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Knowledge and practices on Rift Valley fever among livestock farmers and animal health professionals in Nyandarua County, Kenya

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Abstract

Introduction: *Rift Valley fever (RVF) is a mosquito-borne viral zoonosis that affects cattle, sheep, and goats leading to significant socio-economic and public health impacts. In low-endemic areas like Nyandarua, RVF cases are often underestimated due to underreporting occasioned by uncoordinated community surveillance systems. There is limited knowledge of the causation, transmission, risk factors, and prevention of RVF among communities in low-risk areas. The study aimed to investigate RVF knowledge and practices on RVF among small-scale livestock farmers and animal health professionals (AHPs) in Nyandarua County, Kenya.* ***Methods:*** *in July 2020 and January 2021, a cross-sectional survey was conducted in which structured questionnaires were administered to livestock farmers in 57 farms and an online survey to 31 AHPs to assess their knowledge and practices on RVF.* ***Results:*** *a total of 57 livestock farmers were engaged, 98.2% (56) reported the presence of mosquitoes in their homes, 86.0% (49) noted an increase, and 64.9% (37) used mosquito nets. The farmers reported mortality; in sheep 42.1% (24), cattle 31.6% (18), and goats 7.0% (4) respectively. Cases of sick livestock; cattle 68.4% (39), sheep 56.1% (32), and goats 7.0% (4) were reported by farmers. Only 3.5% (2) vaccinated their animals against RVF. A total of 31 AHPs engaged knew that notifiable diseases should be reported, 96.8% (30) and 87.1% (27) had good knowledge of RVF and vaccine respectively, while vaccination was practiced by 64.5% (20) AHPs. All AHPs knew RVF and had encountered cases of animal abortion that were suspected to be RVF by 51.6% (16). Most AHPs 83.9% (26) related livestock abortion to RVF.* ***Conclusion:*** *the study highlights existing gaps in RVF prevention and control practices despite good knowledge of the manifestations and transmission of RVF. It recommends further one-health community campaigns to enhance awareness of RVF causation, prevention, and control practices.*

Introduction

Rift Valley fever (RVF) is an arboviral zoonosis caused by a *Phlebovirus* of the family *Phenuiviridae* and transmitted primarily by the *Aedes*mosquito. The RVF virus (RVFV) infects domestic animals (cattle, sheep, goats, and camels) [1]. Rift Valley fever (RVF) was first identified in 1931 in sheep with hepatic necrosis and fatal abortions in Naivasha, Kenya [2]. The disease is endemic in tropical Africa and the sub-tropical climates of Madagascar, and the Arabian Peninsula. The epidemics and epizootic are mostly confined to East and South Africa with Kenya experiencing RVF outbreaks in endemic areas in 1968, 1978/79, 1997/98, and 2006/2007 [3,4]. Transmission of RVFV by mosquitoes affects ruminants and causes spontaneous abortions in pregnant females, mortality in young susceptible ruminants, icterus, and hemorrhagic disease [5]. In Kenya, RVF is among the priority zoonotic diseases (PZD) due to its high public health, and socioeconomic impacts [6]. The socioeconomic impacts are attributed to livestock mortality, trade disruptions, and high intervention costs through vaccinations [7,8]. Nyandarua, a previously RVF low-endemic area, experienced livestock abortions, anaemia, diarrhea, and death of young livestock in late 2018 and early 2019. These symptoms suggestive of RVF were reported in the sub-counties of Ol Kalou, Kipipiri, and Ndaragwa [9]. Due to RVF's socioeconomic and public health impacts, studies have been conducted to assess the knowledge and practices related to RVF in other counties, but not in Nyandarua [10-13].

The approaches to preventing and controlling RVF disease and vectors require information on knowledge and practices derived from surveys that utilize qualitative and quantitative methods [14]. Most practices are associated with knowledge and information within the community [15]. The knowledge available on RVF improves the prevention and control policies [16]. Strategies and preparation for future RVF

outbreaks and control have been documented by evaluating barriers to livestock vaccination in Kenya and Uganda [17]. Despite reporting of RVF cases in Nyandarua and other low-endemic areas in Kenya, little is documented about the community´s understanding of the potential risk of transmission, vectors, and control of RVF in new areas [18]. The lack of knowledge on causation, risk, and RVF transmission may lead to the high burden of RVF in vulnerable populations who continue to consume animal and animal products from uninspected sick and dead animals [19]. Therefore, there is an urgent need to raise public awareness of the risk of RVF, prevention, and control measures. These will reduce the burden of infection in humans and animals. Hence, the emphasis is on increasing the knowledge and awareness of livestock keepers in low-endemic areas. This will lead to effective community-based early warning systems and prompt outbreak response on RVF and other zoonotic diseases. This study assessed the knowledge and practices of livestock farmers and animal health professionals in Nyandarua regarding RVF prevention. By evaluating the knowledge gaps and practices of livestock farmers and AHPs. The findings will inform targeted interventions to empower the community to protect themselves and their livestock from RVF.

Methods

Study area: the study was conducted in Nyandarua County which is located in the central region of Kenya, and lies between latitude 0°80´ to the North and 0°50´ to the south and between 35°13´ East and 36°42´ west. In Nyandarua, rainfall is well distributed throughout the year, with a cool and temperate climate. In a typical year, Nyandarua experiences two rainy seasons; long rains from March to May (maximum rainfall of 1,600 mm) and short rains from September to December (maximum rainfall of 700 mm). The average annual rainfall is 1,500 mm. The temperature is moderate. The high temperatures are low compared to the national average mainly occurs from December to March, and the lowest in July. December has the highest temperature with a mean average of 21.5°C, and July has the lowest with 7.1°C. Nyandarua borders 5 counties, Laikipia on the north, Nyeri to the northeast, Murang´a to the east, Kiambu to the south, and Nakuru to the west. The human population density is 194 individuals per square kilometre and 89.6% of the population, lives in rural areas. Agriculture is the backbone of the county´s economy and most residents are involved in farming activities, both in the rearing of livestock and cultivation of crops. Most livestock farmers in Nyandarua practice a small-scale production system with an estimated population of 433,309 cattle, 442,433 sheep, 89,972 goats, and 6,913 donkeys in the whole county.

Study design and sampling: a cross-sectional study was conducted between July 2020 and January 2021 where data was collected through interviews using semi-structured questionnaires. A purposive sampling strategy was employed to select homesteads where livestock had experienced abortions in Ol Kalou, Kipipiri, and Ndaragwa sub-counties, and the consenting household heads were interviewed. In total 57 livestock farmers were interviewed and the inclusion criteria were at least ownership of ruminant livestock, being the carer for the livestock, and being at least 18 years of age. An online questionnaire was shared with 31 animal health professionals practicing in Nyandarua County and attending a continuous professional development (CPD) program. The inclusion criteria were AHPs currently working in Nyandarua, attending the workshop, and with valid and up-to-date registration by the Kenya Veterinary Board (KVB).

Study tools: the semi-structured questionnaire had 30 questions categorized into four sections; i) demographics, ii) livestock farmer details, farm location, iii) characteristics of the farm, and iv) observation by the researcher for mosquito breeding. Mosquitoes were key observations as they are vectors of the RVF virus and play a role in

maintaining transmission in animals and transovarial transmission in the *Aedes* offspring. Epicollect5 questionnaires were pre-tested before being integrated and uploaded as a mobile phone application software Epicollect. The questions required binary responses, (yes/no) and some with selection options. Follow-up questions were asked to livestock farmers to verify if they had noted the presence of mosquitoes and breeding sites, their knowledge and practices against mosquito bites, animal vaccination, and cases of sick and dead animals. The second questionnaire was developed for the animal health service providers including veterinarians and Animal Health Paraprofessionals from the county. The objective was to gather information including challenges in RVF prevention and control. Using a semi-structured Google form questionnaire survey, data on RVF knowledge and prevention practices were collected among the professionals attending a continuous professional development (CPD) workshop. Each respondent had confidentially received the questionnaire and filled it out before the workshop day. The questions asked sought to check whether the professionals had similar or variant views with those of the farmers interviewed.

Statistical analysis: data from Epicollect5 and Google Forms were downloaded as CSV files in Microsoft Excel 2021 (Microsoft Corporation, Redmond, Washington, USA). All qualitative responses to the questions were copied and analyzed. The descriptive statistics were calculated using Excel. The proportions of the various variables; sex, age, location, knowledge, and practices were analyzed.

Ethical considerations: study approval was obtained from the Ethics Review Committee of the Kenyatta National Hospital and University of Nairobi (KNH-UON ERC), Ref: KNH-ERC/A/373. The authorization was obtained from the National Director of Veterinary Services (DVS) and the Nyandarua County animal health authorities to engage the livestock farmers and professionals in the survey. Participation in the study was voluntary and informed consent was obtained from all respondents before data collection. All information was kept confidential.

Results

Participant demographics: in this study, 57 livestock farmers were interviewed, of which 30 (52.6%) were males and 27 (47.4%) were females. Most livestock farmers (42%) were aged between 34 and 49 years, while (28.2%) were aged 50-65 years old. The farmers primarily reared cattle and sheep (50.9%) versus other ruminants´ goats and donkeys. More than half (61.40%) of the livestock farmers had attained a primary level of education, and the majority were small-scale farmers (96.50%) located in Wanjohi (47.40%). Of the 57 farms visited, 3 (5.3%) were commercial farms. Of the 31 animal health professionals interviewed, 24 (77.4%) were males and 7 (22.6%) were females. Most AHPs (64.50%) were qualified in Animal Health Management (1 Degree, 12 Diploma and 7 certificate). The remaining 35.5% had a Bachelor in Veterinary Medicine. In total 12 (38.7%) of AHPs had 5-10 years of work experience and were based in Olkalou (41.9%) (Table 1).

Livestock farmers practices: of the 57 livestock farmers interviewed, 56 (98.2%) had reported the presence of mosquitoes, and 49 (86.0%) had reported an increase in their homestead. The most preferred practice by farmers to prevent human mosquito bites was the use of mosquito nets 37 (64.9%), followed by spraying insecticide 14 (24.6%) while 17 (29.8%) used no measure. There were several mosquito breeding sites within different homesteads that were visited. The natural water ponds were within and around 43 (75.4%) farms while 3 farms (5.3%) had none. Most farmers vaccinated their animals against Foot and Mouth Disease (FMD) (66.7%) followed by Lumpy Skin Disease (LSD) (57.9%). Only 2 (3.5%) farmers had vaccinated their livestock against RVF (Table 2).

Knowledge of animal health professionals on RVF: all the 31 professionals interviewed had good

knowledge of notifiable diseases and acknowledged that RVF should be reported to the veterinary office. Among them, 30 (96.8%) had good knowledge about RVF prevention and 27 (87.1%) on the use of RVF vaccines. Only 16 (51.6%) of the AHPs had suspected RVF cases in animals during their practice. Although all had encountered cases of abortion in livestock, 26 (83.9%) had related frequent abortion to RVF. Only 28 (90.3%) of the AHPs knew that mosquitoes transmitted the RVF virus, either genus *Aedes* 24 (77.4%) or *Culex* 13 (41.9%). All AHPs identified correctly the risks of RVF, control measures, and their responsibility to report to the County Veterinary office, and 30 (96.8%) referred to the RVF disease as a serious problem. AHPs played a key role in vaccination against RVF, with 20 (64.5%) informing the farmers and being part of the team and 8 (25.8%) only Informing farmers about vaccination campaigns (Table 3).

AHPs´ Practices on the prevention and spread of Rift Valley fever: of the interviewed AHPs, 20 (64.5%) assisted in livestock birth without wearing gloves, and 4 (12.9%) used gloves when attending to sick animals. Twenty-seven (87.1%) AHPs handled aborted materials with gloves, while 4 (12.9%) used gloves when available. However, 26 (83.6%) AHPs reported suspected cases of RVF in livestock immediately to the county veterinary office. On the other hand, only 5 (16.7%) AHPs collected blood for laboratory analysis to confirm RVF in livestock (Table 4).

Discussion

The livestock farmers were purposively selected from farms that reported abortions in livestock suspected to be caused by RVF. The largest percentage of the farmers interviewed were between 34 and 49 years and half focused on rearing cattle and sheep. More than half of livestock farmers had completed the basic primary school as their highest level of education. The majority of the farmers, were small-scale farmers, with a small percentage operating commercial farm. Geographically, almost half of the farmers interviewed resided in the Wanjohi ward. The animal health professionals (AHPs) comprised a higher percentage of men compared to women. The majority of AHPs qualified in Animal Health Management and the majority were males, while a smaller percentage had a Bachelor of Veterinary Medicine degree. A considerable number of professionals had work experience of between 5-10 years and were mainly stationed in the Olkalou subcounty. The demographic data is a useful starting point for understanding the livestock farmers and AHPs knowledge and practices on RVF prevention [12,15]. With all this background information, tailor-made intervention practices can be devised to effectively address RVF prevention in Nyandarua County.

Mosquitoes play a major role in the primary transmission of RVF to animals. Therefore, mosquito breeding should be monitored to reduce the population and bites [20,21]. The study observed a higher occurrence of mosquitoes in the majority of livestock farmers' homesteads (98.2%). Enhanced and effective mosquito bite control strategies are needed in humans and animals [22]. Although mosquito nets were the most common preventive measure (64.9%) for mosquito bites, a substantial share of farmers (35.1%) lacked this protection. Addressing the gap is crucial to reducing mosquito bites and potential RVF transmission through bites to humans [23-25] and animals [26]. The presence of natural water ponds within or around most farms (75.4%) presents a significant risk of mosquito breeding [27,28]. Most AHPs knew that RVF is transmitted by mosquitoes. However, the knowledge of the specific mosquitoes that transmit the RVF virus, *Aedes*, and *Culex*was lower. Training in RVF transmission, prevention, and control strategies is necessary. Public health interventions should focus on sensitizing farmers about managing these water ponds to minimize stagnant water which are potential for mosquito breeding. This should be implemented by introducing mosquito control

measures like the use of larvicides or the introduction of mosquito-eating fish [29-31].

The study documents a high acceptability of livestock vaccination practice among farmers against different animal diseases. Livestock were highly vaccinated against Foot-and-mouth disease (FMD) as the vaccine was readily available [32]. However, there is a critical gap in RVF vaccination, with a small number of farmers vaccinating their livestock against RVF [33]. This shows a critical knowledge gap regarding RVF prevention. The low percentage suggested a lack of awareness or accessibility to RVF vaccines. However, most AHPs knew about RVF (96.8%) and played a key role in vaccination, with a good percentage (64.5%) actively participating in RVF vaccination campaigns. Nevertheless, among the AHPs was limited knowledge of the RVF vaccine and its availability involving a small number of the AHPs. Although a small proportion of AHPs are affected, this knowledge gap could hinder effective vaccination and implementation. The cases of sickness and abortion in livestock, particularly cattle and sheep were alarming. This raised great concern as RVF has the potential to have an economic impact on livestock farmers [8,34]. The situation was made worse when only half (51.6%) of AHPs competently suspected the cases of RVF, despite all encountering livestock abortions. This suggests a limitation in recognizing RVF clinical signs or a lack of diagnostic confirmation [18].

In general, this study highlighted the need for improved knowledge and practices on RVF prevention among livestock farmers in Nyandarua County [35]. Existing vaccination practices for other diseases provide an encouraging basis for RVF prevention [36]. Targeted campaigns that promote RVF awareness and vaccination are essential to promote the uptake of vaccine by farmers [37,38]. Based on the study, there is a need for more RVF awareness campaigns to educate farmers on RVF transmission, symptoms, and importance of vaccination. Public health initiatives should also empower livestock farmers in Nyandarua County to protect themselves, their livestock, and their livelihoods from the threat of RVF [39]. There seems to be a potential disconnect between existing practices and comprehensive RVF prevention strategies. Although there are some positive practices, such as the use of mosquito nets, significant gaps remain in RVF vaccination and in addressing mosquito breeding grounds [40]. These gaps necessitate targeted interventions to improve livestock health, and farmers' knowledge, ultimately reducing the risk of RVF transmission and outbreaks.

All AHPs understood the importance of reporting notifiable diseases to veterinary authorities [41]. This is a solid foundation for detection and control. A higher percentage (96.8%) of AHPs were aware and in a position to diagnose RVF. All AHPs had encountered cases of livestock abortions and a large percentage (83.9%) had linked the cases to RVF [42,43]. All AHPs knew the risks of RVF and their responsibility to report RVF cases to the county veterinary office. This is important for RVF early detection to ensure proper notification channels exist for timely responses. While AHPs know RVF, there are crucial areas for improvement. This could be achieved through targeted training programs focused on RVF vaccination, clinical signs, diagnosis, and mosquito vectors. This training will improve the ability of AHPs to detect, report, and participate in effective RVF transmission control strategies. It is important to improve the communication channels between AHPs and farmers on RVF prevention measures [44]. By addressing these knowledge gaps, AHPs can become even more effective allies in protecting animal and public health and preventing RVF transmission and outbreaks in Nyandarua County [45].

The practices of AHPs when related to RVF prevention revealed a disturbing disconnect between knowledge and action. While there are some positive behaviors, there were significant gaps that could contribute to the transmission and spread of RVF. Unsafe practices such as assisting livestock births, and handling sick animals without gloves by AHPs pose a high risk of transmission of

the RVF virus [18]. Only a minority of AHPs collected blood samples from suspected animals for laboratory confirmation of RVF. This hinders timely RVF diagnosis, spread, and outbreak control measures. However, most AHPs (83.6%) reported suspected RVF cases to the veterinary authorities, which could allow faster investigation and intervention. There is a need for comprehensive sensitization campaigns focused on safe animal handling practices among AHPs to prevent RVF transmission [46]. There should be consistent use of gloves when assisting with livestock birth, handling sick animals, and disposing of aborted materials. Additionally, promoting the importance of collecting samples for diagnosis to aid in controlling RVF transmission and outbreaks. The limitation of the study was that the questionnaire did not analyze the attitude of the respondents during the survey.

Conclusion

The level of knowledge and reported practices suggest a need for multifaceted interventions to improve RVF prevention practices among farmers and AHPs. Sensitization campaigns that promote consistent glove use, proper handling of aborted tissues, and the importance of sample collection to rule out RVF are essential for AHPs. Ensuring the availability and affordability of PPE will contribute to safer practices too.

What is known about this topic

- *There is limited information about the knowledge and practices of livestock farmers and animal health professionals (AHPs) regarding Rift Valley fever (RVF) in low-endemic areas like Nyandarua County;*
- *RVF poses a significant threat to livestock and public health, and there is a lack of data on how well communities in these areas are equipped to prevent and control the RVF.*

What this study adds

- *The study assesses the knowledge and practices of livestock farmers and AHPs regarding RVF. This includes their awareness of the disease, its transmission, and the available prevention measures;*
- *The study highlights significant gaps in knowledge and practices, particularly among farmers, which can inform targeted interventions;*
- *Assessment of vaccination reveals low vaccination rates among farmers, suggesting a missed opportunity for disease prevention.*

Competing interests

The authors declare no competing interests.

Authors' contributions

James Wanjama Kabugu, Gabriel Aboge, Caroline Muneri, Angeline Chepchirchir, and Mark Nanyingi conceptualized the work and designed the survey tool. James Wanjama Kabugu led the analysis of data and drafted the work. All authors were involved in revisions of the work and approved the submitted version.

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Tables

Table 1: demographic-socio-economic variables of farmers and animal health professionals from Nyandarua, Kenya

Table 2: practices associated with livestock farmers in preventing mosquitoes and animal diseases in Nyadarua (n=57)

Table 3: knowledge about RVF among animal health professionals in Nyandarua, Kenya (n = 31)

Table 4: practices and preventive measures on RVF among animal health professionals in Nyandarua, Kenya (n = 31)

References

1. Javelle E, Lesueur A, Pommier de Santi V, de Laval F, Lefebvre T, Holweck G *et al*. The challenging management of Rift Valley Fever in humans: literature review of the clinical disease and algorithm proposal. Ann Clin Microbiol Antimicrob. 2020 Jan 22;19(1): 4. **PubMed**| **Google Scholar**
2. Daubney R, Hudson J. Enzootic Hepatitis or Rift Valley Fever. An Un-described Virus Disease of Sheep, Cattle and Man from East Africa. Journal of pathology and bacteriology. 1931;34: 545-79. **Google Scholar**
3. Nanyingi MO, Munyua P, Kiama SG, Muchemi GM, Thumbi SM, Bitek AO *et al*. A systematic review of Rift Valley Fever epidemiology 1931-2014. Infection ecology & epidemiology. 2015;5(1): 28024. **PubMed**| **Google Scholar**
4. Clark MH, Warimwe GM, Di Nardo A, Lyons NA, Gubbins S. Systematic literature review of Rift Valley fever virus seroprevalence in livestock, wildlife and humans in Africa from 1968 to 2016. PLoS neglected tropical diseases. 2018;12(7): e0006627. **PubMed**| **Google Scholar**
5. Wilson ML. Rift Valley fever virus ecology and the epidemiology of disease emergence. Ann N Y Acad Sci. 1994;740(1): 169-80. **PubMed**| **Google Scholar**
6. Munyua P, Bitek A, Osoro E, Pieracci EG, Muema J, Mwatondo A *et al*. Prioritization of zoonotic diseases in Kenya, 2015. PloS one. 2016;11(8): e0161576. **PubMed**| **Google Scholar**
7. Muga GO, Onyango-Ouma W, Sang R, Affognon H. Sociocultural and economic dimensions of Rift Valley fever. The American journal of tropical medicine and hygiene. 2015;92(4): 730. **PubMed**| **Google Scholar**
8. Peyre M, Chevalier V, Abdo-Salem S, Velthuis A, Antoine-Moussiaux N, Thiry E *et al*. A systematic scoping study of the socio-economic impact of Rift Valley fever: Research gaps and needs. Zoonoses and public health. 2015;62(5): 309-25. **PubMed**| **Google Scholar**
9. Wanjama J, Aboge G, Muneri C, Nanyingi M. Sero-Epidemiological Survey of Rift Valley Fever Virus in Ruminants in Nyandarua County, Kenya. East African Agricultural and Forestry Journal. 2022;86(1-2): 11. **Google Scholar**
10. Chiuya T, Fevre EM, Junglen S, Borgemeister C. Understanding knowledge, attitude and perception of Rift Valley fever in Baringo South, Kenya: A cross-sectional study. PLOS Global Public Health. 2023;3(9): e0002195. **PubMed**| **Google Scholar**

11. Muga GO, Onyango-Ouma W, Sang R, Affognon H. Indigenous knowledge of Rift Valley Fever among Somali nomadic pastoralists and its implications on public health delivery approaches in Ijara sub-County, North Eastern Kenya. PLOS Neglected Tropical Diseases. 2021;15(2): e0009166. **PubMed**| **Google Scholar**
12. Abdi IH, Affognon HD, Wanjoya AK, Onyango-Ouma W, Sang R. Knowledge, Attitudes and Practices (KAP) on rift valley fever among pastoralist communities of Ijara District, North Eastern Kenya. PLoS neglected tropical diseases. 2015;9(11): e0004239. **PubMed**| **Google Scholar**
13. Affognon H, Mburu P, Hassan OA, Kingori S, Ahlm C, Sang R *et al*. Ethnic groups´ knowledge, attitude and practices and Rift Valley fever exposure in Isiolo County of Kenya. PLoS neglected tropical diseases. 2017;11(3): e0005405. **PubMed**| **Google Scholar**
14. Kainga H, Mponela J, Basikolo L, Phonera MC, Mpundu P, Munyeme M *et al*. Assessment of knowledge, attitudes, and practices towards Rift Valley fever among livestock farmers in selected districts of Malawi. Tropical Medicine and Infectious Disease. 2022;7(8): 167. **PubMed**| **Google Scholar**
15. Issae AR, Katakweba AAS, Kicheleri RP, Chengula AA, Kasanga CJ. Knowledge, attitudes and practices on rift valley fever among pastoral and agropastoral communities of Ngorongoro in the rift valley ecosystem, Tanzania, conducted in 2021/2022. PLoS Neglected Tropical Diseases. 2023;17(8): e0011560. **PubMed**| **Google Scholar**
16. Nyangau PN, Nzuma JM, Irungu P, Kassie M. Evaluating livestock farmers knowledge, beliefs, and management of arboviral diseases in Kenya: A multivariate fractional probit approach. PLoS Neglected Tropical Diseases. 2021;15(9): e0009786. **PubMed**| **Google Scholar**
17. Mutua E, de Haan N, Tumusiime D, Jost C, Bett B. A qualitative study on gendered barriers to livestock vaccine uptake in Kenya and Uganda and their implications on Rift Valley Fever control. Vaccines. 2019;7(3): 86. **PubMed**| **Google Scholar**
18. Gerken KN, Maluni J, Mutuku FM, Ndenga BA, Mwashee L, Ichura C *et al*. Exploring potential risk pathways with high risk groups for urban Rift Valley fever virus introduction, transmission, and persistence in two urban centers of Kenya. PLOS Neglected Tropical Diseases. 2023;17(1): e0010460. **PubMed**| **Google Scholar**
19. Owiny MO, Ngare BK, Mugo BC, Rotich J, Mutembei A, Chepkorir K *et al*. Assessment of community perceptions and risk to common zoonotic diseases among communities living at the human-livestock-wildlife interface in Nakuru West, Kenya: A participatory epidemiology approach. PLOS Neglected Tropical Diseases. 2023;17(1): e0011086. **PubMed**| **Google Scholar**
20. Drouin A, Chevalier V, Durand B, Balenghien T. Vector competence of mediterranean mosquitoes for Rift Valley fever virus: A meta-analysis. Pathogens. 2022;11(5): 503. **PubMed**| **Google Scholar**
21. Sang R, Arum S, Chepkorir E, Mosomtai G, Tigoi C, Sigei F *et al*. Distribution and abundance of key vectors of Rift Valley fever and other arboviruses in two ecologically distinct counties in Kenya. PLoS neglected tropical diseases. 2017;11(2): e0005341. **PubMed**| **Google Scholar**
22. Tantely LM, Andriamandimby SF, Ambinintsoa MF, Raharinirina MR, Rafisandratantsoa JT, Ravalohery JP *et al*. An Entomological Investigation during a Recent Rift Valley Fever Epizootic/Epidemic Reveals New Aspects of the Vectorial Transmission of the Virus in Madagascar. Pathogens. 2024;13(3): 258. **PubMed**| **Google Scholar**

23. Mohapatra RK, Kutikuppala LV, Kandi V, Mishra S, Rabaan AA, Costa S *et al*. Rift valley fever (RVF) viral zoonotic disease steadily circulates in the Mauritanian animals and humans: A narrative review. Health Science Reports. 2023;6(7): e1384. **PubMed**| **Google Scholar**
24. Birungi D, Aceng FL, Bulage L, Nkonwa IH, Mirembe BB, Biribawa C *et al*. Sporadic Rift Valley fever outbreaks in humans and animals in Uganda, October 2017-January 2018. J Environ Public Health. 2021 Sep 20: 2021: 8881191. **PubMed**| **Google Scholar**
25. Linthicum K, Davies F, Kairo A, Bailey C. Rift Valley fever virus (family Bunyaviridae, genus Phlebovirus). Isolations from Diptera collected during an inter-epizootic period in Kenya. Epidemiology & Infection. 1985;95(1): 197-209. **PubMed**| **Google Scholar**
26. Bron GM, Wichgers Schreur PJ, de Jong MC, van Keulen L, Vloet RP, Koenraadt CJ *et al*. Quantifying Rift Valley fever virus transmission efficiency in a lamb-mosquito-lamb model. Front Cell Infect Microbiol. 2023 Dec 18: 13: 1206089. **PubMed**| **Google Scholar**
27. Mwakutwaa AS, Ngugi HN, Ndenga BA, Krystosik A, Ngari M, Abubakar LU *et al*. Pupal productivity of larval habitats of Aedes aegypti in Msambweni, Kwale County, Kenya. Parasitology Research. 2023;122(3): 801-14. **PubMed**| **Google Scholar**
28. Futami K, Iwashita H, Higa Y, Lutiali P, Sonye G, Mwatele C *et al*. Geographical distribution of Aedes aegypti aegypti and Aedes aegypti formosus (Diptera: Culicidae) in Kenya and environmental factors related to their relative abundance. Journal of Medical Entomology. 2020;57(3): 772-9. **PubMed**| **Google Scholar**
29. Khater H, E Soliman D, Slim A, Debboun M, M Baz M. Larvicidal efficacy of fifteen plant essential oils against Culex pipiens L. mosquitoes in Egypt. Egyptian Journal of Veterinary Sciences. 2023;54(2): 183-92. **Google Scholar**
30. Ahmed AM, El-Kersh TA, Hussein HI, Ayaad TH, El-Sadawy HA, Ibrahim MS *et al*. Larvicidal activities of local Bacillus thuringiensis isolates and toxins from nematode bacterial symbionts against the Rift Valley fever vector, Aedes caspius (Diptera: Culicidae). African Zoology. 2021;56(1): 65-75. **Google Scholar**
31. Padmanaban H, Mandodan S, Bora B, Sivaprakasam M, Vijayakumar A, Lukose J *et al*. Scoping review on impact of mosquito-borne diseases of man and animals and use of potential bacterial larvicidal agents to control mosquito vectors. International Journal of Biological and Pharmaceutical Sciences Archive. 2022;4(2): 046-55. **Google Scholar**
32. Maichomo M, Wachira A, Olum M, Gathumbi J, Mutua J, Waiguru S *et al*. Status on use and delivery of foot and mouth and newcastle vaccines in Kenya. East African Journal of Science, Technology and Innovation. 2024;5(2). **Google Scholar**
33. Kwanik M, Roek W, Rola J. Rift Valley fever-a growing threat to humans and animals. Journal of veterinary research. 2021;65(1): 7-14. **PubMed**| **Google Scholar**
34. Sindato C, Karimuribo E, Mboera LE. The epidemiology and socio-economic impact of Rift Valley fever in Tanzania: a review. Tanzan J Health Res. 2011 Dec;13(5 Suppl 1): 305-18. **PubMed**| **Google Scholar**
35. Alhaji NB, Babalobi OO, Isola TO. A quantitative exploration of nomadic pastoralists´ knowledge and practices towards Rift Valley fever in Niger State, North-central Nigeria: The associated socio-cultural drivers. One Health. 2018;6: 16-22. **PubMed**| **Google Scholar**

36. Win TTZ, Campbell A, Magalhaes RJS, Oo KN, Henning J. What drives small-scale farmers to vaccinate their multiple livestock species animals against common infectious diseases in Myanmar. Plos one. 2021;16(10): e0258765. **PubMed**| **Google Scholar**
37. Wichgers Schreur PJ, Bird BH, Ikegami T, Bermúdez-Méndez E, Kortekaas J. Perspectives of next-generation live-attenuated Rift Valley fever vaccines for animal and human use. Vaccines. 2023;11(3): 707. **PubMed**| **Google Scholar**
38. Bowmer A, Ssembatya J, Okot M, Bagyenyi R, Rubanga SV, Kalema-Zikusoka G. Determining the acceptability of a novel One Health vaccine for Rift Valley Fever prior to phase II/III clinical trials in Uganda. One Health. 2022 Dec 6: 16: 100470. **PubMed**| **Google Scholar**
39. Gibson S, Noronha LE, Tubbs H, Cohnstaedt LW, Wilson WC, Mire C *et al*. The increasing threat of Rift Valley fever virus globalization: strategic guidance for protection and preparation. Journal of Medical Entomology. 2023;60(6): 1197-213. **PubMed**| **Google Scholar**
40. Himeidan YE. Rift Valley fever: current challenges and future prospects. Res Rep Trop Med. 2016 Mar 11: 7: 1-9. **PubMed**| **Google Scholar**
41. Njenga MK, Kemunto N, Kahariri S, Holmstrom L, Oyas H, Biggers K *et al*. High real-time reporting of domestic and wild animal diseases following rollout of mobile phone reporting system in Kenya. PLoS One. 2021;16(9): e0244119. **PubMed**| **Google Scholar**
42. Thomas KM, Kibona T, Claxton JR, de Glanville WA, Lankester F, Amani N *et al*. Prospective cohort study reveals unexpected aetiologies of livestock abortion in northern Tanzania. Scientific reports. 2022;12(1): 11669. **PubMed**| **Google Scholar**
43. Ndengu M, De Garine-Wichatitsky M, Pfukenyi DM, Tivapasi M, Mukamuri B, Matope G. Assessment of community awareness and risk perceptions of zoonotic causes of abortion in cattle at three selected livestock-wildlife interface areas of Zimbabwe. Epidemiology & Infection. 2017;145(7): 1304-19. **PubMed**| **Google Scholar**
44. Smith LJ, Schurer JM, Ntakiyisumba E, Shyaka A, Amuguni JH. Rift Valley fever knowledge, mitigation strategies and communication preferences among male and female livestock farmers in Eastern Province, Rwanda. PLoS neglected tropical diseases. 2021;15(8): e0009705. **PubMed**| **Google Scholar**
45. Gibson S, Linthicum KJ, Turell MJ, Anyamba A. Rift Valley fever virus: Movement of infected humans threatens global public health and agriculture. CABI Reviews. 2022 (2022). **Google Scholar**
46. Owino EA. Enhanced surveillance and cohesive policies needed to tackle Rift Valley fever. Asian Pacific Journal of Tropical Medicine. 2018;11(9): 547-8. **Google Scholar**

Table 1: demographic-socio-economic variables of farmers and animal health professionals from Nyandarua, Kenya		
Demographic variable	**Responses**	**Percentage**
Livestock farmers (n = 57)		
Education level		
Primary education	35	61.4
Secondary education	16	28.1
College/university	3	5.3
Adult literacy	2	3.5
Vocational	1	1.8
Type of farm		
Household farm	55	96.5
Commercial farm	2	3.5
Animal owned*		
Cattle	9	15.8
Sheep	3	5.3
Cattle, sheep	29	50.9
Cattle, goat	1	1.8
Cattle, sheep, goat	6	10.5
Cattle, sheep, donkey	7	12.3
Cattle, sheep, goat, donkey	2	3.5
Animal health professionals (n = 31)		
Qualification		
BVM	11	35.5
AHM	20	64.5
Years of practice		
0 - 5 years	5	16.1
5 - 10 years	12	38.7
10 - 15 years	6	19.4
15 - 20 years	2	6.5
More than 20 years	6	19.4
Sub-county animal health services offered		
Kinangop	7	22.6
Olkalou	13	41.9
Ol Joro Orok	5	16.1
Ndaragwa	4	12.9
Kipipiri	2	6.5
*Some farmers owned multiple animals, BVM: Bachelor of Veterinary Medicine, AHM: Animal Health Management		

Table 2: practices associated with livestock farmers in preventing mosquitoes and animal diseases in Nyadarua (n=57)

Variable	Responses	Farms (n=57)	Percentage
Mosquito presence	During the rainy season	56	98.2
Mosquito increase	Observed increased mosquito	49	86.0
Bites prevention	Spray insecticide	14	24.6
	Use mosquito nets	37	64.9
	Use a mosquito coil	6	10.5
	Lock doors	2	3.5
	Stay indoors at night	1	1.8
	No prevention	17	29.8
Breeding sites	Natural ponds	43	75.4
	Water ways	31	54.4
	Plastic waste bags	7	12.3
	Rivers	8	14.0
	Abandoned quarries	2	3.5
	No breeding site	3	5.3
Animal vaccines	FMD	38	66.7
	LSD	33	57.9
	Enterotoxaemia	9	15.8
	RVF	2	3.5
	No vaccination	12	21.1
Cases of sick animals	Cattle	39	68.4
	Sheep	32	56.1
	Goat	4	7.0
	Donkey	1	1.8
	No sick livestock	8	14.0
Cases of dead animals	Cattle	18	31.6
	Sheep	24	42.1
	Goat	4	7.0
	No dead livestock	22	38.6

FMD: foot and mouth disease, LSD: lumpy skin disease, RVF: Rift Valley Fever

Table 3: knowledge about RVF among animal health professionals in Nyandarua, Kenya (n = 31)		
Description of variables	**Number of responses**	**Percentage**
A notifiable disease/reported to the County veterinary office	31	100
Heard of RVF disease	30	96.8
Availability of RVF vaccine	27	87.1
Suspected cases of RVF	16	51.6
Encountered case(s) of abortion in livestock	31	100
Signs of RVF in livestock*		
Frequent abortions	26	83.9
High mortality especially in young animals	18	58.1
Bloody diarrhoea	12	38.7
High fever	18	58.1
Eye and nasal discharge	13	41.9
Jaundice	10	32.3
Mode of RVF virus transmission in livestock*		
Mosquito	28	90.3
Animal contact	12	38.7
Flies	3	9.7
Inhalation	1	3.2
Mosquitoes that transmit RVF virus*		
Aedes	24	77.4
Anopheles	2	6.5
Culex	13	41.9
Mansonia	1	3.2
No response on transmission	3	9.7
Risk of RVF (serious disease)	31	100
Participate in the control of RVF in livestock	31	100
Believe RVF is a serious problem	30	96.8
AHP responsibility to report RVF cases to the veterinary office	31	100
Knew there was no vaccination against RVF	2	6.5
Part of the team during the vaccination	20	64.5
Inform farmers about vaccination campaigns	8	25.8
There are no vaccines against RVF	1	3.2
Immediately report to the veterinary office	31	100
*Respondents gave multiple responses for the sub-sections, RVF: Rift Valley Fever		

Table 4: practices and preventive measures on RVF among animal health professionals in Nyandarua, Kenya (n = 31)		
Description of variables	**Number**	**Percentage**
Assisted livestock birth without gloves		
Yes	20	64.5
No	9	29.0
No response	2	6.5
Gloves used when attending to sick animals		
Always	4	12.9
Not all time	23	74.2
When available	4	12.9
Gloves used when attending to abortion cases in animals		
I use gloves	27	87.1
I use gloves if available	4	12.9
Measures are taken when RVF is suspected		
Report to the County veterinary office	26	83.9
Collect blood for laboratory analysis	5	16.1
Treat the animal	0	0.0
Vaccinate the animal	0	0.0