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REVIEW ARTICLE
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Rift valley fever in Africa with the emerging interest in Libya

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Abstract

Rift valley fever (RVF) is an acute vector-borne viral zoonotic disease of domestic and wild ruminants. The RVF virus (RVFV) belonging to the *Phlebovirus* genus of the *Bunyaviridae* family causes this disease. Studies have shown that mosquitoes are the vectors that transmit RVFV. Specifically, *Aedes* and *Culex* mosquito species are among the many vectors of this virus, which affects not only sheep, goats, buffalo, cattle, and camels but also human beings. Since the 30s of the last century, RVF struck Africa, and to a lesser extent, Asian continents, with subsequent episodes of epizootic, epidemic, and sporadic outbreaks. These outbreaks, therefore, resulted in the cumulative loss of thousands of human lives, thereby disrupting the livestock market or only those with seropositive cases. After that outbreak episode, RVF was not reported in Libya until January 13, 2020, where it was reported for the 1st time in a flock of sheep and goats in the southern region of the country. Although insufficient evidence to support RVF clinical cases among the confirmed seropositive animals exists, neither human cases nor death were reported in Libya. Yet, the overtime expansion of RVF kinetics in the Libyan neighborhoods, in addition to the instability and security vacuum experienced in the country, lack of outbreak preparedness, and the availability of suitable climatic and disease vector factors, makes this country a possible future scene candidate for RVF expansion. Urgently, strengthening veterinary services (VS) and laboratory diagnostic capacities, including improvement of monitoring and surveillance activity programs, should be implemented in areas at risk (where imported animals crossing borders from Libyan neighborhoods and competent vectors are found) at national, sub-national, and regional levels. The Libyan government should also implement a tripartite framework (one health approach) among the veterinary public health, public health authority, and environmental sanitation sectors to implement RVF surveillance protocols, along with an active partnership with competent international bodies (OIE, FAO, and WHO). Therefore, this review comprises the most updated data regarding the epidemiological situation of RVF infections and its socioeconomic impacts on African and Asian continents, and also emphasize the emerging interest of RVF in Libya.

Keywords: Africa, epidemiology, Libya, one health, rift valley fever.

Introduction

Rift valley fever (RVF) is an acute viral disease of domestic and wild ruminants. The RVF virus (RVFV) belonging to the *Phlebovirus* genus of the *Bunyaviridae* family causes RVF, and mosquitoes transmit this disease. RVF was first described in the Kenyan homonymous rift valley in 1930, where the virus was isolated during an epidemic investigation, with abortion storms in ruminants, mortality in lambs and calves, including human outbreaks serving as observed characteristics in a farm in Naivasha lake at the great rift valley of Kenya [1,2]. Since then, several outbreaks have been reported in other African countries, including Mauritania, Namibia, Zimbabwe, Tanzania, Cameroon, Central African Republic, Mali, and Mozambique [3-7].

Between 1950 and 1976, 16 major epizootics of RVF have occurred in livestock at various locations in Sub-Saharan Africa. In 1987, the first confirmed outbreak of RVF was also reported in West Africa (in Mauritania and Senegal) [8]. However, in the outbreaks that occurred in cattle and sheep during the rainy seasons of 1973/1974 and 1977/1978 in Zambia and Mauritania, respectively, a significant correlation was observed between the serological evidence of RVF virus infections and the presence of large expanses of stagnant water. Therefore, it was proposed that stagnant water provided a suitable habitat for these disease vectors [9,10]. In early 1977, the disease emerged to cause extensive epizootics in Egypt, thereby resulting in abortions and mortality in domestic ruminants and severe clinical disease fatalities in humans (200,000 human infections and 600 deaths) [11,12]. Similarly, during the Mauritanian outbreak that occurred in 1987, approximately 200 human deaths were reported [8]. Furthermore, during the 1991 outbreak, RVFV struck Madagascar and a part of East Africa, which resulted in 500 human deaths [13]. Likewise, in October 1993, at the end of the rainy season, active RVFV transmission was detected in several locations of Southern Mauritania in small ruminants. Unexpected outbreaks of RVF associated with human deaths were also reported in December 2006, which was associated with fever and hemorrhage, including illnesses and deaths among animals in the North-Eastern Province of Kenya [14]. During this outbreak, the Kenya Medical Research Institute confirmed RVF in 10/16 patients by mid-December. Subsequently, the WHO alerted the Global Outbreak Alert and Response Network. From November 30, 2006, to March 12, 2007, 684 cases were also reported in Kenya, including 155 deaths, thereby serving as one of the most major RVF outbreaks in endemic territories [14]. Afterward, severe disease cases were reported in other countries such as Mauritania, Zambia, Tanzania, Central Africa, Madagascar, Kenya, Somalia, Senegal, Namibia and South Africa [3-5,7,13-17]. In 2016, outbreaks of RVF were reported afresh in Niger, which killed at least 21 people over a period of months [18]. Considering the RFV kinetics over Africa, the potential for further geographical spread to areas that have never reported outbreaks of the disease has been suggested [19,20].

In addition, following the extensive RVF circulation in South Africa [21], Monaco *et al*. [16] investigated the RVFV outbreaks that occurred during May-July 2010 in Namibia, where ovine and caprine flocks, showing clinical signs compatible with RVFV, were reported to the Namibian VS. Subsequently, the molecular characterization showed a high degree of sequence identity related to RVFV strains that cocirculated in South Africa that same year, suggesting that these strains belonged to a common viral population circulating between these two countries. Besides circulating in African endemic areas, RVFV showed the ability to also spillover outside its traditional area and gain new territories, thereby having significant impacts. A good example of this possibility was witnessed in 2000, when an RVFV outbreak was reported for the 1st time in the Arabian Peninsula [22,23]. Later, the viral spillover led to significant potential socioeconomic impacts on Saudi Arabia and Yemen [23,24]. Based on the above facts, emerging RVFV outbreaks with unpredictable epidemics in free RVF territories have highlighted the urgent need to implement strategies for routine RVFV bases surveillance programs, especially in countries facing a higher risk of RVFV entrance. Therefore, this review comprises the most updated data regarding the epidemiological situation of RVF infections and its socioeconomic impacts on African and Asian continents. The report also highlights the emerging interest of RVF in Libya.

RVF is among zoonotic vector-borne diseases. Therefore, in the context of one health concept, RVF should be included in the tripartite interface level (animals, environment, and humans) for the prevention and control of future epidemic outbreaks. Although the one health concept in Libya is not in place yet, and a weakness exists in public health capacities, in addition to the lack of intersectoral collaboration between veterinary medicine and public health specialists (one health approach), it has been difficult to implement well-blended strategies for the prevention and control of emerging zoonotic diseases at the human-animal interface. Hence, the one health concept should be improved to enhance the early detection, alert, and response to epidemic outbreaks of emerging, including reemerging diseases like RVF, representing significant threats to humans.

Epidemiology of RVF

The epidemiological cycle of RVF involves enzootic and enzootic-epidemic cycles. Mosquitoes, mainly those of the *Aedes* and *Culex* genera, are both reservoirs and vectors for RVFV, making them able to maintain RVFV and transmit it transovarially to their offspring (through eggs) [25,26]. After periods of heavy rainfall and flooding, more RVFV-infected mosquitoes are proposed to hatch, thereby passing the virus to humans and animals to produce a disease outbreak [3,27]. Subsequently, direct human contact with infected animals can occur during slaughter and VS procedures [26]. Humans can become infected through contact with infected animals or tissues, as well as through mosquito bites [28]. However, no human-to-human transmission of RVF has been reported [29].

Several *Aedes* and *Culex* mosquito species are vectors of this virus, which affects not only sheep, goats, buffalo, cattle, and camels but also human beings [30,31]. Although the bioecology of these two mosquito genera is different, both species are proposed to contribute to the epidemiological cycle of the disease in different ways. *Aedes* females lay their eggs in the mud of temporary water points [24]. The eggs can then survive for several years in desiccated mud if the water point dries up [32]. To hatch, the eggs must first dry out for several days before being submerged in water. Fluctuations in water levels are consequently necessary for the *Aedes* populations to develop. In contrast, *Culex* eggs do not survive desiccation. Therefore, *Culex* populations need the permanent presence of water to develop [4,32]. Outbreaks of RVFV in Africa are thus characterized through distinct spatial and temporal patterns that are directly related to specific environmental parameters associated with mosquito vectors. These vectors, in turn, influence the maintenance (enzootic) and transmission (epizootic) cycles of the virus [33-36].

Domestic ruminants are susceptible to RVF infections. Likewise, wild ruminants serve as natural hosts for RVFV. However, the role of these animals as reservoirs during interepidemic periods and amplifiers during epidemics is not well understood [31,37]. Besides, camels have been suspected to play a key role in the epidemiology of RVF since serologic evidence of RVF in camels has frequently been reported during RVF outbreaks in Egypt and Sudan [27,31]. Clinical symptoms of RVF, ranging from mild to peracute forms with death within 24 h in the latter, have been described in Mauritania as well [3].

Furthermore, RVFV infections can cause abortion in pregnant animals and high mortality in newborns [38]. In older animals, the infection is mild or asymptomatic. However, the case fatality rate varies from 30% in adult cattle and sheep to 100% in young animals [39]. Nevertheless, although birds and reptiles are refractory to infections, important livestock species, such as pigs, horses, and other equidae, are resistant to these infections [40]. Conflicting published results concerning rodents exist. However, according to field and experimental studies, rodents potentially influence the maintenance of the virus during interepizootic periods of the natural cycle, thereby resulting in variable susceptibility to infections between rodent species [41,42]. Camels are work animals in many African countries that can move long distances during traveling and transportation in addition to their movement during illegal transitional and nomadic pastoral life. Therefore, the agro-pastoral characteristics of many African regions, which depend on high livestock transitional movement at national and regional (sometimes illegally) levels for trade, can increase the likelihood of RVFV endemic and epidemic exposures as well [31]. Consequently, camels can play an important role in the epidemiology of RVF according to several seroprevalence investigative reports, which propose that camels play significant roles in RVF transmission [3,31,43,44]. Similarly, serological investigations have revealed that seropositivity hazards of importing camels infected with RVFV to Egypt from Sudan were among the main causes of emerging and reemerging RVFV outbreaks in Egypt during 1977, 1978, 1993, and 1997 cases [45]. Thus, the role of the Camelidae in RVF's epidemiology, particularly in Africa, cannot be neglected.

In 2000, when the RVFV outbreak was first reported in the Arabian Peninsula, the disease caused 882 human cases; 747 (85%) Saudi nationals and 113 (13%) Yemenis [46,47]. That outbreak was linked to animal importation (cattle and camels) from endemic areas, which were coincident with environmental factors like vegetation index values that influence vector composition (densities) and activity [1]. In East Africa, RVF outbreaks are closely associated with heavy rainfall events as well [48]. Therefore, satellite measurements of global and regional elevated sea surface temperatures, elevated rainfall, and satellite-derived normalized difference vegetation index data should accompany the prediction of RVF occurrence [49].

Public Health and Socioeconomic Impacts of RVF

RVF influences both public health and economic sectors. An outbreak of RVF also results in losses at the local/regional level, which directly affects communities of agricultural producers [47] globally due to the ban of animal movements from epidemic or endemic areas. Since the 30s of the last century, RVF struck Africa, and to a lesser extent, Asian continents, with subsequent episodes of epizootic, epidemic, and sporadic outbreaks, which resulted in the cumulative loss of thousands of human lives and livestock [50]. Among the drawbacks of RVF outbreaks, a serious risk to food security threaten international trade as it constitutes a limitation to export live animals and their products, consequently leading to negative implication on social and religious practices. Intense commercial trade activities of import and export of huge cattle and small ruminant numbers are characteristics of holy months, peaking just before the religious festivals of Ramadan and Eid Al-Adha [22] when millions of animals (sheep, goats, bulls, and camels) are sacrificed. Therefore, once an RVF outbreak coincides with that period, a significant imposition of trade bans of live animals and slaughtering of infected animals results. Following the RVF outbreak in Saudi Arabia, the complete ban on animal trade of live animals from the Horn of Africa (Ethiopia, Somalia, and Kenya) was enforced, with a significant influence on economic activities [22,24]. One study estimated that the Somali region of Ethiopia's total economic value fell by US$132 million because of the trade bans [51]. According to reports of the 2006/07 RVF outbreaks, the Tanzania Veterinary Laboratory Agency indicated deaths of 16,973 (0.10%) cattle, 20,913 (0.18%) goats, and 12,124 (0.31%) sheep, in addition to 15,726 (0.09%) abortions in cattle, 19,199 (0.16%) in goats, and 11,085 (0.28%) in sheep [52]. In addition, in most African countries, livestock is an important source of livelihood for pastoralists, with livestock trade representing over 90% of pastoral incomes, particularly in the householder poverty communities [53]. The RVF does not affect just producers, but also other service providers within the livestock supply chain and other parts of the larger economy [51]. Thus, the economy of African countries during the ban is deeply affected since livestock trade is a significant and dominant part of their incomes [52]. Hence, not all countries strictly follow and apply OIE/FAO prescriptions, thereby posing the risk of RVF transmission with devastating results.

RVF with Emerging Interest in Libya

Located in Central North Africa, Libya can be considered a zone for emerging Transboundary Animal Diseases (TADs), but RVF. This exception is because this disease circulates in neighborhood countries having common borders, thereby expanding to new regions and having harmful socioeconomic and public health impacts [20]. Namely, those countries with endemic RVF status and possessing a direct emerging potential are Egypt, Sudan, and Niger [31,34,54]. In addition, countries at risk of having an RVF status, such as Tunisia and Algeria, represent an indirect emerging potential for Libya and vice versa.

RVF in the Libyan neighborhood dates to the seventies of the last century, where the disease emerged in Egypt (a Libyan neighbor with a long border), thereby causing extensive epizootic outbreaks that resulted in abortions and increased mortality in domestic ruminants, in addition to severe clinical disease with fatalities in humans [27]. However, before 1977, considerable aggregates of RVF encephalitic, ocular, and other fatal hemorrhagic diseases of RVF human deaths had been reported [27,45]. In early July 1978, an increased incidence of human and animal disease was also reported from villages near Belbeis and the Upper Egypt Governorates of Minya and Asyut, where increased abortions among sheep and cattle were observed [45]. The emerging and reemerging of RVFV cases in Egypt during 1977-1978, 1993-1994, 1997, 2000, and 2003 were considered among the most significant epizootic outbreaks [45,55,56]. However, RVF outbreaks during 1977-1978 were among the worst epidemic in human history [27]. Consequently, RVF epidemic outbreaks led to high morbidities and mortalities, which include approximately 200,000 human infections and more than 500 deaths [45,55,56]. Thus, according to many surveillance programs for investigating RVFV in Egypt during long interepidemic intervals, it was suggested that the circulation of the virus in certain areas was related to a high potential risk of RVF occurrence [56,57]. In addition, the reemerging 1993 RVFV case in South Egypt caused 600-1500 human infections, with critical clinical cases being recorded. However, according to many serological investigations during interepidemic periods (2003-2008), antibodies against RVF have been reported among the Egyptian population across several governorates in Egypt [57]. Hence, serological evidence of RVF cases reported in various Egyptian municipalities during epidemic and interepidemic periods of RVFV outbreaks is an indicator of the underestimated circulation of the virus. Thus, by considering only sporadic and point epidemics of RVF outbreaks [58], in addition to the maintenance of the virus in vectors, the potential influence of maintaining the enzootic cycle of RVF is proposed [45].

RVF has also been recorded in Sudan, a Libyan neighbor with a shared border that participates in considerable livestock trade (particularly sheep and camels). During the 2007 RVF outbreak in Sudan, approximately 430 human cases were reported from 41 localities [59]. Sudan was affected as a part of this RVF outbreak wave, which occurred in Central and Eastern Africa in 2007 with a high fatality rate of 31.8% in human cases. Later, in 2019, RVF reemerged in Sudan [59]. Therefore, a probability exists that the epidemic led to the incursion of the disease to neighboring border countries like Libya, as transboundary free animal movement and the importation of these animals from an endemic region forms part of the potential risk factors that have led to the RVFV's entrance [60,61]. Consequently, such illegal livestock trade movement poses a significant potential risk of the entrance of the RVFV into Libya, which can then play a role as the main corridor to introduce many diseases further into the region, thereby promoting its spread to southern Europe. Furthermore, illegal transitional animal movements to Libya, especially camels having high importation numbers from south bordering countries, are particularly noteworthy since RVF seropositivity among the Sudanese one-humped camels (*Camelus dromedaries*) is highly significant [31]. In a similar scenario, uncontrolled transboundary movement of animals across the south borders was considered the main risk factor for introducing RVFV that led to one of the worst outbreaks during the last century in Egypt. RVFV antibodies have also been detected in animals imported from Sudan, which assumed the transboundary introduction of RVF into Egypt through infected animals [45,50]. Hence, the proximate of the endemic area to Libya with a high prevalence rate of RFV [62,63] can serve as a potential factor for future RVF outbreaks.

In Niger, another Libyan neighbor with a long border, the first occurrence of RVF was reported in September 2016, when the Republic of Niger declared its first RVF outbreak in the northern region of Tahoua near the Malian border. During this outbreak, significant human deaths and cattle loss were reported [34]. The 2016 RVF epidemic in Niger was coincident with the rainy season between August and September, when higher activities of the mosquito's population increased, thereby serving as a potential source for RVFV transmission [34]. Moreover, molecular epidemiological investigations revealed similarities between RVFV strains from the Nigerien 2016 outbreak and those of Senegal 2013 and Mauritania 2015 [10,34]. Consequently, RVF outbreaks in Niger are proposed to be linked to the introduction of infected livestock from neighboring countries (Senegal and/or Mauritania). Therefore, uncontrolled animals' movement and illegal livestock trade were considered again as the main cause of RVFV's transboundary circulation between neighboring countries, particularly with a weakness in their quarantine measures. Like with Egypt and Sudan, the reemerging epidemic outbreaks of the RVF in Niger or neighboring countries are also proposed to be a potential risk of the introduction of RVFV to Libya. Despite RVF's emergence in Libya, only serologically evident strains were reported recently [60]. Worryingly, the risk of an epidemic with clinical presentations remains high.

In Tunisia and Algeria, which are countries belonging to the Maghreb region (MR) and sharing the West Libyan border, RVF has not been recorded yet. Nevertheless, these countries are considered at risk of RVF. Furthermore, since unique epidemiological cases characterized by MR Unite, in addition to their disease patterns and ecosystems are similar, many epizootics reported in one country can easily reach neighboring countries in different ways [63]. Nonetheless, the fragility of quarantine measures, uncontrolled animal movements, and illegal livestock trade in the MR are potential factors for the occurrence of many TADs. In addition, many TADs were recorded in those countries, which include foot and mouth disease [64], pests des petits ruminants [65-67], blue tongue [63,68,69], and the epizootic hemorrhagic disease [61,70].

The 2019-2020 Alkoufra Outbreak in Libya

According to the study by Mahmoud *et al*. [20] in 2018, which highlighted no serological evidence of RVF in Libya, its results pointed out that some areas in the country exist as highly potential risks of RVFV entrance. Expectedly, the National Center for Animal Health, Libya, recently reported (on January 13, 2020) serological evidence of RVFV among sheep and goats in the Alkoufra Province (southeast of Libya) [60]. This report was generated as part of a surveillance project, which FAO supported for combating TADs. Reports have proposed that the virus has been circulating before this time, even though no human cases have been reported yet, neither has any clinical outbreak occurred in any animal species. However, although neither case of RVF nor evidence of infections in some Maghreb countries (namely, Algeria, Tunisia, and Morocco) have been recorded, the fluctuation of climatic conditions, in addition to competent vectors, can increase the potential risk of RVFV incursion to these countries [20,71]. A report showed that interepidemic periods characterized RVFV's environmental cycle, with no viral circulation being reported, even for decades [20]. Nevertheless, the risk of introducing RVFV to those countries remains high due to the presence of the virus in South Libya, and the uncontrolled animal movement (animals crossing the border and illegal animals' importation). Moreover, heavy rains that accompany climate changes, followed by floods in the region can play an important role in emerging and reemerging epizootic RVF outbreaks [59,60]. This case is similar to those reported in Libya, from May 28, to June 5, 2019, when heavy torrential rains and devastating floods stroked the Ghat municipality in the southwest of the country, a factor, which also plays a crucial role in facilitating a suitable ecosystem for vector-borne viral diseases (VBVDs) like RVF. Therefore, even though no data exist about the distribution of the competent vector in Libya, a few MR studies have reported *Aedes* and *Culex* distribution [71]. Hence, the role of such vectors as a risk factor for potential incursion remains high.

Indeed, the transitional animals' movement influences the transmission of the RVFV from an endemic area to a free one. Accordingly, the recent serological evidence of RVF in the southeast of Libya in a flock of sheep confirms that the virus was introduced from neighboring countries [60]. Therefore, the spread of RVFV into Libya and the Middle East, in association with climatic changes and an increase in livestock trade, highlights RVFV as a threat to all MR from which the disease can spillover further into South Europe. Still, all the Mediterranean countries would be at potential risk of the virus' introduction.

Other than the seropositive presence of RVFV next door, its emergence and reemergence to Libya and the North African neighborhood are potentially expected due to other epidemiological factors such as uncontrolled livestock trade activities, unrestricted transitional animal movements locally and regionally, presence of vectors, and climatic factors. Therefore, a weakness like the lack of VS and control programs should be considered in this context

Livestock Trade Activities and Transitional Animal Movements

Libya is among the African countries with high livestock trade activities on regional and international levels as its characteristics. The high rate of meat consumption in this country makes its meat source dependent, therefore, forming an important part of the transmission process during the exportation of live animals. Livestock importation, especially before Eid Al-Adha from European countries, is considered the pathway for the introduction of live animals into Libya. In spite, the risk of introducing RVF from European countries remains low, which makes the transmission an absolutely rare event. However, that does not exclude the introduction of other exotic diseases if the Libyan authorities do not implement strict measurements regulating the importation of live animals and implement animal quarantine measurements that are not always compliant with OIE criteria and high-quality diagnostic testing capacity and technical knowledge to perform exotic diseases diagnosis. The other source of importation is the unrestricted livestock movement to Libya, which is one of the risk factors that introduced many TADs to the country [61]. Moreover, the lack and weakness of the legislations that rollout and regulate animal movements within the country between different Libyan provinces pose a risk factor for the occurrence of an epizootic outbreak. Specifically, instability and political conflicts during the last years have led to haphazardly huge animal imports, especially from southern countries (Niger and Sudan) with a history of recent RVF outbreaks.

The Competent Vectors (*Culex* and *Aedes* Mosquitoes)

The RVF is a VBVD. Many species of mosquitoes exist that are involved in the enzootic and enzootic-epidemic cycles. These species can maintain the virus for long through vertical transmission [26]. It has been reported that the *Aedes* and *Culex* genera are the main mosquito vectors [24]. The virus was isolated from mosquitoes (*Culex zombaensis*, *Mansonia africana*, and *Aedes quasitunivittatus*) collected during an outbreak in domestic animals from Kenya. Besides, *Aedes albopictus* should also be considered a potential vector of RVF virus [36,72]. Therefore, the lack of entomological surveillance for vectors related to Libyan RVFVs makes it difficult to understand epidemiological patterns of RVFs, especially in the southern region. Livestock market activities where imported animals are gathered in one market characterize these epidemiological patterns. From there, they move forward toward the northern part of the country. Consequently, RVF seropositive animals reported in the southern region are proposed to pose a potential risk of amplification and transmission of RVFVs to another part of the country. Therefore, it is important to understand the vector's ecology and anthropogenic factors that are responsible for RVF's transmission, especially during the long interepizootic phase.

The Climatic Factors

Climatic fluctuation has a significant influence on epidemic outbreaks of VBVDs [73]. The RVF disease occurs in animals during climatic conditions, thereby favoring the breeding of mosquito vectors, abortion, neonatal mortality, and liver damage as characteristics [2]. The emerging and reemerging of RVF are linked with climatic changes [74]. Therefore, during a heavy rain season, floods (referred to as "dambos") serve as suitable environments for the flare-up of mosquito eggs that maintain the virus [52,75]. Similarly, in Libya, waves of heavy rainfall resulted in floods, which were witnessed in Southwest Libya (Ghat municipality) during 2019, thereby representing a good example of climatic changes that play substantial roles in creating a suitable ecosystem for RVF transmission. These climatic changes also increase the potential risk of RVFVs to settle and emerge through the entire country and further regionally.

Veterinary Service (VS)

The quality of VS in any country is considered fundamental for improving animal and public health through the prevention, control, and eradication of devastating diseases, thereby creating socioeconomic and public health impacts.

In Libya and particular note for combating the TADs, among them, RVF, the strengthening of the country's VS is a crucial measure. In this context, experienced and well-trained veterinarians serve as clue points in the early warning of suspected cases. Other factors, such as employing qualified personnel, providing preliminary diagnostic materials, and establishing veterinary reference laboratories compliant with international organizations' criteria (OIE and WHO) for early sample submission and diagnosis (screening) also arise. Hence, enforcing border quarantine measures with routine random sampling (which will reduce the transmission), considering outbreak surveillance and response plan and implementing rigorous diagnostic and reporting services represent the most important factor that can influence the quality of VS in the country. This factor shapes the prevention/control capabilities and the impact of possible future outbreaks. Therefore, keeping strong partnerships with international organizations, namely, OIE, FAO, and WHO are of great value for that end.

Conclusion

Although no evidence of RVF clinical cases among the confirmed seropositive animals has been identified, neither human cases nor deaths have been reported in Libya yet. Nevertheless, an overtime expansion was noticed through RVF kinetics in the Libyan neighborhoods. An instability and security vacuum was also experienced in the country, in addition to the lack of outbreak preparedness, availability of suitable climates, and disease vector factors, which makes this country a possible future scene candidate for RVF expansion. In addition, the weakness of VS, outbreak surveillances, and reporting can cause an underestimation or misdiagnosis of RVF cases in the country. Therefore, as an urgent need, strengthening the VS, laboratory diagnostic capacities, as well as implementing monitoring and sero-surveillance activity programs should be implemented in the area at risk (where imported animals crossing borders from Libyan neighborhood and competent vectors are found) on national, sub-national, and regional levels. The Libyan government should also implement a tripartite framework among veterinary public health and public health authorities, in addition to environmental sanitation to implement surveillance protocols and strategies for the prevention and control of RVF that complements the FAO Emergency Prevention System and the WHO early warning alert and response network system, among collaborations with countries of the MR, other neighboring countries, including competent bodies (OIE, FAO, and WHO).

Authors' Contributions

ASM and EMB: Conceived the design of the review and drafted the manuscript. ASM: Drafted the manuscript. OKS and ORE: Performed the literature search, provided critical comments, feedback, and helped in drafting the manuscript. All authors read and approved the final manuscript.

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Competing Interests

The authors declare that they have no competing interests.

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