, *et al.*, 2017; WHO, 2012). The risks for health workers therefore vary according to context. For instance, in highly volatile areas such as the North Rift valley region of Kenya often prone to insecurity and cattle rustling, health workers are faced with potential insecurity scares. From the Shifta wars to present day, the border regions of northeast Kenya have been a zone of conflict. Security concerns may lead to a concentration of people in a specific locality as refugees or migrants, where disease can transmit easily (Dzingirai, Bett, *et al.*, 2017).

There is also the danger that local attitudes to health-seeking, coupled with mistrust of authorities, might result in poor uptake of health care services. For example, in the case of RVF there was a conflict in having people admitted and socially isolated. Some members of the community were not comfortable with hospital admissions, because of associations with death. Their distrust of the health facilities was further compounded by not being allowed to visit their sick relatives. Winning the trust of the community is paramount to their uptake of RVF interventions.

A sizeable proportion of the burden of zoonotic disease seems likely to result from endemic, chronic, disabling, frequently misdiagnosed and often-unreported infections of remote populations that are dependent on livestock for their survival and asset base. Such populations, often nomadic, have limited contact with or access to formal health services and live beyond the reach of surveillance systems (WHO, 2012).

Despite the socio-political changes affecting pastoralists in sub-Saharan Africa, they still practice a traditional way of life that is rooted in a cultural system, which guides all spheres of life, including human health. Health and illnesses are approached using both naturalistic and ritual activities which inform their causes and the subsequent interventions. Livestock keepers in Africa in general and Tanzania in particular, face a potential double burden of animal and human diseases as they fend for their livelihoods.

Pastoralists and agro-pastoralists are a group at risk of zoonosis due to livelihood and livestock keeping practices, which puts them in direct contact with their livestock and wildlife (Mangesho *et al.*, 2017). Herders, animal health extensionists and human health workers, may have different (on occasion non-biomedical) models of disease. The success in the prevention, diagnosis and treatment of infectious diseases, including zoonoses, will depend on the dialogue between these different (and sometimes competing) models of animal and human health.

Health-seeking behaviours

People in different contexts speak of the symptoms of zoonotic diseases in different ways defined by their environment and perceptions of disease. Pastoralists who have lived close to their animals for millennia have broad based indigenous knowledge systems to identify and address both human and animal afflictions (Mangesho *et al.*, 2017).

As mentioned above, pastoral communities may have different beliefs, practices, priorities and constraints regarding their interaction with animals and their by-products. Their animal keeping practices and attitudes could increase their susceptibility and risk of exposure to zoonotic diseases. To these communities the effect of zoonoses on humans has not been fully conceptualised (Krönke, 2004; Mangesho *et al.*, 2017; WHO, 2012). The value attached to livestock and the services that the community derives from them has implications on the transmission of RVF from animals to humans in case of an outbreak.

Among the livestock keeping communities in Africa, models of disease include natural and non-natural causation and a diversity of explanations in terms of causes, treatment, and prevention of diseases, even though there are common themes in description of transmission patterns (e.g., insects, water, grass, seasonality) (Moritz, Ewing and Garabed, 2013). The Maasai pastoralists, like many other African traditional societies combine religious beliefs and empirical knowledge when it comes to seeking healing. Prescription of the most relevant treatment has to come from understanding the source of the illness since they make a distinction between illnesses caused by the natural and supernatural (Mangesho *et al.*, 2017).

It is easier to recognise a disease as zoonotic if the signs are recognisable in humans and animals in the same place at the same time (Moritz, Ewing & Garabed, 2013). As such, the knowledge on these local disease perspectives is important to facilitate communication between pastoralists on the one hand, and animal and human health experts on the other (Dzingirai, Bett, *et al.*, 2017; Mangesho *et al.*, 2017; WHO, 2012).

Medical pluralism is characteristic of many of RVF endemic contexts. RVF response in humans must take into account that people may seek treatment or advice from different health providers when they experience RVF symptoms. People may seek biomedical treatment, particularly so when they think their non-specific symptoms are due to malaria. On other occasions they may seek treatment at a drug store or visit a traditional healer. Complications in terms of people's relationship to biomedical health services may arise when patients present haemorrhagic symptoms. On some occasions these patients are initially isolated during an outbreak, as further diagnosis and confirmatory tests are done to rule out any highly contagious diseases such as Ebola. This can lead to confusion among the local communities and thus there is a need for a better dialogue with communities and accurate and transparent messaging.

The treatment procedure of RVF that requires patients especially those who exhibit signs of haemorrhage to be socially isolated, elicited negative emotions from the families of patients, lending support to the theory that cultural values and societal norms impact upon social isolation compliance rates. Perceptions about the health facility and the health personnel especially during times of epizootics, is a critical determinant for utilisation of conventional health services as opposed to use of the folk sector. Bukachi *et al.* (2018) recorded negative perceptions of certain health facilities and health providers as places where people go to die. These kinds of perceptions normally arise from first-hand observations and experiences by a few individuals who end up sharing their perceptions whether right or wrong and with time, these perceptions may get engrained in the community leading to beliefs that govern health-seeking behaviour.

There is consensus that the awareness of the human symptoms of RVF is quite low with the most commonly cited symptoms being haemorrhage, fever, backache and headache (Abdi *et al.*, 2015; LaBeaud *et al.*, 2015; Mutua *et al.*, 2017; Alhaji *et al.*, 2018). Jost *et al.* (2010) noted that the Somali pastoralists called RVF '*sandik*' meaning 'bloody nose'. In their study among agro-pastoralists in Tanzania, Shabani *et al.* (2015) observed that over 70% of RVF patients sought biomedical treatment. This is more so since fever was associated with malaria and free treatment was offered at the health facilities. Indeed, malaria-like symptoms were the most

often cited as the RVF symptoms and since people were more aware of malaria, they went to seek medical treatment in the health facilities. In Ijara, however, it was noted that after community members observed the way that the RVF patients were being socially isolated, they were increasingly hesitant to take sick people to health facilities. In Uganda, the poor knowledge on RVF was associated with the disease not being as common in the region studied (de St. Maurice *et al.*, 2018). Additionally, most of the RVF complications in humans such as visual impairment was not well known (Mutua *et al.*, 2017).

In terms of health-seeking behaviour, raw blood, animal fat and raw milk from livestock have been used to treat people suspected to be suffering from RVF. Studies have shown that fat from sheep was consumed to treat illnesses including patients manifesting RVF symptoms such as fever and bloody diarrhoea (Muga *et al.*, 2015). It is important to establish the indigenous health practices of affected communities to understand how they deal with diseases from a local perspective.

As per one of the precepts of the health belief model, understanding the perceived threat from disease, understanding lay beliefs and how these beliefs influence health behaviour and the adoption of preventive practices is critical in management of disease (Hausmann-Muela, Ribera and Nyamongo, 2003). The pastoralist communities in North-eastern Kenya did not believe that their food practices in relation to eating livestock products during an RVF outbreak was the cause of the infection in humans. People believed that the disease was transmitted to humans through mosquito bites, not through contaminated animal products. Their first-hand experience of seeing people eat animal products during the past two RVF epizootics, which had included human cases, was key for this belief, proving that cooking killed the disease. Non-compliance with government warnings were also attributed “to the lack of alternative sources of food, the need to salvage the meat from their livestock and the belief that God would protect them” (Ng’ang’a *et al.* 2016: 6). Beliefs about causes of ill health determine where people seek for help. Understanding of the health beliefs of a community and their health-seeking behaviour is paramount in dealing with RVF outbreaks.

Recommendations for health systems & health-seeking:

• Health systems

- Train health workers to better identify RVF, the risks of transmitting the disease, as well as provide culturally appropriate advice for local communities.
- Capacity building of health systems needs to be accompanied with trust- building in health institutions as well, especially in marginalised areas that are most vulnerable to shocks of the disease and where people are most hesitant to access formal health services.
- Trust-building cannot be done in isolation: an easy way to do so would be to increase responsiveness to community concerns, such as by allowing families to visit admitted suspect RVF patients and adopting better communication strategies.
- Rethink how to provide health services in pastoral settings, especially if formal health providers remain difficult for them to access in a timely manner.

• Health-seeking

- Given the limited understandings of the concept of zoonoses, develop communication strategies around promoting general awareness about zoonoses, including common signs, risks associated with specific diseases and how to respond.
- Promote awareness in community for identifying and reporting RVF.
- Recognise food safety advice might be contrary to social beliefs and practices and devise communication strategies that seek to engage communities in understanding risks associated with consumption of unsafe animal products.

7. Risk Communication

How risk is communicated can have a significant impact on the quality of surveillance activities. Indeed, this has been the case in some situations on communication of RVF information. The major messages communicated to herders during an outbreak are warnings against consumption of raw meat and milk, ban on the slaughter of livestock and ban on livestock movement (Munyua *et al.*, 2010).

However, often an outbreak follows flooding and therefore roads may be impassable meaning that people are not able to access alternative sources of food (Ng'ang'a, Bukachi and Bett, 2016). Consequently, while some studies have shown that the pastoralists refrained from consuming meat during an outbreak (K'Oloo *et al.*, 2015) other studies reveal that the consumption of meat and raw milk continued during the RVF outbreak season (Ng'ang'a, Bukachi and Bett, 2016). The in-depth study by Ng'ang'a *et al.* (2016) conducted in the Ijara region revealed that the local people identified that they did not often get sick after consuming raw milk and thus continued with the practice despite risk communication by the government arguing that they ate the meat and did not die. Uni-directional communication can lead to misunderstanding of the message.

According to Dell'Arciprete *et al.* (2014), the emphasis placed by local health services on one-directional and instrumental communication takes for granted that a) the health threat is clearly identified by the population at-risk, b) those considered health experts agree on the adopted course of action, c) the at-risk or currently affected population shares a similar degree of alarm to the extent that the message is clear (Kimani *et al.*, 2016). In order for these assumptions to be met, notions and practices of health and disease on both sides of the communication relationship (i.e., the health system/indigenous population) must be aligned.

During RVF outbreaks in Kenya, the radio was one of the key channels of transmission of RVF information, yet electronic media was described as having delivered sometimes inaccurate information resulting in public panic and fear (Kimani *et al.*, 2007).

When working with pastoralist populations, Déglise, Suggs and Odermatt, (2012) provided evidence that mobile phones are an appropriate and promising tool for disease control interventions in developing countries. They further established in a study in Ethiopia that pastoral community platforms, pastoral field schools and village community banks were important potential channels for delivering messages on key maternal and child nutrition practices to promote positive behaviour change. These structures can also be used as conduits for surveillance information up and down to the relevant government officials and community level vice versa.

Traditional leaders are highly esteemed and respected in many pastoral communities. Hierarchies exist mainly given the leadership structure based on age. They make key decisions related to livelihoods hence are key entry points for disseminating information on RVF and they can be appointed as champions of behaviour change in relation to advising the community on adopting RVF control strategies. They also act as key informants in relation to identifying where other pastoralists and their herds have migrated. Involvement of local officials and other respected individuals/gate keepers and the primary health care workers as noted by Smit. (2013) in a study on brucellosis, are necessary for the ownership and uptake of the information being disseminated.

When working with pastoralist communities, health education materials including relevant infographics and radio messaging about RVF, its control strategies and other preventive health behaviours are important in conveying relevant information. Use of branded promotional material have also been found to be useful strategies in reaching out to the pastoral communities. Given the low literacy levels in pastoral communities, orally transmitted information either through word of mouth from one to another or radio are key in disseminating behaviour change information (Car-Hill & Ondijo, 2011). Cell phones are currently a key mode of communication hence surveillance information for RVF/behaviour change information/vaccination campaigns can be conveyed through the mobile phones while at the same time, social mobilization of the community for vaccination campaigns or other health related actions can also utilize the same. However, prior to

development of the RVF communication and control strategy, there is need to undertake a situational analysis and needs assessment of the community in relation to key socio-cultural and epidemiological aspects relevant to RVF and its control program to help tailor relevant and appropriate control strategies that are relevant to the different contexts.

In relation to gender and access, issues of accessibility to RVF information sources arise when most of the information especially from technical personnel is described as being accessible mostly to men. This implies that media can be a rapid mode of information transfer. However, efforts should be made to ensure accurate information transfer (Kimani *et al.*, 2007). This can be achieved by providing the media with accurate information in a transparent manner.

In addition, there should be concerted efforts to increase information diffusion from technical sources to the public and mostly using local existing structures in person-to-person models, such as chiefs' baraza, churches, women groups, extension groups etc. The livestock keepers recommended that the low pre-outbreak awareness levels can be resolved through regular/routine public education by frontline veterinary staff, who should inform them well in advance on diseases (Kimani *et al.*, 2007). They also recommended that more veterinary staff should be employed to improve information flow.

One health approaches have been hailed as crucial in control and management of zoonotic diseases. In relation to RVF, the two health sectors (animal and human) have been accused of initially delivering conflicting information on prevention of animal to human transmission. The Ministry of Health in Kenya advised that livestock keepers should not touch or milk animals in addition to consuming animal's products. Veterinary personnel, however, advised the households to drink only boiled milk and cook meat thoroughly while avoiding products from sick animals and use of protective clothing. Most members of the communities adhered to the recommendations due to fear of being infected and the risk of subsequent death (Kimani *et al.*, 2007).

Recommendations for Risk communication:

- Devise a risk communication strategy for RVF that promotes transparency and accurate information.
- Ensure that human and animal health sector messaging is harmonized to avoid conflicting advice.
- Promote accessibility of information by different audience groups, including women, given their roles in childcare and animal husbandry.
- Identify which are the most trusted communication channels (e.g. radio in Kenya), and respond to misinformation and panic on electronic media by providing constant and updated accurate information. Explore the possibility of mobile phone communication with pastoralists.
- Utilise local influencers such as health providers, traditional leaders, chiefs, baraza, church women groups, etc. to disseminate technical advice using person-to-person models.

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Credits

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Citation: Abbas, S.; Bukachi, S.A. and Ripoll, S. (2019) *Social Science in Epidemics: Rift Valley Fever Lessons Learned*, SSHAP Lessons Learned Issue 4, UNICEF, IDS & Anthrologica.

This document has been funded by UNICEF and the U.S. Agency for International Development (USAID) Office of U.S. Foreign Disaster Assistance (OFDA). However, the views expressed herein are those of the author(s) and do not necessarily reflect those of USAID or OFDA, or the partners in the Social Science for Humanitarian Action Platform (SSHAP).

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This Lessons Learned paper is part of a portfolio on Social Science Lessons Learned in Epidemics and was supported by the Office of U.S. Foreign Disaster Assistance (OFDA) and UNICEF.