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Rift Valley fever outbreaks forecasting models

Joint FAO - WHO experts consultation

Rome, Italy
29 September–1 October 2008

GLOBAL ALERT AND RESPONSE

World Health Organization

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Food and Agriculture Organization of the United Nations

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Executive Summary

Rift Valley fever (RVF) is a mosquito-borne viral zoonosis that primarily affects animals but also has the capacity to infect humans. RVF outbreaks in eastern Africa are closely associated with periods of heavy rainfall and RVF forecasting models and early warning systems have been developed to enable national authorities to implement measures to avert impending outbreaks. Despite these precautions a series of RVF outbreaks from 2006 to 2008 dramatically affected countries in Africa, the Sudan and islands in the Indian Ocean.

Based on practical considerations experienced during 2006–2008 RVF outbreak control operations, the Food and Agricultural Organization of the United Nations (FAO) and the World Health Organization (WHO) have developed a common strategy for RVF outbreaks, from forecasting to response. FAO and WHO are currently defining joint guidelines for countries, to provide a framework for a coordinated and integrated prevention and control strategy, before, during and after RVF outbreaks. Part of this effort must be dedicated to early warning based on RVF outbreak modelling and forecasting, which is critical for providing a time window for preventive measures before the amplification of the virus is out of control.

To further this effort, FAO and WHO invited a group of experts on RVF modelling and forecasting to a two-day Rift Valley fever outbreak forecasting models workshop to share feedback from the 2006–2008 outbreaks, share experiences, identify gaps and explore potential improvements in RVF outbreak models. The objectives of the workshop were to review the natural history of RVF, review the forecasting models and risk distribution maps available and being developed, and propose how these tools might be improved. The final goal was to define a roadmap, in the form of recommendations, for the development of tools for forecasting RVF outbreaks and for real-time analysis of RVF spread during outbreaks.

The following report presents a summary of the presentations of different RVF forecasting models and RVF outbreak risk mapping strategies with possible improvements identified by the speakers, the main points of discussion and the concluding recommendations based on the points listed below.

1. The accuracy of RVF potential major outbreak area maps should be increased in order to improve forecasting models.

2. Forecasting models should be further developed to be more specific.

3. Models should be coupled to buy time and precision; an alert signal should be sent six months before the start of an animal outbreak.

4. RVF forecasting models and potential major outbreak area maps should be used to monitor evolution of RVF outbreaks over time.

5. The participation of ministries of meteorology, ministries of health and ministries of agriculture in the forecasting alert system should be enhanced.

I. Introduction

Rift Valley fever (RVF) is a viral zoonosis that was first identified in Kenya in 1931. This mosquito-borne disease primarily affects animals but also has the capacity to infect humans. The majority of animal infections result from the bites of infected mosquitoes, while most human infections are caused by direct or indirect contact with the blood or organs of infected animals. Such contact may occur during the care or slaughtering of infected animals or possibly from the ingestion of raw milk.

RVF outbreaks in eastern Africa are closely associated with periods of heavy rainfall that occur during the warm phase of the El Niño/Southern Oscillation (ENSO) phenomenon, which affects the mosquito populations acting as vectors and reservoirs of the disease. Forecasting models and early warning systems for RVF using satellite images and weather/climate forecasting data have been successfully developed, enabling national authorities to implement measures to avert impending epidemics.

In late 2006 and the first semester of 2007, RVF outbreaks linked to unusual rainfall associated with El Niño, dramatically affected countries in the Horn of Africa (Kenya, Somalia, and the United Republic of Tanzania). The disease reappeared in the Sudan in September 2007 following excessive rainfall driven by a post-El Niño, unusually warm, sea temperature in the Indian Ocean. Southern African countries (Swaziland and South Africa) and islands in the Indian Ocean (the Comoros, Mayotte, and Madagascar) were affected in 2007 and 2008.

The outbreaks were predicted for the coastal countries of eastern Africa. Forecasting models and early warning systems based on near-real-time climatic data were available at the continental level and proved to be efficient in raising the alert before the onset of the epidemic. Warning messages were sent, but the implementation of preventive measures and key control activities in this context was difficult for various reasons.

FAO and WHO collaborated in the emergency response effort with other international organizations including the Centers for Disease Control and Prevention (CDC, Atlanta, USA), the Institut Pasteur, (Madagascar, and Paris, France), the World Organisation for Animal Health (OIE, Paris, France) and the United Nations Children's Fund (UNICEF); national organizations; and the national authorities of the affected countries. National action plans were reviewed, disease control activities implemented and a significant amount of resources allocated to increase disease detection surveillance and control. As a result, unique human and animal data were collected which can now be used to adjust and complement the existing RVF forecasting models. In addition, FAO and WHO officers in the field had the opportunity to widely use outcomes from the different models and identify gaps or needs that could be filled in order to improve the use of these predictions in an integrated disease prevention and control perspective.

FAO and WHO are currently working on the definition of joint guidelines for countries to improve the level of preparedness and capacity for early response to RVF outbreaks. Part of this effort must be dedicated to early warning based on RVF outbreak modelling and forecasting as it is a key point that may provide a time window for preventive measures, before the amplification of the virus is out of control.

To further this effort, FAO and WHO held a Rift Valley fever outbreak forecasting models workshop, 29 September–1 October 2008. RVF modelling and forecasting experts were invited to share feedback from the 2006–2008 outbreaks, share experiences, and identify gaps and explore potential improvements in RVF outbreak models in order to further adapt model outcomes to fit the needs of RVF control strategies. The objectives of the workshop were to review the natural history of RVF, review the forecasting models and risk distribution maps available and being developed, and propose how these tools might be improved. The final goal was to define a roadmap, in the form of

recommendations, for the development of tools for forecasting RVF outbreaks and for real-time analysis of RVF spread during outbreaks.

II. What is needed to improve RVF forecasting and outbreak management?

Return from experience from recent outbreaks and expectations from FAO and WHO

Dr Stéphane de La Rocque, FAO, Rome and Dr Pierre Formenty, WHO, Geneva

The first warning of an increase in the probability of RVF activity at the end of 2006 was due to the development of an El Niño event and was launched by the NASA/Goddard Space Flight Center in mid-September of the same year. FAO and WHO forwarded this warning to their representatives in the at-risk countries and consolidated warnings were sent in November. However, too short notice, limited confidence of the countries in this sort of prediction, a decrease in awareness and resources dedicated to RVF and the absence of clear regional strategies and common contingency plans at the country and regional levels made the implementation of preventive measures difficult.

Based on practical considerations experienced during RVF outbreak control operations conducted in some of the affected countries - mainly Kenya, Madagascar, Somalia, the Sudan, and the United Republic of Tanzania - FAO and WHO have developed a common strategy[1] for RVF outbreaks, from forecasting to response. FAO and WHO are currently defining joint guidelines for countries to provide a framework for a coordinated and integrated prevention and control strategy before, during and after RVF outbreaks. FAO and WHO have the common goal of supporting development of the RVF forecasting effort to improve the capacities of existing models in order to increase the period in which preventive measures can be undertaken.

For various reasons, RVF forecasting is more advanced in some countries than others; RVF high-risk ecological areas are well understood in Kenya, Somalia, and the northern part of the United Republic of Tanzania, and less well identified in the Sudan. Areas where the disease had never been reported, such as the centre of the United Republic of Tanzania, were affected during the recent epidemics. Forecasting is still exploratory in some countries, such as Madagascar, due to a limited understanding of the epidemiology of RVF in the different ecosystems of the island. The role of animal movements in the spread of the disease makes it necessary to distinguish between the primary area of emergence and secondary foci where the virus has been introduced and amplified, especially in irrigated areas, e.g., the Gazeera irrigation scheme in the Sudan, the Ifakarra rice valley in Tanzania or rice valleys in the centre of Madagascar.

There is therefore a real need to further improve the spatial accuracy of forecasts and monitor conditions in regions of interest in order to deploy resources and strengthen efforts for active surveillance detection and control. FAO and WHO have identified, in practical terms, some of the limitations of and remaining questions for forecasting activity:

[1] P Formenty and S de La Rocque. Rift Valley fever outbreaks in Africa and the Middle East: forecasting, surveillance and control. In: Rift Valley Fever Workshop, January 27–29, 2009, Cairo, Egypt (http://www.ars.usda.gov/meetings/rvf2009/presentations.htm)

- When should FAO and WHO alert the countries? How should the NASA RVF monthly maps of areas at risk for RVF outbreaks be interpreted when only one big outbreak (2006–2007) has been observed in seven years and when strong warnings can be highly damaging?
- Could the modelling framework be improved with good field data such as soil type, elevation, vector ecology maps, etc.?
- How can we address the fact that climatic models apply well in eastern and southern Africa, but are more difficult to apply to western Africa (Senegal, Mauritania), the Middle East (Egypt, Saudi Arabia, Yemen) or Madagascar? Will this affect the confidence we have in the existing models?
- RVF warnings are given two months in advance, but six months are needed between the forecasting alert and outbreak onset in order to implement preventive measures, including social awareness and mass animal vaccination. Is this feasible?

III. The Natural History of RVF

Epidemiology and ecology of RVF and key drivers for endemicity and epidemics

Dr Glyn Davies

RVF endemic cycles occur in temperate, tropical and sub-tropical zones of Africa. The virus is capable of inhabiting a variety of different bioclimatic conditions including wet and tropical areas such as Côte d'Ivoire and the Congo, hot and arid areas such as Yemen or Chad, and irrigated regions such as the Senegal River valley and the Nile Delta. Most RVF viral activity is cryptic at a low level and not associated with detectable disease in humans and animals. Many African countries have found significant seroprevalence in sheep, goats and cattle for the RVF virus throughout various agro-climatic zones, without clinical signs being reported in humans or animals. Most countries are not really aware of the circulation of the virus because of a lack of systematic surveillance activities.

At irregular intervals of about 5–12 years, large epidemics of RVF have occurred in southern and eastern Africa; these epidemics have been associated with above average rainfall, a large amount of vector activity and the presence of susceptible livestock. The 1997–1998 epidemic in the Horn of Africa, which is considered as one of the most devastating RVF epidemics in eastern Africa, was associated with torrential rains - 60–100 times the seasonal average - that resulted in the worst flooding