



## Review Article

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# An Overview of Sixteen Years Control Program against Rift Valley Fever in Saudi Arabia: A Review Study

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## Abstract

Rift Valley Fever (RVF) is a serious life-threatening disease with severe clinical manifestations and health consequences for humans and a wide range of domestic animals. In September 2000, a RVF outbreak was reported in Jazan region south-west Saudi Arabia with 886 human cases including 124 deaths. This review provides: 1) An overview of RVF control program in Saudi Arabia and current control measures; 2) A feasibility assessment of some intervention measures that have been launched since the early recognition of RVF. Currently, with the exception of Saudi Arabia, devastating outbreaks of RVF continue to occur frequently in the 21<sup>st</sup> century and the number of countries reporting cases have increased rapidly. Around 19 large outbreaks including substantial numbers of human and animal deaths have been reported for the period between 2000-2018. In contrast to the aforementioned situation in endemic areas, control program against RVF in Saudi Arabia has completely reversed the risk of outbreaks over the past 16 years and provide long term protection against RVFV exposure. The successful control program had the following parts: Vector control campaigns using ULV; fog and sprinkle sprayers; draining and filling of water swamps with soil; biological control; mosquito surveillance; sustaining vaccination campaigns; regular examination of sentinel herds; serological examination of clandestine imports at Al-Twal quarantine station (at the border with Yemen); and targeted sero-surveillance during rainy seasons.

The effectiveness of the current control program can be demonstrated not only by the decreased in prevalence of RVF from 12.3% in 2000 to 0.015% in 2015, but also by the absence of human and animal active cases since the 2000 outbreak. Additionally, vector control measures that targeted outdoor habitats in Jazan region, contribute to significant reduction in malaria case incidence from 2000 to 2014. The Saudi's current control initiative could be used as a guideline for control or as a suitable model to replicate in other endemic countries.

## Keywords

RVF-control-prevention

## Introduction

RVF is a serious infectious disease in humans and a wide range of domestic ruminants, caused by mosquito-borne virus that belongs to the family *Bunyaviridae*, genus *phlebovirus*. Human can be infected either by mosquito bites or through the exposure to blood, aborted fetal materials, body fluids, or tissues of infected animals [1]. It was first reported among livestock in Kenya in 1931, since then it has been reported not only in most African countries, but also in Arabian Peninsula, particularly in Saudi Arabia and Yemen in the year 2000 [2,3]. This outbreak was the first appearance of the RVFV in new geographical areas outside Africa [4] Jazan region-South west Saudi Arabia-has had the hardest hit by the disease. Out of the total animal cases, (65.6%) were occurred in Jazan region, (26.9%) in Asir and (7.5%) in Alquenfeda [5]. High mortality rates from RVF in hospitalized patients were reported during the outbreak including 124 deaths. Small percentage of people developed much more severe signs involving, hemorrhagic manifestations, retinitis, meningoencephalitis and

death (19.4%, 9.7%, 4.2% and 33.9%) respectively. The main factors leading to deaths in humans could be attributed to hepatocellular failure (75.2%), followed by acute renal failure (41.2%) [6]. This outbreak raised concerns about the potential incidence and establishment of the disease in different environmental conditions and could affect areas haven't ever experienced the disease before as a consequence of climate change and globalization of trade in animals and its products [7]. Surprisingly, it has been proved in a retrospective study that Saudi Arabia was free from RVF until 1995 and most probably before the 2000 epidemic [8]. The virus apparently

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**Table 1:** Sentinel herds investigations.

Number of Herds	Number of animals in each Herd	Total number of animals	Sampling program
11 herds	30 animal	330	Monthly during rainy season



introduced to Saudi Arabia during the religious festivals (Eid Aladha) through importation of live animals from African Horn countries, since, the virus isolated from the first patients during 2000 outbreak had an RNA sequence similar to the virus isolated in 1997-1998 East African outbreaks [9,10]. The adverse effects of the disease and the serious socio-economic impacts obliged the relevant veterinary authorities in Saudi Arabia to devote an effective control program based on breaking the transmission cycle and raising herd immunity. This paper specifically aims to: 1) Summarize control measures against RVF that operated in Saudi Arabia since 2000; 2) Assess the effectiveness and benefits of the current RVF control program.

**Methods of Data Collection**

A systematic review was conducted by searching Google Scholar (<https://scholar.google.com/>) up to November 15, 2018. The search terms “RVF” and “Saudi Arabia” were combined using the operator “AND” to identify the original research articles. A total of 1610 articles were identified by searching Google Scholar. The identified studies were screened on the basis of its relevance to the aim of study and published in English-language. Of 1610 screened reports, 17 articles were finally selected. Additional data were obtained from Veterinary records in Ministry of Environment, Water and Agriculture K.S.A as well as from World Health Organization (WHO), Centers for Disease Control and Prevention (CDC).

**Component of the RVF control program**

Various control measures have been implemented in Jazan over the past sixteen-years including the following: 1) Restriction of animal movement, which was implemented in the affected areas in Jazan, Tohamet Aseer, Tohamet Mekkahand Tohamet Al-bahah. Unvaccinated animals are not allowed to leave the outbreak zones; 2) Vector control campaigns using ULV, fog and sprinkle sprayers in rural farms, cities and villages were routinely adopted; 3) Draining and filling of water swamps with soil as well as biological control; 4) Mosquito surveillance and virus detection

in mosquitoes by molecular techniques. Finally, sustaining vaccination campaigns, regular examination of sentinel herds, serological examination of clandestine imports at Al-Twal quarantine station (at the border with Yemen), and targeted sero-surveillance during rainy seasons.

**Vaccination against RVF:** The live attenuated vaccine (Smithburn strain) has been used as the gold standard vaccine in Jazan region since the outbreak of 2000. Although, the annual vaccination program of RVF in high risk areas is restricted to nonpregnant animals above six months of age before or at the mating season to ensure maternal antibodies and to avoid abortion, it has been proved through serological surveys that vaccination is effective and highly beneficial in controlling infections [11].

**Sentinel herds:** Sentinel animals are unvaccinated animals, related to the local breeds and imported from regions free from RFV infection. These animals were subjected to IgM and IgG antibodies tests against RVF before they were placed on ideal habitats for RVF vectors so as to investigate the potential circulation of RVFV during inter-epizootic period (Table 1) [12].

**Land spraying:** Outdoor land spraying with residual insecticides that is targeting adult mosquitoes is used to control mosquito populations in vegetation or resting sites such as animal shelters at times relevant to mosquito activity, mainly 1-2 hours after sunset or 1-2 hours before sunrise. Both of ULV spraying and thermal fogging equipment are usually mounted on ground vehicles Figure 1.

**Arial spraying:** Arial spraying targeting adult and immature stages has effectively reduced the insect populations over a large scale, notably, in areas not accessed by roads or ground vehicles such as dense vegetation, forested lands, valleys, streams, lakes and sewage stations. Both of helicopter and fixed wing aircrafts contribute importantly to vector control Figure 2.

**Biological control:** The numerous disadvantages of insecticides such as increasing resistance to commonly used pesticides and the global growing concerns over the use of

**Table 2:** Vector control activities.

Lands covered by arial spray per year	Number of ponds treated by BTI	Animal shelters treated by pesticides
44000 Hictar	2422	277678

**Table 3:** Mosquito surveillance activities in Jazan region.

Trap type	Average number of trap sites per week	Average number of investigated ponds per week
CO <sub>2</sub> baited trap/clarck	48	24



**Figure 2:** Aerial spraying in inaccessible areas by fix wing planne.



**Figure 3:** Drainage of stagnant water in Jazan region during rainy season.

insecticides in the environments, have promoted the use of biological control and environmental management rather than chemical control. Biological control aimed to kill larvae without polluting or damaging the environment by using liv-



ing organism like bacteria *Bacillus thuringiensis* var. *israelensis* (B.T.I) (Table 2).

**Environmental management:** Environmental management is an effective approach in vector control to maintain permanent control of mosquito via altering or removing vector breeding sites, which can be obtained by covering water containers, removal of small used cans or tires, flushing streams, draining water to follow the natural flow, filling in ditches with soil or stones, subsoil drainage, and removing vegetation from water bodies [13], Figure 3.

**Entomological surveillance:** Mosquito surveillance commonly conducted before insecticides treatments to test the density of mosquitoes in breeding habitats and post treatments to evaluate the efficiency of spraying. A light CO<sub>2</sub> baited traps placed overnight at different locations where

mosquito breeding sites are found (Table 3). These traps are usually collected the following morning before sending to the laboratory Figure 4.

## Evaluation of RVF control program

**A zero incidence of RVF infection in human:** Currently, with the exception of Saudi Arabia, outbreaks of RVF continue to occur frequently in the 21<sup>st</sup> century and many countries were harder hit by the disease. Around 19 large outbreaks with a substantial numbers of animals and humans deaths have been reported for the period between 2000-2018, in particular, Mauritania which has been affected in (2010, 2012, 2013 and 2015) (Table 4). By contrast, no human fatalities have ever been reported in Saudi Arabia since the 2000 outbreak. It is obviously that the control program plays a significant role in RVF prevention over the past sixteen-years, despite the recent climate change in Arabian peninsula and early warning alerts that issued from the National Aeronautics and Space Administration (NASA) and indicated elevated risk of RVF activity in Saudi Arabia due to above normal rainfall in 2005 and 2015 [14,15].

**Low incidence of RVF in local herds and sentinel animals:** The efficacy of the current control program can be demonstrated not only by the absence of human cases, but also by the high decrease in prevalence of RVF in local herds from (12.3%) in 2000 to (0.015%) in 2015 [5,16], Currently, the circulation of RVFV mainly be restricted to sporadic cases without clinical signs mostly in sentinel herds. The absence of clinically active cases in humans as well as in animals since the first outbreak reflects the high efficiency performance in control program [17].

**Evaluation of vaccination (a pooled analysis of cross-sectional surveys):** A pooled Analysis of positive cases of RVF that were diagnosed through cross-sectional surveys in high risk areas and sentinel herds screening program (information taken from veterinary records) has been done to evaluate whether or not vaccination has a significant effect in preventing outbreaks as long as both of sentinel herds and local animals are exposed to the same level of RVFV infection (Table 5).

The risk of RVF infection in sentinel herds is  $36/330 = 10.9$  cases per 100 animals. While the risk in vaccinated animals is  $53/18287 = 0.29$  cases per 100 animals. The odd ratio is (0.02) P-values < 0.05, which tells us that vaccination seems to be protective against RVF.

**A significant decrease in malaria incidence:** From 2000 to 2014, efforts to control malaria in the Kingdom of Saudi Arabia has successfully reduced malaria cases, particularly in locally acquired cases wherein a significant decline was observed from (2756 cases; 35.3 per 10,000 population) in 2000 to (15 cases; 0.11 per 10,000 population) in 2014 Figure 5. This reduction attributed to coincidental expansion of control efforts including RVF vector control program that targeted outdoor habitats [18].

## Conclusion

To sum up, the study has provided some results which

**Table 4:** RVF Outbreaks from 2000 to 2018 [19-21].

Date	Country	Human deaths	Human cases
2003	Egypt	29	*
2007	Kenya	155	684
2007	Tanzania	144	511
2007	Somalia	114	51
2007	Sudan	222	698
2008	Mayotte	10	*
2008	Madagascar	17	418
2008	Swaziland	*	*
2010	Mauritania	13	63
2010	South Africa	25	302
2010	Botswana	*	*
2012	Mauritania	17	34
2013	Senigal	*	535
2013	Mauritania	*	*
2014	Botswana	*	*
2015	Mauritania	8	*
2016	Uganda	*	*
2016	Niger	33	266
2016	Mali	*	*
2016	China	1	*
2018	Kenya	6	26

China's first imported case of RVF was from a patient came from Angola in July, 2016.

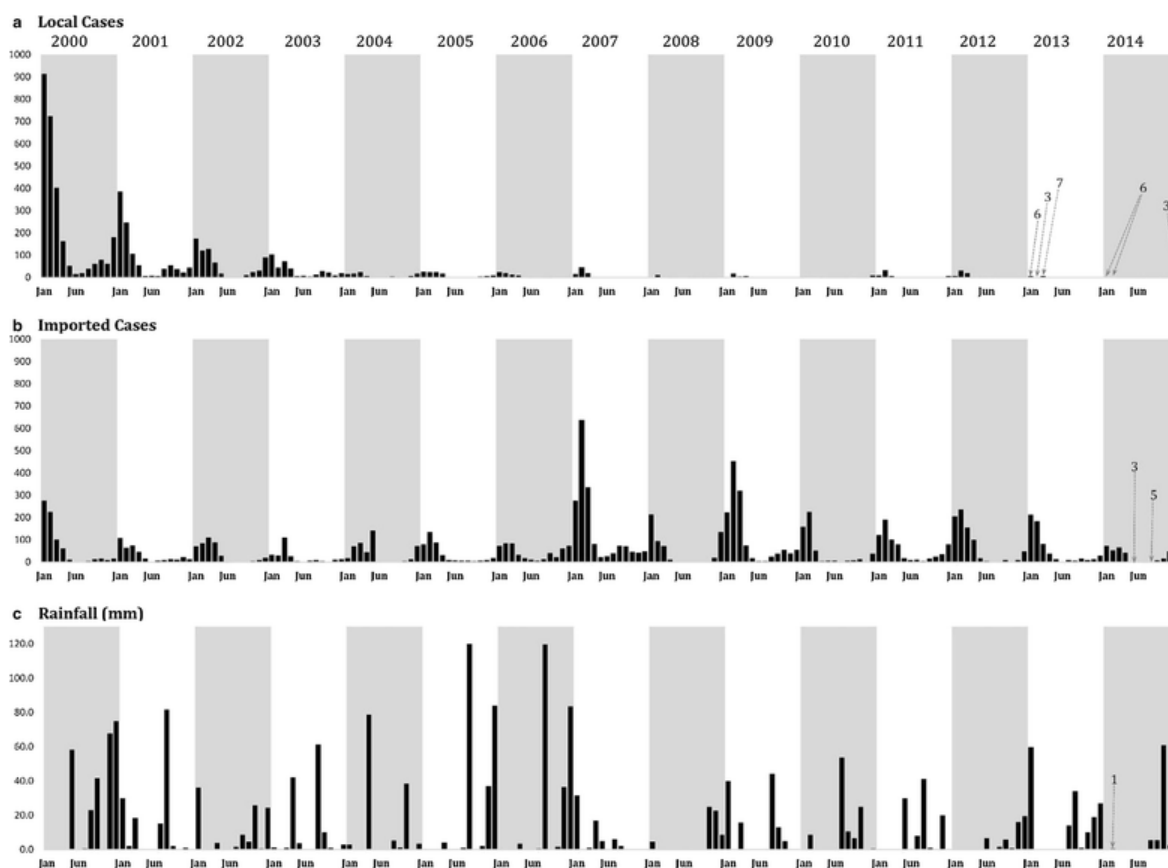
\*No information available.

**Table 5:** The risk of RVF in both of local herds and sentinel animals.

	Disease	No disease	Total
Exposed (vaccinated animals)	53	18234	18287
Unexposed (Sentinel herds) Unvaccinated	36	294	330
Total	90	18472	18617



**Figure 4:** CO<sub>2</sub> baited traps for mosquito surveillance in Jazan region.



**Figure 5:** Locally acquired malaria case burdens January 2000 to December 2014.

can be reviewed as follows: 1) RVF can be controlled through routine vaccination in combination with vector control in high risk zones as well as effective surveillance system based on sentinel surveillance, targeted surveillance during rainy season and mosquito surveillance; 2) The study has recognized the control program in Saudi Arabia has as highly effective in preventing outbreaks as long as; a) No clinically active cases in humans and animals since the first outbreak; b) The prevalence of RVF is remarkably decreased from (12.3%) in 2000 to (0.015%) in 2015; 3) The integrated vector control strategies that have been implemented in the region could help to reduce incidence of emergent mosquito borne diseases such as malaria; 4) The current control program could be used as a successful model to replicate in other endemic countries.

## Competing Interests

The author declares that there is no conflict of interest regarding the publication of this paper.

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