COMMUNITY KNOWLEDGE, ATTITUDE AND PRACTICES REGARDING RIFT VALLEY FEVER IN NYANDARUA COUNTY, KENYA

BY:

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DECLARATION

Declaration by the candidate

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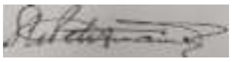

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DEDICATION

This work is dedicated to my husband Dr. Michael Ndonga for his constant encouragement, financial and moral support during the study period.

ABSTRACT

Background: Rift Valley Fever is a mosquito-borne viral zoonosis of international importance. The disease causes high abortion rates and neonatal mortality in animals while humans experience a febrile illness that may progress to a fatal hemorrhagic syndrome. In Kenya, severe outbreaks of the disease have been experienced among the pastoralist communities but recently there have been reports of the disease spread to non-endemic areas. A Rift Valley Fever (RVF) outbreak was reported in Nyandarua in 2019 making it the first outbreak within the region.

Objectives: Determine the Knowledge, Attitude and Practices regarding RVF and to describe the economic impact among livestock farmers in Nyandarua County.

Methods: A cross sectional study was carried out in Nyandarua County. Livestock farmers were sampled using systematic random sampling within Ol'Kalou, Kipipiri and Ndaragwa sub counties. Data was collected using an interviewer administered questionnaire. A total of 205 participants were interviewed. Descriptive analysis was done using frequencies and proportions. The relationship between demographic characteristics and community's Knowledge, Attitude and Practices regarding RVF was assessed using a multiple linear regression. The economic cost of Rift Valley Fever outbreak was estimated by computing the loss of production and cost of vaccination.

Results: The overall knowledge score on RVF was 8.8% and 94% of respondents did not know the transmitting vector of RVF. None (0%) of the respondents knew that the disease causes high mortality of young animals while only 20% knew that the disease causes abortions in pregnant animals. About 91% of the respondents were not aware of the disease in humans with less than 10% mentioning correct signs of RVF in humans. Approximately 48.5% had a neutral attitude about RVF and 61% did not know they were at risk of contracting the disease. About 34% agreed that the disease could be prevented by vaccinating animals. A high proportion (65.3%) of the respondents handled aborted materials without protection. An estimated household level economic loss of Ksh 35, 463 within a period of 3 months was attributed to this outbreak.

Conclusion: The knowledge about RVF disease was low. Study participants had a neutral attitude but engaged in risky practices. RVF outbreak led to economic losses in Nyandarua County.

Recommendation: Provide community education on RVF disease manifestation in both animals and humans and advocate for use of personal protective clothes when handling sick animals, slaughtering and assisting animals to give birth.

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DEFINITION OF TERMS

Knowledge: Awareness of causes, symptoms, mode of transmission and preventive measures of Rift Valley Fever

Attitude: A feeling or opinion about something. In this study attitude is used to refer to community's evaluation of Rift Valley Fever and their perception of the disease as a public health problem

Practices: Preventive measures undertaken by community members in an attempt to avoid contracting Rift Valley Fever

Community members: Individuals living in Nyandarua County for the last five years

ABBREVIATIONS

CDVS	County director of veterinary services
KAP	Knowledge, attitude and practices
RVF	Rift valley fever
VHF	Viral hemorrhagic fever
WHO	World health organization

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CHAPTER ONE: INTRODUCTION

1.1 Background Information

Rift Valley Fever is a zoonotic disease caused by the rift valley fever virus, a phlebovirus in the family Bunyaviridae. It is spread by mosquitoes resulting in moderate to severe hemorrhagic fever in humans and substantial prenatal and neonatal mortality in ruminants (Kitandwe et al., 2022). In animals, the disease commonly affects cattle, sheep, goats and camels. Besides, the disease has been shown to occur in a wide range of wild animals (Evans et al. 2008). The causative virus was first identified in 1912 at a sheep farm in Naivasha area in the Rift Valley of Kenya. Thereafter, it was first isolated as the causative agent for Rift Valley Fever in 1931 (Daubney et al., 1931). The disease and the virus acquired their name following its discovery within the Rift Valley region of Kenya.

The disease causes high rates of abortions and neonatal mortalities in animals (Daubney et al., 1931). In humans, it is characterized by a febrile illness which may progress to severe form associated with encephalitis, retinitis, generalized hemorrhagic syndrome, renal failure and miscarriages (Baudin et al., 2016).

Rift Valley Fever transmission in animals occurs through bites of infected mosquitoes (Bird et al., 2009a). Humans acquire the infection through handling of blood, body fluids or tissues of infected animals. Individuals handling animals including herdsmen, veterinarians and slaughterhouse workers are at an increased risk of contracting Rift Valley Fever from infected animals. It has also been documented that bites of infected mosquitoes can also transmit the disease to humans. There is no record of human to human infection (Swanepoel et al., 2004).

The disease has been reported to occur in cycles of every 5-15 years and follows periods of heavy rainfall with flooding (Anyamba et al., 2001). From 1951 to 2007, Rift Valley Fever has been reported in many African countries most notably in East Africa; Kenya, Tanzania and Somali (Woods et al., 2002a; Murithi et al., 2011). Other African countries where the disease has been reported include Sudan, South Africa, Zimbabwe, Egypt, Senegal, Gambia, Madagascar and Mauritania (Zeller et al., 1997; Perez et al., 2010; Drake et al., 2013; Lancelot et al., 2017). In 2002, outbreaks were reported in Saudi Arabia and Yemen marking the first cases outside of the African continent (Madani et al., 2003a).

Between 1921-1950, the disease in Kenya was confined to Nakuru district. From 1951, the disease has continued to spread affecting more localities in the country. The 2006/2007 outbreak was the most extensive affecting 38/69 districts in the country (Murithi et al., 2011). Five counties in the former Nyanza region and five in the former Western region have never reported any rift valley fever activity in both livestock and humans. Until recently, Nyandarua County remained the only region within the former Central region that had not reported the disease (Murithi et al., 2011). Rift valley fever outbreak has recently been reported within Olkalou Sub-County in Nyandarua county involving both humans and livestock. By the end of February 2019, 68 human cases had been reported by WHO and more than 200 livestock cases as reported by the Office International des Epizooties' (OIE).

Livestock vaccination remains the most effective control strategy for Rift valley fever. There are no human vaccines available for commercial use. To reduce human infections and death, it is important to raise awareness of the risk factors of infection and educate people on protective measures they can take to reduce mosquito bites.

There is need to identify the knowledge gaps that exist among community members in order to inform prevention and control strategies. Therefore, this study aimed at identifying knowledge gaps and risky practices related to rift valley fever spread among community members of Nyandarua County which will form the basis for designing effective prevention and control programs.

1.2 Problem statement

Despite their importance in public health, zoonotic diseases are generally under investigated and undiagnosed. About 60% of infectious diseases in humans and 75% of emerging diseases are transmitted between animals and humans (Taylor et al., 2001). Rift Valley Fever has been rated the fifth most important zoonotic disease in Kenya (Munyua et al., 2016). Since its discovery and identification, Kenya has had several outbreaks of RVF with the most severe one being in 1997-1998 and 2007-2008. These major outbreaks led to significant losses of livestock and also caused human mortality. The disease has been shown to spread to new territories and by the end of 2007, 38 out of 69 administrative districts had reported the disease in Kenya. Nyandarua County together with 5 other counties all within the former Western and Nyanza regions were the only places that had not reported Rift Valley Fever activity.

By the end of 2018, farmers in Rurii and Kaimbaga wards, Ol'Kalou Sub-County, Nyandarua County reported increased cases of abortions in sheep and cattle. Blood samples from livestock that had aborted tested positive for RVF. Further, two laboratory confirmed human cases of RVF had been reported from the same region. Following the confirmed cases in both livestock and humans, the County government issued an alert on outbreak of Rift Valley Fever in the region. By the end of February 2019, a total of 68 human cases had been reported by WHO. The OIE had also reported 70 cases in cattle and 140 cases in sheep within the County. Reports have shown that livestock infection preceded human infections. Since it is important for community members to have the right knowledge about a particular disease in order to reduce the rate of infection and subsequent mortalities, this study was therefore designed to assess the community's KAP regarding RVF.

1.3 Justification of the study

Rift Valley Fever is a major zoonotic threat whose pathogen has the potential for international spread. There is an increasing episode of the disease in the African continent and beyond (Nanyingi et al., 2015). The disease outbreak in human and animal population causes a significant challenge for public and veterinary health authorities due to morbidity and mortality. It is estimated that the 2006-07 outbreak in Kenya led to losses valued at US$32 million (Rich and Wanyoike, 2010).

The virus has potential to spread to new territories and re-emerge in traditionally endemic regions. The (2006/2007) outbreak in Kenya spread for the first time to areas that were previously known as non-endemic. Nyandarua County has recently reported the disease for the first time. Due to the unpredictability of RVF outbreaks there is need to assess the knowledge, attitude and practices (KAP) on RVF among communities. This will form the basis for health education and promotion. Studies done in Kenya on KAP regarding RVF have concentrated in the pastoral communities where high human cases were reported (Abdi et al., 2015) and (Affognon et al., 2017) but no information is available in areas which have reported the disease for the first time and vulnerable to future outbreaks like Nyandarua County. There is need to understand the KAP around RVF among local communities in all the affected areas in the country for effective control strategies. Developing policies aimed at curtailing outbreaks would benefit from participation and involvement of local communities. Therefore, information generated from this study will inform the design of control and preventive strategies based on local knowledge of the disease. It will identify the needs for further education and sensitization to effectively manage the disease.

1.4 Research question

What is the knowledge, attitude and perception of the residents of Nyandarua County towards Rift Valley Fever outbreaks?

1.5 Objectives

1.5.1 Broad objective

To determine the community knowledge, attitude and perception of Rift Valley Fever in Nyandarua County.

1.5.2 Specific objectives

i. To determine the community's knowledge pertaining to Rift Valley Fever.

ii. To assess the attitude of the community towards Rift Valley Fever

iii. To determine the prevention practices and coping mechanisms against Rift Valley Fever by community members

iv. To estimate the perceived economic impact of Rift Valley Fever within the community

CHAPTER TWO: LITERATURE REVIEW

2.1 Etiology of rift valley fever

The ability of the Rift Valley Fever Virus (RVFV) to spread across major natural geographic barriers and produce significant and widespread epidemics in both human and animal populations is a significant worry for global veterinary and public health authorities (Chevalier, 2013). This is demonstrated by the virus's ability to dispersed throughout the Red Sea, Sahara Desert and Indian Ocean in the last three decades (Chevalier, 2013). Although the disease and its etiological agent have made significant strides in recent years, science is still faced with challenges related to the unpredictable nature of virus emergence, gaps in our understanding of the virus's ecology, and the mystery surrounding the mechanisms underlying the virus's inter-epizootic transmission (Paweska, 2014). The disease is commonly reported in cattle, sheep, goats, camel and buffalo it has the potential to infect and cause mild to severe disease in humans (CDC, 2002).

2.2.1 The biology of the causative agent of Rift Valley Fever

Rift Valley Fever is a mosquito-borne viral illness caused by the Rift Valley Fever virus belonging to the family *Bunyaviridae* and genus *Phlebovirus* (Wright *et al.,* 2019). The tri-segmented single-stranded RNA genome of RVFV has an ambisense polarity, or negative polarity (Wright et al., 2019). The viral particles have a diameter of 90–110 nm and are made up of a ribonucleocapsid (RNP) and an envelope. The envelope is made up of a lipid bilayer that contains heterodimers of the glycoproteins Gn and Gc, which are the building blocks of 122 capsomers organized in a T 5 12 lattice (110 hexamers and 12 pentamers) (Kalyanaraman et al., 2023).

The virion contains the viral ribonucleoproteins that correspond to each of the three genomic segments that are linked to different copies of the RNA-dependent RNA polymerase L and the nucleoprotein N (Sherman et al., 2009). The approximately 12-kb RVFV genome is made up of three single-stranded RNA segments: large (L), medium (M), and small (S). These segments function as models for the production of complementary RNA and messenger RNA (mRNA). (cRNA). There is negative polarity in the L and M parts. The viral RNA-dependent RNA polymerase (L protein) is encoded by the L segment. The M segment encodes two non-structural proteins, known as NSm1 and NSm2, and the progenitor of the glycoproteins Gn and Gc in a single open reading frame (ORF) (Sherman et al., 2009).

Glycoproteins have a role in the virus's penetration and virions' escape from infected cells. They trigger the synthesis of neutralizing antibodies, which are crucial for defense (Mandell et al., 2010). No matter which genome segments are examined, RVFV has limited genetic diversity despite widespread geographic dispersion, a broad variety of susceptible arthropod vectors, and vertebrate hosts (Bird et al., 2007). RVFVs low genetic diversity—4% at the nucleotide and 1% at the protein coding levels, respectively—most likely stems from the evolutionary restraint arboviruses have placed on themselves as a result of their altered replication in arthropod and mammalian hosts (Bird et al., 2007). According to recent research, host alternation is crucial for preserving the NSs gene's stability and enhancing RVFV ability to elude the innate immune response (Moutailler et al., 2011).

2.2 Transmission of Rift Valley Fever

In endemic areas, there are notable variations in the ecology and patterns of RVF transmission. Substantial RVF outbreaks in eastern and southern Africa occur erratically every 15 years, after periods of intense rain and flooding (Bird et al., 2009). Although the virus's inter-epizootic phase (IEP) fate is unclear, cryptic maintenance and transmission cycles have been hypothesized (Paweska et al., 2014). There are multiple modes and vehicles through which Rift Valley Fever is transmitted including;

2.2.1 Vectors

Biological vectors of RVFV are mosquitoes of the subgenera Neomelaniconion of Aedes and Culex (Pepin et al., 2010). The more nocturnal *Culex* spp. spread out far and wide in search of vertebrate hosts for blood feeding, while the floodwater *Aedes* spp. tend to stay close to dambos and only feed at twilight and dawn.

The have three main breeding categories based on ecological lifestyle: those that breed in permanent water, those that breed in floodwater, and those that breed in artificial containers or tree holes. Permanent bodies of water, such as lakes, ponds, ditches, and swamps that don't typically dry up are preferred by *Anopheles* and *Culex* mosquitoes (Goddard & Goddard, 2018). Floodwater mosquitoes lay their eggs in low-lying regions of the earth, where they hatch during periods of flooding. The *Aedes* genus of mosquitoes includes both artificial container/tree hole and floodwater breeders. While *Aedes aegypti* and *Aedes albopictus* are examples of manmade containers or tree holes breeders, *Aedes* vexans is an example of a floodwater mosquito (Goddard & Goddard, 2018).

Aedes eggs can endure dry environments for extended periods of time if the embryo develops, but if the eggs are placed prematurely, they may die if they get too dry (Prasad et al., 2023). Due to this phenomenon, *Aedes* mosquitoes can now spawn in manmade containers, tree holes, and occasionally flooded marshes, among other temporary water sources (Sarfraz et al., 2012). The *Aedes* mosquito has spread throughout the world in this manner, laying its eggs in tires, water cans, and other man-made containers. The eggs develop into air-breathing larvae, which are need to periodically surface in order to obtain oxygen (Sarfraz et al., 2012).

There are three molts (scraping off of the outer skin) for mosquito larvae (Master et al., 2020). The size of the head grows by roughly 50% with each molt. An instar is the interim between molts. The larvae will molt into a pupae after their fourth instar, and then they will develop into adults (Master et al., 2020). Since floodwater zones are transitory water locations, they lack natural predators. If the water stays in these areas for a week or more, multiple kinds of floodwater mosquitoes will spawn there. Aedes mosquitoes are thought to be the principal vectors in the transmission cycle of the RVF virus, with Culex and Anopheles being the secondary species (Owino, 2018).

When *Culex* and *Mansonia* species colonize stagnant floodwaters, there are a lot of secondary vectors, which raises the risk of transmission to humans and domestic animals (Hartman, 2017). On the other hand, it may also be of epidemiological significance to show that the larvae of *Cx. pipiens*, *Ae. mcintoshi*, and Ae. circumluteolus contract the infection through feeding on liver homogenates from experimentally inoculation hamster. It is also possible that the virus can propagate into RVF-free areas because these areas have competent mosquito vectors (Turell et al., 2008).

2.2.2 Virus Amplifiers

The main species afflicted and most likely the main viral amplifiers, are domesticated ruminants, however serological data indicates that several herbivorous and other African wildlife species may also be involved in the RVF epidemic (Olive et al., 2012). Humans are extremely vulnerable to RVF infection and can become sufficiently infected and spread the disease to uninfected areas and function as a source of transmission by mosquitos (Paweska, 2014). Given that wild animals serve as an RVF reservoir, it is not established, but it is not ruled out, that African buffalo (*Syncerus caffer*), other wild native or endemic ruminants, wild rodents, or bats contribute to the virus's spread (Wilson et al., 2018).

2.2.3 Non-vector mode of transmission

It has been reported that humans, animals, and vectors can all experience direct transmission in a vertical fashion. Contact with the blood, bodily fluids, tissues, organs, and aborted animal foetuses is the primary means of human infection (Bird et al., 2009). According to Grossi-Soyster et al. (2019), a considerable proportion of RVF cases, particularly in endemic areas and during outbreaks, may be caused by exposure to raw milk (Kwaśnik et al., 2021). There isn't any proof of direct horizontal transmission between humans, however there have been reports of occasional vertical transfer of RVF from mothers to their babies (Adam & Karsany, 2008). Inhaling aerosols containing infected bodily fluids can also lead to infection. Occupational hazards that pose RVF infection risk are veterinary practices and the skinning or slaughtering of diseased animals.

Animals can become infected with RVF by direct contact with diseased animal tissues, body fluids, or fomites—especially if the virus is linked to abortions

(Kwaśnik et al., 2021). Large amounts of virus particles are found in placental membranes and aborted fetal tissue, which might infect nearby animals or directly contaminate the surrounding environment (Kwaśnik et al., 2021). As evidenced by in vitro studies, the RVF may last in the environment for comparatively lengthy periods of time. Movement of infected animals can spread the disease over vast distances, such as across a nation or region (Chevalier et al., 2004).

2.3 Clinical presentation of Rift Valley Fever

2.3.1 Clinical presentation in humans

Humans infected with RVF have a variety of signs of disease, none of which appear to predispose to another (Swanepoel & Coetzer, 2004). Most infections in people are either undetectable or linked to moderate-to-severe, non-fatal feverish illnesses that resemble the flu and cause headache, nausea, myalgia, and arthralgia joint pain. Some people have light sensitivity, nausea, vomiting, and stiff necks (Nguku et al., 2007). Most human infections cause a self-limiting feverish illness. About 50% of infected persons show no clinical symptoms at all, and the remaining 40% may show flu-like symptoms (Nguku et al., 2007).

In human beings, severe RVF disease can present in a variety of ways. A vast array of clinical symptoms can manifest in humans, such as rhinitis, hepatitis, delayed-onset encephalitis, and, in the most extreme circumstances, hemorrhagic illness (Connors and Hartman, 2022). The disease's hemorrhagic and/or encephalitic variants occur in less than 1% of human patients. Although the ratio of the overall cases of fatalities is thought to be between 0.5 and 2%, it seems to have been greater in more recent disease outbreaks in South Africa and East Africa (Mohamed et al., 2010). Most human instances with neurological disorders, hemorrhagic complications, or jaundice have a higher chance of mortality (Gray et al., 2012).

The meningoencephalitis version of the illness often manifests one to four weeks following the first illness onset. Severe headache, loss of memory, hallucinations, disorientation, confusion, vertigo, convulsions, fatigue, and coma are among the clinical symptoms (Anywaine et al., 2022).

The signs of severe liver impairment usually precede the bleeding manifestations (bleeding from venepuncture sites, petechiae, purpura, ecchymoses, gastrointestinal bleeding, bleeding from the nose or gums, menorrhagia) that characterize the hemorrhagic symptoms of RVF, which typically appear two to four days after the illness begins. Patients who acquire the hemorrhagic version of the disease may have a case-fatality rate (CFR) of up to 50%. Usually, three to six days after symptoms start, a person passes away (Anywaine et al., 2022).

In a small percentage of cases, ocular lesions that appear at the beginning of the illness or up to four weeks which later may exacerbate the disease. The prevalence of ocular complications in human infections is estimated to be between less than 1% and 20% (Nielsen et al., 2020). The ocular condition typically manifests as a reduction of central vision acuity, though scotomas can occasionally form as well. In most cases, the lesions and loss of visual acuity go away over several months with varying amounts of residual retinal scarring; nevertheless, in cases where there is significant retinal hemorrhage and retinal detachment, permanent unilateral or bilateral blindness may result (Schwarz et al, 2022).

It is anticipated that the ratio of overall case fatalities is in the range of 0.5% to 2% (Petrova et al., 2020). In human cases, there is an increased chance of death with jaundice, neurological disorders, or hemorrhagic complications (Petrova et al., 2020).

2.3.2 Clinical presentation in animals

The disease cause severe illness in cattle, sheep and goats among which sheep are the most severely affected (Pezzanite et al., 2009). Clinically, the illness is typified by high incidence of abortions and mortality among the young animals (Ikegami & Makino, 2011). In lambs less than a week old the mortality rate can be higher than 90% and associated with hepatic necrosis while in adults the rate is often less than 10-30% (Bird et al., 2009a). Among pregnant animals the rate of abortion is between 40-100% (Swanepoel & Coetzer, 2004). Adult animals may also exhibit other signs including anorexia, diarrhea, nasal discharge, colic, jaundice, lacrimation (Swanepoel & Coetzer, 2004).

2.3.2.1 General characteristics of RVF among livestock

A common feature of RVF virus epizootics is the abrupt emergence of large-scale storms of abortion across vast regions after unusually high rainfall (Swanepoel & Coetzer, 2004). Livestock infected by Rift Valley fever disease exhibit per-acute to acute onset of inappetence, nasal discharge, and diarrhea; around 1×10^6 to 1.0×10^8 PFUs/mL are viremic. Pathologic features at necropsy include splenomegaly, widespread hepatic necrosis, and gastrointestinal bleeding. Viral antigen is abundant in the reticulo-endothelial system and other organs, including the liver, kidneys, ovaries, and endometrium (Nabeth et al., 2001).

2.3.2.2 Clinical presentation in sheep

Lambs under one month of age are particularly vulnerable to infection by the RVF virus; fatality rates can range from 90% to 100% (Swanepoel & Coetzer, 2004). The disease's clinical course is brief in lambs, lasting roughly 12 to 24 hours after incubation. This is succeeded by a noticeable fever increase from 41° to 42°C, which progresses quickly to death in the next 24 to 72 hours (Evans et al., 2008). Adult sheep have lower infection rates; the mortality rates of afflicted individuals range from 10% to 30%. Abortion storms linked to RVF virus epizootics are as a result of high abortion rates, ranging from 90% to 100% (Swanepoel & Coetzer, 2004). Multiple organ infection and fetal necrosis and placental cotyledon and caruncle necrosis, are characteristics of fetal loss and abortion caused by RVFV.

It is interesting to note that hydranencephaly, arthrogryposis, and hydrops amnii have been linked to live-attenuated Smithburn strain RVF virus immunization given to pregnant sheep between 30 and 105 days of gestation (Kitandwe et al., 2022). In adult sheep, the symptoms of Rift Valley fever include a widespread febrile reaction, lethargy, hematemesis, hematochezia, and nasal discharge. The illness takes 24 to 72 hours to incubate. Widespread organ involvement in spontaneously infected sheep is further confirmed by gross and histopathologic findings. Large, mushy, friable, and discolored (yellow to tan), the liver's parenchyma contains a number of light foci of necrosis. There are hemorrhages in the subcutaneous, visceral, and serosal areas; icterus, as well as abomasal and intestinal hemorrhages, are frequently observed (Mandell et al., 2010).

Histologically, deadly infections are distinguished by diffuse or multifocal hepatocellular necrosis along with a neutrophil and macrophage infiltration (Bird et al., 2007). There is minimal white pulp lymphoid necrosis in the spleen and widespread lymphoid necrosis in the lymph nodes' cortex and medulla. Some animals experience widespread necrosis of lymph node tissue in the alveoli and peribronchiolar areas in addition to bronchial obstruction and edema (Bird et al., 2007).

2.3.2.3 Clinical presentation in cattle

Newborn calves (less than one month of age) tend to be less susceptible to deadly RVF infection than are neonate lambs, although as well fatality rates are high; 10% to 70% (Odendaal et al.,2021). The histologic findings and illness course are comparable to those observed in lambs (Mandell et al., 2010). Even though they are susceptible to RVF virus infection, mature bovids are less susceptible to a fatal illness than sheep; among older cattle, the reported mortality ratio is between 5% and 10% (Mandell et al., 2010). Cattle with Rift Valley fever sickness typically have a fever lasting one to four days, along with inappetence, lethargy, hematochezia, and possibly epistaxis (Mandell et al., 2010).

Lactating cows may experience a noticeable but transient drop in milk output, and there has been anecdotal evidence of the RVF virus infecting people after drinking raw milk (Swanepoel & Coetzer, 2004). Histopathologic observations noted during infection indicate the presence of disseminated intravascular coagulation due to diffuse to multifocal centrilobular hepatic tissue necrosis, which may be followed by fibrinogen thrombi in the portal triads, core veins, and hepatic sinusoids (Kwaśnik et al., 2021).

2.3.2.4 Clinical presentation in goats

Relatively little information has been published regarding the pathophysiology of goat RVF viral infestation. Goats can withstand severe or fatal sickness than sheep, despite their great susceptibility to infection (Nfon et al., 2012). Research conducted in western Africa found that during enzootic times, between 2% and 10% of goats have anti-RVF virus antibodies; during epizootics, this percentage increased to over 70%. Around 48% of the deaths in 223 goat herds that were examined after the 1998 Mauritania epizootic were in young animals (Tinto et al., 2022). According to the findings of a recent study on the epidemic-epizootic in Kenya in 2006–2007, sheep and goats have comparable levels of IgM specific to the RVF virus. When the RVF virus infects goats, the severe symptoms (abortion, lethargy, and inappetence) are comparable to those seen in sheep (Sang et al., 2010).

2.3.2.5 Clinical presentation in camels

The discovery of the Rift Valley fever virus in camels came about in 1961 during a widespread abortion outbreak in northern Kenya (Hudges et al., 2020). Although the study found that 45 percent of the 60 camels under examination had serum IgG antibodies specific to the RVF virus, the RVF virus was not proven to be the primary cause of the sickness outbreak. Studies carried out during and after the 1977–1979 Egyptian epizootic showed that among 466 camels tested, the frequency of serum anti–RVF virus IgG antibody was almost 21%; abortions were also reported within this Egyptian herd of camels (Bird et al. 2009). In 1998, Mauritania had an RVF epizootic and epidemic. Of the adult camels, only around 3% contained serum IgM or IgG antibodies against the RVF virus, and there was a notable neonatal mortality rate in calves (about 20%) (Caminade et al., 2014).

2.3.2.6 Clinical presentation in horses

Despite the paucity of research, levels of anti-RVF virus IgG antibody were found to range from 3% to 10% in horses from Nigerian regions where the virus is endemic as well as in horses from places where the 1977–1979 Egyptian epidemic epizootic afflicted horses. The RVF virus, at high doses could infect Shetland ponies, according to the findings of an outstanding research by Yedloutshnig et al. (1981); however, no clinical symptoms were observed, and the peak viremia following the challenge did not exceed $1.0 \times 10^{2.5}$ mouse LD50/mL. The researchers came to the conclusion that horses probably had minimal bearing on the ecology of RVF virus infection as a whole.

2.3.2.7 Clinical presentation in wildlife

Few controlled investigations on the pathophysiology of RVF virus infection in wildlife have been conducted to date. The role that wildlife plays in the natural ecology of RVF infection has been established by several field studies, serologic test findings, and virus isolation. Wildlife can serve as vulnerable hosts in the event of epidemics or as possible maintaining hosts in between outbreaks (Rostal et al., 2017). African buffalo, elephants, warthogs, black rhinos, zebras, thompson's gazelles, lesser kudus, impalas, and waterbucks have all been shown to have previously contracted the RVF virus in a study conducted in Kenya (Evans et al., 2008).

2.4 Differentiation of Rift Valley Fever from similar disease entities

The RVFV is a member of a ventilator-associated hemorrhage (VHF) agent group (Struthers, 2017). While these are distributed globally, a given pathogen is typically limited to an area that is known to be endemic, where it is dependent on the presence of natural reservoirs and competent arthropod vectors. Similar to the majority of VHFs, RVF presents non-specific symptoms, making clinical diagnosis challenging (Sahadulla, 2017). As a result, the differential diagnosis covers a wide range of illnesses, particularly in situations where initial cases occur during an outbreak that is not yet known to be occurring. The illnesses include viral hepatitis, rickettsial infections, meningitis, dysentery, plaque, brucellosis, typhoid fever, Ebola fever, and hemorrhagic fever with renal syndrome linked to hantavirus infections. Some sepsis from bacterial infections is also included in this list (Suh et al., 2001; Olano and Walker, 2009). Further, it is also critical to take into account non-infectious causes of acute leukemia and disseminated intravascular coagulopathy. The availability of test data and epidemiological data typically aids in reducing the range of possible differential diagnoses. A tentative etiology can be presumed based on recent travel and exposure history (such as mosquito bites, animal contact, or consumption of animal products) in endemic areas (Paweska, 2014).

Abortion during infection of pregnant animals is a differentiating feature of RVF (Rostal et al.,2020). Despite the stage of pregnancy, the high number of nearly synchronous abortions amongst pregnant ruminants is the traditional RVF epizootics' defining feature. These widespread abortions, sometimes known as "abortion storms," enable the separation of RVF from several more typical infection that cause ruminant abortions, including toxoplasmosis, chlamydiosis, salmonellosis, Q fever (*Coxiella burnettii*), and listeriosis (Thomas et al., 2022).

Similar to other VHFs, the RVF confirmatory diagnostic procedure must take into account all clinical, pathological, laboratory, and epidemiological data that are currently accessible (Petrova et al., 2020).

2.5 Immune responses against Rift Valley Fever Virus

The immunological responses against RVFV are directed toward nucleoprotein (N) components; heterodimers of Gn and Gc (Faburay et al., 2017). Although early research has not determined the precise molecular correlations between immunological defense against RVF in either people or animals, the production of neutralizing antibodies against Gn and Gc has offered a reliable correlate of protection (Pepin et al., 2010). Consequently, the primary antigen targets for the development of the RVF vaccine have been Gn and Gc (Faburay et al., 2017).

When RVF and other bunyavirus infections are present, nucleoprotein N stimulates high amounts of IgG and IgM antibodies, but these antibodies are not neutralizing (Pepin et al., 2010). This protein is a target for complement-dependent cytotoxicity (CDC) and antibody-dependent cell-mediated cytotoxicity (ADCC), as well as a strong human CD8+ T cell antigen, suggesting that anti-N immune responses may contribute to protection against RVF (Xu et al., 2013, Jansen van Vuren et al., 2012). The early proliferation of CD4+ and CD8+ T cells and the production of Th1 cytokines were linked to non-lethal outcomes in African green monkeys challenged with RVF (Wonderlich et al., 2018). In humans, fatal cases were linked to greater concentrations of IL-10, a cytokine that suppresses Th1 responses, in contrast to non-fatal instances (McElroy and Nichol, 2012).

The host's inherent protection mechanism detects the presence of a virus and triggers the immune system to mount a defense. The innate immune system of the host possesses the ability to identify foreign substances and infections by utilizing shared conserved characteristics (Alberts et al., 2008). These molecular signatures, referred to as pathogen-associated molecular patterns (PAMP), are identified by intracellular and membrane-bound pattern-recognition receptors (PRR) of the host cells. They consist of specific components of the cell membrane and genetic material of the pathogen. Some PRRs that identify PAMPs and trigger the signaling cascade that regulates invasive pathogens are Toll-like receptors (TLR). The TLRs have a N terminal domain that detects chemical patterns and a C terminal domain that engages in the conveyance of signals through the Myeloid Differentiation Factor (MyD88) pathways (Sameer & Nissar 2021).

The TLRs 3, 7, 8, and 9 are able to identify genetic material and trigger immune responses to eliminate pathogens. In order to distinguish between the genetic material of the virus and the host cell, the long dsRNA is recognized by the melanoma differentiation-associated gene 5, whereas uncapped 5′-triphosphate ssRNA and short dsRNA produced as a result of viral replication are recognized by the retinoic acid-inducible gene-I. When viral RNA binds to receptor-like proteins (RLRs), it can cause recruitment of the mitochondrial antiviral signaling protein (MAVS), phosphorylation of TBK-1, or activation of NF-κB, which functions as an interferon transcription factor and interferon-stimulated genes (Thompson et al., 2011).

A gamma interferon activated sequence or an interferon-stimulated response element controls the stimulation of interferon-stimulated genes' transcription as a result of interferons (IFN) autocrine or paracrine interaction with the interferon receptor, which phosphorylates STAT protein (Tolomeo et al., 2022). The RIG-I molecule identifies the RVFV genome and initiates the downstream signaling cascade, which culminates in the synthesis of interferon-inducible transmembrane proteins -2 and -3. These proteins limit the life cycle of a virus during the initial phases after integration and before it replicates in vitro (Mudhasani et al., 2013).

2.6 Immune evasion strategies of Rift Valley Fever virus

The nonstructural (NS) protein of RVF viruses that cause sandfly fever block the phosphorylation of Stat-1 and Jak-1 as well as the JAK-STAT pathway, which is necessary for the synthesis of IFN-stimulated regulatory facto (ISG). The RVF reproduces by means of the interaction between its NSs protein and the host Sin3A-associated protein 30 (SAP30), a part of the complex known as histone deacetylase, which keeps the IFN-β signaling inactive for transcription. Mutants of NSs with deletions of amino acids that are critical for SAP30 binding eliminated its association with the IFN-β promoter sequence, allowing the infected cells to survive (Ikegami et al., 2009).

The promoter region of the host double-stranded RNA-dependent protein kinase (PKR), which is triggered by IFN, is in charge of initiating immunological responses in paracrine signaling. By breaking down PKR, the NSs make sure that natural immunity is blocked in uninfected cells. Additionally, PKR is in charge of phosphorylating eIF2α to facilitate effective translation of host and obstruct translation of the virus. In addition, PKR destruction by NSs guarantees viral translation, inhibits eIF2α phosphorylation, and shuts down the host's immunological response (Ikegami et al., 2009).

Several cell lines are activated by incoming RVFV viruses through classical autophagy mechanisms which lead to viral spread. The RVF infection triggers autophagy in primary mouse hepatocytes, primary rat mixed neuroglial cultures, mouse embryonic fibroblasts, and human osteosarcoma cell lines (U2OS) (Moy et al., 2014). When RVFV infection occurred in THP-1 PMA-derived macrophage cells, the interaction between the viral nucleoprotein and host sequestome 1 led to the development of autophagosomes and facilitated the spread of the virus. However, RVFV infection with Huh7 cells, also known as human umbilical vein endothelial cells stimulated autophagy, which was not required for the virus to replicate (Zhu et al., 2023). Therefore, pro- or anti-viral effects of RVFV-triggered autophagy depend on the kind of infected cell.

A class of extracellular vesicles known as exosomes is created when endocytosis occurs and the cell membrane fuses with it afterwards (Kalluri & LeBleu, 2020).

When exosomes containing viral RNA from an RVFV infection are created, the RIG-I pathway may be activated, producing interferon-β (IFN-β) and increasing autophagic flux resulting to virus spread (Alem et al., 2021). Also, RVFV changes 5′ termini as a means of immune evasion and avoids RIG-I detection (Habjan et al., 2008).

2.7 Human RVF Epidemics

Humans can contract the RVF virus through two different secondary cycles: the urban peridomestic cycle and the sylvatic cycle (Kwaśnik et al., 2021). Those who work in the cattle business are susceptible to the sylvatic cycle, which is spread by zoophilic mosquitoes. Humans contract the virus through contact with animals (Kwaśnik et al., 2021). This kind of cycle is what initiated the RVF outbreak that struck Kenya in 1997–1998. The urban peridomestic cycle is the second type of secondary cycle, wherein anthropophilic mosquito bites infect people with RVF (Gerdes, 2004). This kind of transmission was primarily responsible for the high number of human cases in Egypt in 1977 (Gerdes, 2004). In Egypt, this outbreak was the cause of 598 deaths. Before 1977, RVF was primarily a veterinary issue, and laboratory personnel and those who lived near afflicted animals had previously been found to have contracted the disease from humans (Gerdes, 2004). Two other epidemics, besides those in East and South Africa, emerged in other areas after dam construction and resulted in significant ecological alteration of the surroundings (Paweska, 2014).

2.8 Epidemiology

In this era of developing and re-emerging illnesses, details about illnesses that affect wildlife, particularly those that traverse the border between wildlife, domestic animals, and humans, is becoming more and more relevant. One of the Office International des Epizooties’ (OIE) responsibilities is to notify member nations about dangerous viruses, like the avian influenza virus and the RVF virus, to organizations that deal with domestic animals, wildlife, and public health (OIE, 2008).

Sheep abortions are usually the first sign of an epidemic (Jupp et al., 2000). It is believed that the trans-ovarial transfer of the RVF virus in floodwater Aedes mosquitoes is the mechanism that allows the virus to survive between epizootic periods and endure in mosquito eggs until the subsequent time of intense rain (Bird et al., 2009). Epidemics cause much more havoc to local herding economies and pastoral nomads because they kill a large number of adult animals, ruin the next generation of animals, and endanger the residents who depend on milk and meat to survive.

Large RVF outbreaks also result in a considerable number of human infections, which poses serious problems for healthcare in environments with limited resources. It has also been shown that touching infected animals or products, getting bitten by mosquitoes, and consuming raw milk can all expose people to the virus at work (Gerdes, 2004).

2.8 Association between RVF epizootics and epidemics

The OIE has classified 15 diseases, including the RVF virus, as having a high potential for fast transmission, major effects on the economy or public health, and a major influence on the worldwide trade of animals and animal products (IOE, 2008). As of right now, OIE regulations mandate surveillance and the absence of RVF viral activity for two years after an epidemic before the disease is declared to have eradicated and import/export trade restrictions are subsequently loosened (IOE, 2008).

The RVF is characterized by both epizootic and inter-epizootic cycles in its epidemiology (Meegan & Bailey, 2019). In Africa, RVF epizootics frequently happen under exceptionally high rainfall. During epizootics; cattle and sheep are the most important livestock amplifiers of the virus. The RVF interepizootic survival is thought to be dependent on the virus's transovarial spread in floodwater *Aedes* mosquitoes (Linthicum et al., 1985).

When mosquito eggs hatch and produce RVF-infected mosquitoes during the subsequent period of intense rains, the virus can still be present in the eggs (Mbotha, 2020). The ability of infected mosquitoes to spread the virus to many hosts that are vertebrates or to start a widespread RVF epizootic depends on a number of variables, including the presence of susceptible vertebrates, adequate numbers of competent mosquito vectors, and suitable environmental conditions (Mbotha, 2020).

The RVF epizootics have a cyclical structure and are distinguished by protracted intervals between epizootic periods. In locations that are wetter, these cycles might last 5–15 years, whereas in areas that are drier, they might last 15–30 years (Chambaro et al., 2022). There is a chance the virus exists in areas near forests during the inter-epizootic phase in an endemic relationship involving Aedine mosquitoes and unidentified hosts that are vertebrates. Alternatively, livestock linked to Aedine mosquitoes that lay their eggs in depressions during low tide (dambos) in savannah settings may have low-level transmission (Gerdes, 2004).

Following re-emergence of the RVF virus through floodwater mosquitoes, high-risk animal populations experience a notable amplification of the virus, leading to an increase in animal prevalence (Hartley et al., 2011; Gerken et al., 2023). Viremic animals will serve as food for other mosquito species when epizootic conditions are optimal, potentially spreading the RVF virus to people and igniting an epidemic (Hartley et al., 2011; Gerken et al., 2023).

2.8.1 RVF occurrence outside Kenya

The disease in humans and animals has been shown to occur in approximately 30 countries (Rolin et al., 2013). Since its discovery, the disease had been restricted to the East African region but in 1951 a major outbreak was reported in South Africa where 100,000 sheep died and about 500,000 pregnant ewes aborted (Laughlin et al., 1979; Meegan, 1979). The disease has spread to other African countries including Mauritania (Nabeth et al., 2001), Senegal, Zimbabwe, Namibia, Zambia and Madagascar. In 2000, a major outbreak was reported in Saudi Arabia and Yemen representing the first case outside the African continent (Madani et al., 2003a). East Africa have heard 2 major epidemics in 1997-1998 and 2006-2007 affecting Kenya, Tanzania, Somalia (Murithi et al., 2011) and spreading to Sudan (Hassan et al., 2011).

2.8.2 RVF occurrence in Kenya

The disease occurrence in Kenya has been described in detail by Murithi et al. (2011). Kenya first reported a Rift Valley Fever like disease in 1912. Rift valley fever virus was then isolated as the etiological agent of the disease in 1931 at a sheep farm along the shores of Lake Naivasha in the Rift Valley region, Kenya. The disease caused sudden death of approximately 4700 lambs and ewes in a period of 4 weeks (Daubney et al., 1931). Between 1912 and 1950, the disease was confined in a region prone to flooding within the Rift Valley province. It later spread to eight districts within the province by 1955. By 2007, 38 districts out of 69 districts in the country had reported the disease. From 1951 to 2007, 11 national RVF epidemics have been reported with a range of 1-7 years. The 1997-98 and 2006-07 outbreaks were the largest. The most recent 2006-2007 outbreak caused huge animal and human mortalities in 29 of 69 districts in Kenya (Munyua et al., 2010).

2.9 The pathogenesis of Rift Valley Fever

Depending on the animals' sensitivity or resistance, three categories of infection patterns are typically seen in animals that are infected both spontaneously and through experimentation (Ikegami & Makino, 2011). When an animal has an uncontrolled acute infection and a high blood viral load, it can result in viraemia, a deadly condition where the animal dies acutely. The second type is characterized by a rapid decline in viraemia and mild to asymptomatic illness. The third pattern has two phases; the first phase is characterized by delayed infection problems onset with fever and viraemia; in the second phase, there may be another fever episode (Ikegami & Makino, 2011).

These infections may extend to various parts of the body, particularly the central nervous system following passage of the blood-brain barrier and the retina, frequently linked to detrimental long-term effects (Kwaśnik et al., 2021; Xu et al., 2023). Liver is the primary site of RVF-induced lesions in both humans and animals. Histopathological analysis of the tissues of experimentally infected sheep has sufficiently proven that this finding is consistent among severe cases (Coetzer & Ishak, 1982). The virus's tropism is restricted to monocytes and hepatocytes. Hepatocellular alterations brought on by infection may develop to necrosis, which is characterized by elevated liver enzyme levels, leukopaenia, or thrombocytopaenia (Findlay, 1932).

2.10 Risk factors

Three subjects are used to define the variables influencing the prevalence of RVF: biological, environmental, and socioeconomic factors;

2.10.1 Biological risk factors for Rift Valley Fever

2.10.1.1 Livestock age and species

Animal-level risk elements for the possibility of RVF occurrence include host-related risk variables; age and species. Any species' young members are far more vulnerable than their adult counterparts. Research conducted after an outbreak revealed that young animals had a lower seroprevalence than adult animals (Chevalier et al., 2011). The explanations for this may include minimal survival in the younger demographic following an outbreak, the reproduction process replacing weaker animals, and the fact that adults will have experienced this exposure for an extended period.

There is clear evidence of a gradient in the sensitivity of different animals to mortality caused by RVF, with sheep and goats being the most susceptible, followed in order by cattle and camels. Nonetheless, research conducted in West Africa after an outbreak revealed that sheep and goats had comparable seroprevalence levels (Thiongane et al., 1991).

Young and newborns appear to be less affected by the illness, as opposed to the exceptionally high death rate observed in juvenile ruminant animals during outbreaks (Madani et al., 2003). Additional research is necessary to determine whether the reported variation in susceptibility between young animals is due to a lack of exposure, or if variations in susceptibility do exist between species. Research show that RVF incidence levels are comparable between age divisions both within and between species (cattle, sheep, and goats) (Lancelot et al., 1990).

Comparable degree of contagiousness, or the per capita risk of an infected host, is implied by similar incidence values. This is based on a number of parameters for transmission, including vector bite rate, the likelihood that an infectious mosquito may spread to a vulnerable host in the event of contact, vector to host ratio, vector blood meal index (which is based on host preference), and RVF prevalence in the vector.

2.10.1.2 Sex of the host

Given that an RVF infection in a female host might end a pregnancy at any point, pregnant female animals are more likely to experience extra RVF burden. According to Bird et al. (2009), the species susceptibility gradient is followed by abortion rates, which almost reach 100% in sheep, goats, cattle, and camels. Pregnant women versus pregnant ruminants exhibit a similar scenario to the one detected in children as opposed to newborn ruminant deaths; that is, pregnant women were less prone to contract the illness than ruminant animals, who were known to have huge abortion storms (Madani et al., 2003). Similarly, research is needed to determine the cause of these variations.

2.10.1.2 Immune responses by the host

A surprising biological element that influences the success or failure of an infection is immune state. According to theory, an RVF infection can produce lifelong neutralizing immunity (Pepin et al., 2010). It is unclear what constitutes a fully protective immunity threshold. There is a deficiency in comprehensive understanding regarding the natural immunology of RVF, necessitating additional in-depth research on several aspects such as the virus strain, inoculation route, dose, vector proficiency, and factors at the animal level.

2.10.2 Vectors of Rift Valley Fever Virus

The RVF has the ability to adapt to a surprising variety of vectors, such as ticks and different types of insects, in contrast to the most arboviruses, or viruses carried by arthropods, which are spread by a limited number of vectors (Pepin et al., 2010). The epidemiological significance of mosquitoes as capable RVF vectors is supported by the minimum infection rates (MIR), which are determined by counting the number of isolations per 1000 adult female mosquitoes (Pepin et al., 2010).

Aedes mcintoshi in Kenya (83.3/1000), *Aedes dentataus* in Zimbabwe (43.5/1000), and *Culex theileri* in Zimbabwe (9.7/1000) are among the species having elevated MIRs for RVF in adult female mosquitoes collected in the wild (Pepin et al., 2010). The vector competence index (VCI) is utilized in an experimental evaluation of a vector's competency (Jupp and Kemp, 1993). The VCI combines the rates of infection and transmission into a single figure (Pepin et al., 2010; Gachohi, 2015). According to Pepin et al. (2010), some species of adult female mosquitoes examined in the field had high vector-borne virus (RVF) concentrations. These include *Culex theileri* in South Africa (0.22-0.53), *Culex pipiens* in Egypt (0.05-0.91), and *Aedes palpalis* in the Central African Republic (0.46).

Several mosquito species have been found to transmit the Rift Valley fever virus, including *Anopheles*, *Eretmapodites*, *Coquillettidia*, and *Mansonia*. Nonetheless, studies on vector competence showed that most of the time they cannot spread to hosts (Pepin et al., 2010). In particular, *Aedes vexans arabiensis* was linked to significant epidemics in Saudi Arabia in 2000 (Jupp et al., 2002) and West Africa in 1997 (Zeller et al.). *Culex tritaeniorhynchus* (Jupp et al., 2002) and *Culex poicilipes* (Diallo et al., 2000) were the Saudi Arabian epidemic/amplifying secondary vectors in 2000.

According to entomological research conducted during the RVF outbreak of 2006–07 in Kenya, 77 mosquito pools belonging to ten different species proved positive for RVF: According to Sang et al. (2010), there are 26 pools for *Aedes mcintoshi/circumluteolus*, 23 pools for *Aedes ochraceus*, and 15 pools for *Mansonia uniformis*. Additionally, there are 3 pools each for *Culex poicilipes* and *Culex bitaeniorhynchus*, 2 pools each for *Anopheles squamosus* and *Mansonia africana*, and 1 pool each for *Culex quinquefasciatus*, *Culex univittatus*, and *Aedes pembaensis*. These species attained threshold susceptibility to RVF, however it is unclear if they are capable of transmitting the virus further.

2.10.3 Environmental risk factors

Environmental variables and mosquito population dynamics are strongly related. Environmental elements interact with the temporal dynamics of vector and RVFV to facilitate the disease transmission. Climate, altitude, vegetation, and hydrology can all be used to establish the spatial focus of RVF transmission. Rainfall, for example, is essential to mosquitoes' ability to have appropriate breeding sites (Anyamba et al., 2009). Temperature is a significant factor of mosquito and RVF life cycle features that come together to have an impact on intensity of transmission (Ezeakacha and Yee, 2019). At various scales, these variables may change the intensity of RVF transmission. There are two levels of environmental factors influencing transmission: large-scale ecological risk factors and local viral transmission pathways.

2.10.4 Excessive Rainfall and Ecological Changes

Water including heavy rainfall and ecological changes are two main elements responsible for RVF epidemics (Lo Iacono et al., 2018). The Egypt, Mauritania, and East African epidemics have been attributed to water and heavy rainfall, whereas the Madagascar outbreak has been attributed to changes in ecology (Himeidan *et al.,* 2014). Water is typically used in agriculture growth through irrigation or dam construction, as demonstrated in Egypt (1977) and Mauritania (1987), or through flooding and extreme rainfall, as seen in East Africa (1997–1998). The flooded create breeding sites for vectors (Lo Iacono et al., 2018).

Consistent rainfall, which is typical of the plateau regions of several African states, generates shallow depressions, floods meadows, and raises the water table. When these depressions flood, a huge number of floodwater mosquitoes emerge, clinging to the vegetation on the edge that serves as a breeding site for Aedes ground pool reproduction (Day, 2016). Apart from flooding, another significant factor contributing to the onset of RVF outbreaks is land use change, as evidenced by the construction of dams in Senegal in 1987 and Egypt in 1977 (Gerdes, 2004).

Numerous writers have linked meteorological conditions to the narrative of arboviral epidemics. In an effort to provide light on the devastating St. Louis Encephalitis epidemic (SLE) in the USA in 1933, the US Department of Agriculture declared that the winter of 1932–1933 was twice as warm as usual at the time, while the rainfall was above average (US Department of Agriculture, 1933).

In dry land locations, it has been observed that RVF epidemics occur after extended and continuous periods of rainfall (Chiuya *et al.*, 2023). Aedes mosquitoes, the main vector, breed in the savannah regions of East Africa in ephemeral floodwater pools. In the dry and semi-arid zones, flooding is reliant on patterns of rainfall and happens both frequently and infrequently (Davies and Martin, 2003). Numerous significant research on human and animal diseases have demonstrated using meteorological satellite data's the link between heavy rainfall in dry areas and elevated RVF vector activity (Anyamba et al., 2010). By analyzing El Nino data, predictions have been generated for RVF in order to anticipate a wet season. Retrospective studies conducted after the Kenya RVF outbreak in 1997–1998 revealed that the amplitude of the expected river flow and excess rainfall could have been predicted using satellite data models and measurements of rainfall obtained the catchment regions that are not next to floodplains (Linthicum et al., 1987). A minimum of three months' advance is provided by the predictive models (Linthicum et al., 1987; 1999).

By utilizing these types of models, one can keep an eye on RVF virus activity within a certain region and prepare to contain epidemics. Pope et al. (1992) expanded on Linthicum's research by identifying possible nesting sites using Landsat Thematic Mapper (TM). High resolution multipolarization was used to do this, and the evaluation of the eXtreme (X) band data to differentiate between breeding locations that were inundated and those that weren't. A system for mapping areas at risk of RVF outbreaks has been developed. It makes use of the normalized difference vegetation index (NDVI), derived using data from the national oceanographic and administrative satellites' known as advanced very high resolution radiometer (AVHRR) sensor (Anyamba et al., 2002).

The greenness and brownness of the vegetation, as well as the region's potential for photosynthesis or green leaf biomass, are measured by the NDVI as a measure of the soil's moisture content (Martinez and Labib, 2023). It provides a chance to pinpoint the environmental factors linked to disease outbreaks across sizable regions (USA DoD-GEIS, 2007). For regional, national, and worldwide organizations tasked with controlling RVF in both humans and animals, this approach has the potential to be a valuable resource. It enables the prompt and targeted execution of an epidemic monitoring.

The Southern Oscillation Index (SOI) and the Sea Surface Temperature (SST) of the Pacific and Indian oceans are two more forms of remote sensing satellite warning systems (Gerdes, 2004). If surface temperature of the sea stays at 0.5°C above or below the normal for a specific ocean location, the conditions are considered neutral (Gerdes, 2004). The SST was 5°C above average during the El Nino year of 1997–1998 and there was significant flooding in the Horn of Africa (Anyamba et al., 2001). Tahiti (East Pacific) and Darwin (West Pacific) have different atmospheric pressures, which are measured by the Southern Oscillation Index (SOI). Negative SOI is linked to heavy rainfall. Variations in temperature, precipitation, wind, and sea level due to global warming impact vector, vertebrate, and virus interactions (El-Sayed & Kamel, 2020). Two mosquito species have been shown to migrate northward to somewhat colder regions in order to avoid rising temperatures (Colón-González *et al.,* 2021). Thus, there is a strong correlation between vector-borne illnesses and climate change.

2.10.5 Local processes of RVF transmission

Differentiated landscapes are a defining feature of the transmission of Rift Valley Fever throughout Africa and the Arabian Peninsula (Soti et al., 2013). A new generation of transmission foci is the end outcome. Statistical methods and remote sensing may be used to define these foci (Soti et al., 2013). Water-related variables are the primary parameters associated with the local processes of RVF transmission, such as the distribution and surface area of bodies of water, past occurrences of RVF in the area, soil type and hydrology, flat topography and shallow depressions that easily support flooding, vegetation density index, local bio-ecosystem factors, local rainfall patterns, and proximity to wildlife (Soti et al., 2013).

2.10.5.1 Large-scale ecological risk factors

Large-scale ecological risk variables for the occurrence of RVF principally include global ecological indicators (particularly vegetation) and markers of climate unpredictability, like patterns in sea-surface temperature (SST), cloud cover, rainfall, and cloud cover (Anyamba et al., 2009). Between 1950 and 2007, every known minor or major RVF epidemic in the Horn of Africa has been linked to widespread, above-normal rainfall brought on by ENSO (Anyamba et al., 2009). Areas in the RVF endemic zone with the best ecological circumstances for mosquito vector emergence and survival can be found by combining elevated SSTs, heightened rainfall, and the continuation of conditions that were greener than usual for a span of three months (Anyamba et al., 2009).

2.10.6 Socio-economic factors

Socio-economic aspects include factors like demographics, livestock commerce, livestock migrations, and mixing patterns that have an impact on decisions about livestock management at the herd and community levels. Agriculture-related anthropogenic causes change the diversity of ecosystems, which may have an impact on the frequency of RVF outbreaks (Anyamba et al., 2009).

Since animals have significant rates of illness, the first documented direct socioeconomic effect of RVF on farmers of livestock. This is a substantial stock loss, particularly for young livestock (Bird et al., 2009). Furthermore, the disruption of herd dynamics may cause production losses that continue for a number of years or maybe multiple animal generations (long-term consequences). Perception of these effects in the long run depends on how these financial mechanisms—which go beyond simple herd dynamics (Ng’ang’a et al., 2015).

In addition to destocking, these adjustment responses could involve using credit, altering their sources of income, changing their modes and levels of consumption, depending more on social networks, and changing their production mode (Peyre et al., 2015). Even said, the long-term viability of these changes is debatable and may indicate indicators of anxiety rather than genuine policing tactics (Leyro et al., 2010). Moreover, not all households possess the same capacity to execute these tactics, which could result in redistributive impacts that benefit those with greater resilience—that is, those who are better equipped to handle modifications in their household economy.

The manner in which RVF directly affects cattle losses can be somewhat minimized if the home economy is sufficiently diversified, that is, if there are other possibilities or activities to earn revenue (Holleman, 2003; Rich and Wanyoike, 2010). This may apply to households engaged in agropastoral farming or to commercial producers who engage in non-agricultural pursuits. If not, there is a risk to the household's safety and food security. The size of the herd, or endowment, and the capacity to cut expenses by using modification techniques and the development of new modest revenue-generating ventures are thus critical factors that influence resilience (Holleman, 2003).

Pastoral communities that depend on the livestock industry are particularly susceptible to diseases that could affect their animals, including RVF (Davies and Martin, 2006). Furthermore, pastoralists in the Horn of Africa, comprising of 15–20 million have shifted their focus to market integration and international trade (USAID, 2005). Due to our growing connection with the global economy, this has created both new development prospects and risks (USAID, 2005).

2.11 Public health and economic importance

Rift Valley Fever causes significant human morbidity and mortalities. In 1974-1975, South Africa experienced an outbreak that resulted in seven deaths from 110 laboratory confirmed human cases. Most of the patients were farmers, farm workers and veterinarians who were reported to have acquire the infection while handling carcasses of animals that had died of RVF (McINTOSH et al.,1980). Egypt experienced a large outbreak in 1977-1979 that resulted in 598 human deaths from an estimated 200,000 human cases. (Laughlin et al., 1979). In 1987, an outbreak in Mauritania caused a considerable 220 human deaths (Digouttee et al., 1989). East Africa experienced a large outbreak in 1997-1998 that resulted in 478 human deaths from an estimated 89,000 human cases. (CDC, 1998). In the year 2000, the first outbreak outside of the African continent occurred in Saudi Arabia and Yemen. The outbreak is reported to have caused 123 human deaths in Saudia Arabia. Yemen recorded 166 human deaths from 1328 human cases (Madani et al., 2003a). The 2006/2007 major outbreak in East Africa reported 684 human cases with 155 deaths, a case fatality rate of 23%. Of the reported cases, 234 (34%) were laboratory confirmed (WHO, 2007). Analysis of both the livestock and human data showed that livestock infection presided virus identification in humans (Munyua et al., 2010). In 2008, Sudan experienced an outbreak that caused 230 human deaths from an estimated 747 human cases (Baba et al., 2016).

RVF outbreaks has the potential to cause severe economic losses (Bird et al., 2009a). Livestock are a major economic source of livelihood for many communities where the disease has been endemic. It is estimated that the 2006/2007 outbreak in Kenya led to losses valued at US$32 million on the Kenyan economy (Rich & Wanyoike, 2010). Livestock serves as a major livelihood for communities that keep them. During RVF outbreaks, trade bans on livestock and livestock products from endemic disease zones causes losses of livelihood for communities. Further, livestock keepers experience losses from the death of the animals, loss in potential milk production and loss of future stock caused by induced abortions on livestock (Rich & Wanyoike, 2010)

2.7 Diagnosis

The RVF diagnosis methods include RVF nucleic acid detection, virus isolation and the identification of certain IgM or IgG antibodies. To find antibodies against RVF, the enzyme-linked immunosorbent assay (ELISA) provides a sensitive and dependable technique. Several ELISA types in various formats are available in the market or are currently being development (Fafetine et al., 2007; Liu et al., 2016). In several nations, they are regularly employed for surveillance, epidemic control, and single case diagnosis. For the majority of species, both IgG and IgM ELISAs are available.

It is possible to differentiate vaccinated animals from diseased ones (DIVA) and to differentiate between recent and previous presence of IgG infection based on the ELISA type that was used. An antibody response to both N and NSs would be anticipated in naturally occurring illnesses, but only an antibody response to the N protein would be seen in those who received the attenuated vaccinations (McElroy et al., 2009). As a result, a dual-target ELISA for DIVA has been created using the two viral proteins, N and NSs. Viral RNA can be detected or viruses isolated from serum or whole blood samples obtained during the acute (febrile) stage of the disease, as well as different post-mortem organs such as the brain, liver, or spleen collected from fresh corpses or aborted foetuses (Kwaśnik et al., 2021).

A variety of extremely sensitive molecular assays have been created for diagnosis of RVF. They including recombinase polymerase amplification, multiplex polymerase chain reaction (PCR) based microarray assay, quantitative real-time PCR, real time (RT) loop-mediated isothermal amplification and nested RT-PCR (Sall et al., 2002; Oreshkova et al., 2013; Warimwe et al., 2016). In the Kenyan monitoring program, RVF in mosquitoes has also been found via molecular testing. Hence, RVF can now be detected and quantified during epidemics most quickly and sensitively utilizing both traditional and real-time RT-PCR techniques (Garcia et al., 2001). Recently, strategies based on TaqMan array cards, colorimetry, and next-generation sequencing methodologies have been developed; nevertheless, the majority of these approaches are costly and require specialized trained staff (Zaher et al., 2018; Liu et al., 2016).

The RVF virus is isolated using various approaches. Generally, inoculating nursing mice or different vulnerable cultures of mammals or invertebrates; such as the kidney of an African green monkey of the Vero lineage, the kidney of a BHK-21 baby hamster, or AP61 mosquito cells. Typically, a cytopathic impact appears five days after vaccination, and immunostaining is used to demonstrate that RVF is present (Kwaśnik et al., 2021; Lapa et al., 2024). A lateral flow immunochromatographic strip test or pen-side test was created to identify the RVF nucleoprotein. When there are continuous outbreaks, this kind of test aids in the more effective management of RVF early detection and control (Cêtre-Sossah et al., 2019).

2.13 Management, prevention and control of Rift Valley Fever

2.13.1 Rift Valley Fever vaccine development

A key strategy for disease control in both endemic and non-endemic areas is the immunization of animals against RVF. Various approaches have been employed in the creation of RVF vaccinations. Viral RVF isolates were used to create the first vaccines, including inactivated shots and the live-attenuated Smith burn preparation (Faburay et al., 2017). The NDBR103 Entebbe strain, which was discovered from a mosquito in Uganda, served as the basis for the first formalin-inactivated RVF vaccination (Randall et al., 1962).

One of the earliest and most popular vaccinations for the prevention of RVF is the Smith burn vaccination, live attenuated viral particles. The strain was obtained from Erectmapodites spp. in Uganda in 1944. The Smith burn vaccine, while effective and inexpensive, has a number of drawbacks, including residual pathogenicity, the inability to prevent fetal abnormalities and abortion, and the potential for the vaccine to revert to its full virulence. Vaccines with reduced viability are only permitted in nations devoid of the rhinovirus and cannot be administered to pregnant animals. When the vaccine is administered during outbreaks, there's also a chance of reassortment, which could boost the virus's variability (Botros et al., 2006).

The US Army Medical Research Institute of Infectious Diseases (USAMRIID) produced TSI-GSD200, formalin-inactivated RVF vaccine. This was further developed into TSI-GSD200 a fresh cohort of RVF vaccine produced by the U.S. Army Medical Research Institute of Infectious Diseases (USAMRIID). Further, a live attenuated vaccine, called MP-12, was created by the USAMRIID for use in humans and animals. It did this by using the virulent strains of ZH548 and ZH501 that were obtained from Egyptian patients and serially passing them through 12 times in MRC-5 cells while 5-fluorouracil was present as a mutagen. The MP-12 strain has repetitive changes in each of the three genomic regions and is sensitive to temperature. Generally speaking, MP-12 can generate antibody titres high enough to shield vaccinated animals against RVF, and immunizing pregnant animals may have the added benefit of protecting the offspring (Ikegami, 2019).

The Clone 13 attenuated vaccine was created as a result of the NSs gene's natural deletion of 549 nucleotides (about 70%) (Kwaśnik et al., 2021). The 74HB59 plaque-purified clone, which was isolated in the Central African Republic, served as the basis for this vaccine (Kwaśnik et al., 2021). The differentiating infected from vaccinated animals (DIVA) test makes it simple to distinguish vaccinated animals from naturally infected animals that are clone 13 (Kitandwe et al., 2022). The primary drawback of the vaccine is that the mutant virus cannot multiply effectively with immunized animals and does not elicit a sustained immune reaction (Kwaśnik et al., 2021).

Subunit protein vaccines, DNA vaccines, vaccines generated from recombinant viruses created by reverse genetics, virus-like particles (VLPs), vaccinations containing viral replicon particles, virus vectored vaccines, and modified live vaccines are among a class of novel vaccinations made with recombinant DNA technology being pursued for development of RVF (Liu et al., 2016, Warimwe et al., 2016). Because they are extremely safe and pose no risk to the environment, recombinant protein-based vaccinations, vector-limited polymers, and DNA vaccines that are DIVA-compatible appear to be the most promising alternatives for prevention of RVF (Faburay et al, 2017).

Although an inactivated vaccination for humans has been created, it is not authorized for use and has only been tested on laboratory and veterinary staff who are highly susceptible to exposure to RVF (Rusnak, 2011). Still, a lot of potential vaccinations are being developed (Bird et al., 2011). The safe, efficient, and cost-effective immunization of animals in endemic areas would be the most effective strategy for protecting humans against RVF. However, no vaccinations are approved for use in veterinary applications anywhere else, with the exception of Africa, where restricted animal use of inactivated or live attenuated Smithburn vaccines is permitted (Kamal, 2011).

2.13.2 Knowledge and contact control

Restriction on contact and consumption of livestock products may be useful in reducing the rate at which the virus spreads from contaminated to uninfected areas (Paweska, 2014; Nielsen et al., 2020). Since animal cases of RVF typically occur before human cases do, public health authorities must have an ongoing system of animal health surveillance to spot any new cases and issue a warning. Implementing control measures to lessen the severe effects of RVF epidemics depends on the early detection of animal cases during an outbreak and the sharing of case information between the veterinary and public health sectors. For signaling heightened danger of RVF outbreaks, early warning systems and forecasting models that use satellite imagery and weather/climate prediction data are helpful (Anyamba et al., 2012).

To minimize human infection and mortality rates in the absence of a specialized therapy or vaccine it is important to increase public knowledge of the risk factors for infection with RVF and the preventive steps people can take to avoid mosquito bites (Swanepoel & Coetzer, 2004). The community should be trained how to avoid contact with blood or tissues from animals that may be infected with RVF can greatly lower one's risk of infection; this is especially important for those who interact with animals in places where RVF is endemic. When there is an RVF outbreak, more care should be taken and veterinarians and other cattle industry professionals should be made aware of the possible health dangers connected with handling or transporting ill animals' tissues and other zoonotic agents (Grossi-Soyster and LaBeaud, 2020).

The main goal of public health messaging should be to lower the possibility of animal-to-human transfer caused by careless methods used in the housing and killing of animals (Kimani et al., 2016; Kwaśnik et al., 2021). Wearing gloves and other suitable protective gear is important, as is exercising caution while working with diseased animals, their tissues, or during the killing of animals. All animal products (blood, meat, and milk) in the epizootic zones should be boiled or pasteurized before consumption (Grossi-Soyster and LaBeaud, 2020).

In affected areas, there should be a strong emphasis placed on the significance of protecting oneself and one's community by use of impregnated mosquito netting to prevent mosquito bites, applying personal insect repellent, dressing in light colors, long sleeves, and long pants, and avoiding outdoor activity, especially during mosquito biting peak hours (Bird et al., 2009).

2.13.2 Vector control

Control of adult mosquitoes and/or young mosquitoes (mostly larval control) are the main components of vector management programs for control of RVF transmission (Anyamba et al., 2010). Controlling adult mosquitoes can effectively eliminate them within a short period of time by taking into account their feeding and sleeping habits. Using ultra-low volume or thermal fogging (ULV) spraying to directly target flying or resting adults is one method of vector management; another is to target resting adults by barrier spraying artificial surfaces or plants (Anyamba et al., 2010).

Adult mosquito management can lessen the amount of progeny produced, which in turn reduces mosquito-host interactions and the risk of RVF transmission to people and animals (Anyamba et al., 2010). When larval mosquito treatment is applied before or after flooding, it lowers the adult emergence rate. Applying insecticide to aquatic habitats where mosquitoes breed can help control mosquito larvae. Larval control in regions that have flooded, like those that occur during epidemics of RVF, can be accomplished by using airplanes and helicopters to spray insecticides (Anyamba et al., 2010).

Reports regarding the usefulness of vector control on RVF transmission patterns are non-coherent (Anyamba et al., 2010). However, immature control products, also known as insect growth regulators (IGRs), such as methoprene in sustained release AltosidTM Pellets (Wellmark International, Schaumberg, IL), have proven to be successful in managing the Aedes and Culex vectors of RVF, even after being reintroduced into breeding grounds months before floods (Anyamba et al., 2010).

2.13.3 Movement control

Following the 2006 confirmation of an RVF epidemic in Kenya, the Department of Veterinary Services in Kenya put policies in place to stop the virus from spreading by limiting animal transportation, closing livestock markets, and outlawing the killing of animals (Gachohi et al., 2012). Vector and animal movements have been implicated as potential pathways of RVF introduction and transmission by risk assessments and associated techniques including pathway evaluation and ranking (Métras et al., 2011). There is genetic proof that the virus spreads from the mainland of East Africa to

Madagascar Island (Carrol et al., 2011) and throughout Africa (Bird et al., 2007). If animals are being transported from designated enzootic zones for various reasons, animal surveillance should be put in place.

2.13.4 Isolation Precaution

Despite the absence of proof supporting human-to-human transmission of RVF, healthcare personnel may still be exposed to the virus if they come into contact with infected blood or tissues from patients (Paweska, 2014). Healthcare professionals should carefully follow standard precautions when providing care to individuals who have confirmed or suspected RVF. Samples from suspected instances of RVF in humans and animals should be managed by individuals who possess the required training, and they should be processed in suitably equipped laboratories (Paweska, 2014).

2.13.5 RVF's Therapeutic Approach

Antiviral medication ribavirin was demonstrated to have therapeutic efficacy against RVF in mice, different cell cultures, hamsters, and rhesus monkeys. It was also recommended that ribavirin be taken in humans with benign RVF infections to prevent potentially dangerous sequelae (Javelle et al., 2020). However, ribavirin did not prevent patients in Saudi Arabia from developing encephalitis later on, and its usage is currently deemed contraindicated (Linthicum et al., 1983).

According to a study by Reed et al., mice given ribavirin treatment after being aerosol exposed to RVF were not protected against the virus and experienced significant neuropathology. The study's findings demonstrate the need for more candidate antivirals for the treatment of RVF infections and post-exposure prophylaxis, particularly in situations where an aerosol exposure may occur. Many novel antiviral medications are being studied (Narayanan et al., 2012; Scott, et al., 2012).

Currently there is no specific treatment available right now for Rift Valley Fever. In addition to symptomatic treatment, general supportive therapy is offered in cases deemed more severe (Wahl-Jensen et al., 2013). Until an RVF diagnosis is made, patients should receive broad-spectrum antibacterial and antiparasitic therapy due to the high prevalence of tick-borne rickettsial illness and malaria in Africa (Paweska, 2014). Strict barrier and isolation nursing should be used since critically sick patients have significant viremia. This is especially important in situations where intravenous transfusions of fresh frozen plasma, blood, and albumin are performed. Patients experiencing severe acute renal insufficiency might receive hemodialysis in addition to other critical care and supportive measures including mechanical breathing as needed (El Imam et al., 2009).

2.13.6 Integrated control

Using at least two control strategies in the best possible combination is termed as integrated disease control. Integrated control of Rift Valley fever was successfully implemented during the epidemics that occurred in Egypt along the Nile River in 1977–1979 (Chevalier et al., 2004). The RVF vaccination was given inactivated in more than 1.2 million doses as part of the extensive immunization and testing program that the Israeli government started in the Sinai Peninsula. All across the Gaza Strip and Sinai Peninsula, stringent vector control strategies were implemented concurrently with movement control, the elimination of diseased animals, and other measures. The successful prevention of RVF's northward spread into Israel was achieved by these coordinated efforts (Klopfer-Orgad et al., 1981).

2.14 Knowledge, attitudes and practices (KAP) on Rift Valley Fever

A KAP survey collects information in a specific population on what is known, believed and acted on in relation to a particular topic. “K” stands for Knowledge of the problem or disease, “A” for attitude towards the problem or disease, while “P” for preventive practices to protect against the problem or disease. Attitude assessment measures the feelings and beliefs of participants about the disease or health problem. Information on practices measures the preventive behavior an individual follow to avoid a problem or disease. The KAP studies are important in improving disease control. It is assumed that knowledge, attitude and practices are interconnected. Knowledge and attitude directly influence preventive practices. Protection measures undertaken against a disease are related to the person’s knowledge and beliefs (Stop TB Partnership (World Health Organization), 2008).

Knowledge on rift valley fever refers to the participants understanding of the disease cause, transmission, signs and symptoms in both human and animals. Attitude towards rift valley fever refers to participant’s feelings and beliefs about the disease as a public health problem. Practices are the preventive measures participants take in an attempt to avoid contacting rift valley fever. Despite its public health importance, few studies have been conducted to access rift valley fever awareness among communities.

A recent study in Nigeria revealed gaps in level of knowledge and practices regarding Rift Valley Fever among nomadic pastoralists (Alhaji et al., 2018). The results reported that 84.6% of respondents and 76.6% knew that high mortality in newborn calves and sudden onset of abortion in pregnant cows respectively as the major clinical signs in animals but very low proportion knew other signs. Only 23.7%

reported contact of aborted fetus as a mode of transmission to humans (Alhaji et al., 2018). Another study done in Sudan revealed that 82% of the participants did not know the mode of transmission and 70% could not identify the vector of RVF (Rehima et al., 2011).

In Zimbabwe, Ndengu et al. (2017) reported a low awareness on zoonoses focusing on Rift Valley Fever, Brucellosis and Leptospirosis. Only 11.5% of the respondents knew that RVF caused abortions in cattle. Interestingly, none of the respondents in this study reported knowledge of known human infections of any zoonotic disease and therefore there were no prevention measures known. Another study by Augustino et al. (2013) in Tanzania reported that participants had little knowledge about RVF. Knowledge on each clinical sign scored less than 50%. In a similar study by Shabani et al. (2015); only 8.8% of the respondents knew that mosquitoes were transmitting vectors of RVF. Other 73.7% mentioned unhealthy practices related to handling and consumption of dead animals. Further, 24.3% reported use of protective gears to handle dead or sick animals while 15.5% reported that they were consuming meat from dead animals (Shabani et al., 2015). A study done in Uganda revealed that 68% farmer, 79% herdsmen and 88% butchers thought they were at risk of contracting RVF. Less than 20% of the butchers used gloves when handling animals despite them reporting use of aprons and gumboots as personal protective equipment (Maurice et al., 2018).

A few studies have been done in Kenya on KAP regarding RVF. These studies concentrated among the pastoral communities where most cases of the disease were reported. Abdi et al. (2015) reported positive attitude towards RVF prevention among the study participants but identified gaps in knowledge and good practices. Only 11%

and 10% of the respondents knew abortion and high mortality in young animals respectively as major clinical signs of RVF. This study also revealed that only 4% of the respondents reported use of protection when handling sick animals. In another study by Affognon et al. (2017), despite having good knowledge (65.2%), participants still engaged in risky behaviors as majority did not use protection when handling sick animals or aborted fetuses. Mutua et al. (2017) also reported that the communities engaged in practices that would expose them to RVF in the event of an outbreak.

Health education interventions improves knowledge and attitude among the society. Improved knowledge enhances self-care practices. Improved attitude improves practices which at the end lead to improved health outcomes (Wan, 2014).

2.15 Outstanding gaps and Future Trends for Rift Valley Fever

There are now only a few approved RVF vaccinations available, and they are all intended for use in animals. These vaccinations, which are built on the premise of inactivated viruses, naturally weakened live virus, or classical live-attenuated virus, are, however, not entirely licensed in RVF non-endemic locations because of undesirable traits (Alhaj, 2016). Formalin-inactivated RVF vaccines are not recommended for use in nations where the virus is widespread because they require several doses to establish and sustain protective immunity. On the other hand, despite its effectiveness, the frequently used live attenuated vaccine, Smithburn, has been linked to pathologies associated with RVF, fetal abnormalities in pregnant animals, miscarriages, and in certain circumstances, mortality (Anthony et al., 2021).

Additionally, there is a chance that the Smithburn vaccine has the potential to cause genetic reassortment with wild-type RVF and a return to virulence (Ikegami, 2012). Although there has been a report that the second approved naturally attenuated live virus vaccine, Clone 13, can likewise induce fetal abnormalities when administered in excess to ewes who are pregnant during the first trimester. The vaccine has a considerably superior safety record than the Smithburn (Makoschey et al., 2016). Aside from Clone 13, the RVF vaccines that are currently licensed but do not meet the DIVA compatibility requirements, which makes them unsuitable for usage in places where RVF is not an endemic disease.

Due to the inadequacies of the veterinary and human RVF vaccines that are currently licensed, extensive research is being done to create safer vaccine candidates (Faburay et al., 2017). The development of vaccines has benefited enormously from advances in DNA technology, as well as a greater understanding of molecular biology of the RVF and the defense immune reactions that must be produced (Kitandwe et al., 2022). Live attenuated vaccines have excellent vaccination efficacy due to their strong protective immune responses that are induced after a single dose, despite their subpar safety. Hence, a key tactic in the development of safer RVF vaccinations, live attenuated has been the application of reverse genetics to get rid of or alter the genes causing virulence in wild-type and conventionally attenuated live RVF viruses (Faburay et al., 2017). It has been shown that these genetically altered live attenuated vaccines elicit strong protective immunological responses, frequently resembling those elicited by the Smithburn vaccine but with far fewer and far milder side effects (Faburay et al., 2017).

In mice and sheep, plasmid DNA vectors expressing either RVF Gn, its ectodomain, or both Gn and Gc have been demonstrated to elicit protective immunological responses (Chrun et al., 2019). Unfortunately, in order to generate and sustain protective immune responses, DNA vaccines typically need to be administered repeatedly via specialized delivery techniques like gene guns (Saade and Petrovsky, 2012). Although they are still in the early phases of development, novel methods including the utilization of enhancers of pharmacokinetics like elastin-like re-combinamers and microencapsulation are being investigated to increase the immunogenicity of DNA vaccines (Kitandwe et al., 2022).

Compared to the live attenuated vaccines, various vaccine platforms, including recombinant subunit proteins, replicon deficient virus replicons, and VLPs, have demonstrated improved features of safety while maintaining comparable immunogenicity and efficacy (Kitandwe et al., 2022). It is therefore justified that these candidate RVF vaccinations be advanced into field trials in order to get licensure. The stricter regulations for human vaccine licensure have contributed to the slower pace of progress in developing adequate human RVF vaccines as compared to veterinary RVF vaccines. The licensing of human vaccines requires efficacy trials, however, these may be impossible for the development of vaccinations against some diseases that are on the rise, such as RVF, whose prevalence is sporadic. As a result, in order to approve drugs and biologicals for marketing when research on human efficacy is impractical or unethical, the US Food and Drug Administration (FDA) created the Animal Rule in 2002. This opened up a new path for human RVF vaccination licensing (Kortekaas, 2014). The greatest method of preventing human RVF outbreaks is still to vaccinate animals, especially when combined with other strategies like vector control, as animal outbreaks frequently precede human outbreaks. Regardless of the possibility of human transmission, vaccination of animals would still be advantageous because it would save huge financial losses and livestock mortality, particularly for pastoral communities (Hopker et al., 2021).

The lack of the DIVA property, which renders the majority of commercially available RVF vaccines unfit for use in RVF nonendemic areas, is a significant drawback (Petrova et al., 2020). There are currently no commercially available diagnostic tests for Clone 13, the only DIVA-compatible vaccine that is available, that can utilize this characteristic (Petrova et al., 2020). Fortunately, the great majority of newly produced RVF vaccinations are DIVA compatible, meaning that they can be used in non-endemic or RVF-free countries for the purpose of control and eradication, as well as by those who export cattle products to these nations. The timely development of widely-accepted diagnostic assays need to coincide with the development of these innovative vaccinations (Petrova et al., 2020).

Because RVF outbreaks are frequently irregular, producing and storing vaccines against this zoonotic illness can be costly because of the biologicals generally limited shelf life. (Mahase, 2020). Additionally, as RVF is endemic in Sub-Saharan Africa, a region with low financial and technological resources for vaccine production, RVF vaccines have to be easily and affordably produced. Messenger RNA (mRNA) is a revolutionary vaccination platform that can be processed rapidly. It can be produced in the self-amplifying or standard non-amplifying formats. The first two licensed COVID-19 vaccines, which rank among the most effective to date, were created with this technology, demonstrating the value of mRNA in the quick manufacture of vaccines (Mahase, 2020).

RNA-dependent RNA polymerase (RdRP) of alphaviruses and self-amplifying RNA (saRNA), which encodes the mRNA sequence of the target antigen, have the potential to reduce the cost of mRNA vaccines (Bloom et al., 2021). In contrast to traditional mRNA vaccines, the RdRP gene permits saRNA to reproduce itself after it is introduced into the cell cytoplasm, enabling the application of reduced RNA concentrations. Although no saRNA vaccine has been given the go-ahead to be used, a number of them have participated in preclinical research; nevertheless, just around five have finished or are in the process of finishing clinical testing (Bloom et al., 2021).

Thermostability is another factor to take into account when developing new RVF vaccines. Since many Sub-Saharan countries lack reliable power supplies or have irregular supply, maintaining the cold chain is a significant challenge in this very relevant region, especially in rural regions. For the purpose of facilitating the effective distribution of RVF vaccinations in this area, investigation and creation of vaccines that are thermostable is also crucial. In this regard, thermostabilized vaccines for ChAdOx1 and Clone 13 RVF have been created, and work is still being done to generate similar vaccines for additional vaccine platforms including RNA (Stitz et al., 2017).

2.16 Conceptual framework

Conceptual framework is graphical presentation of the connectedness of the study variables (Green, 2014). Figure 2.1 reveals the relationship between demographics, knowledge, attitudes, practices and rift valley fever.

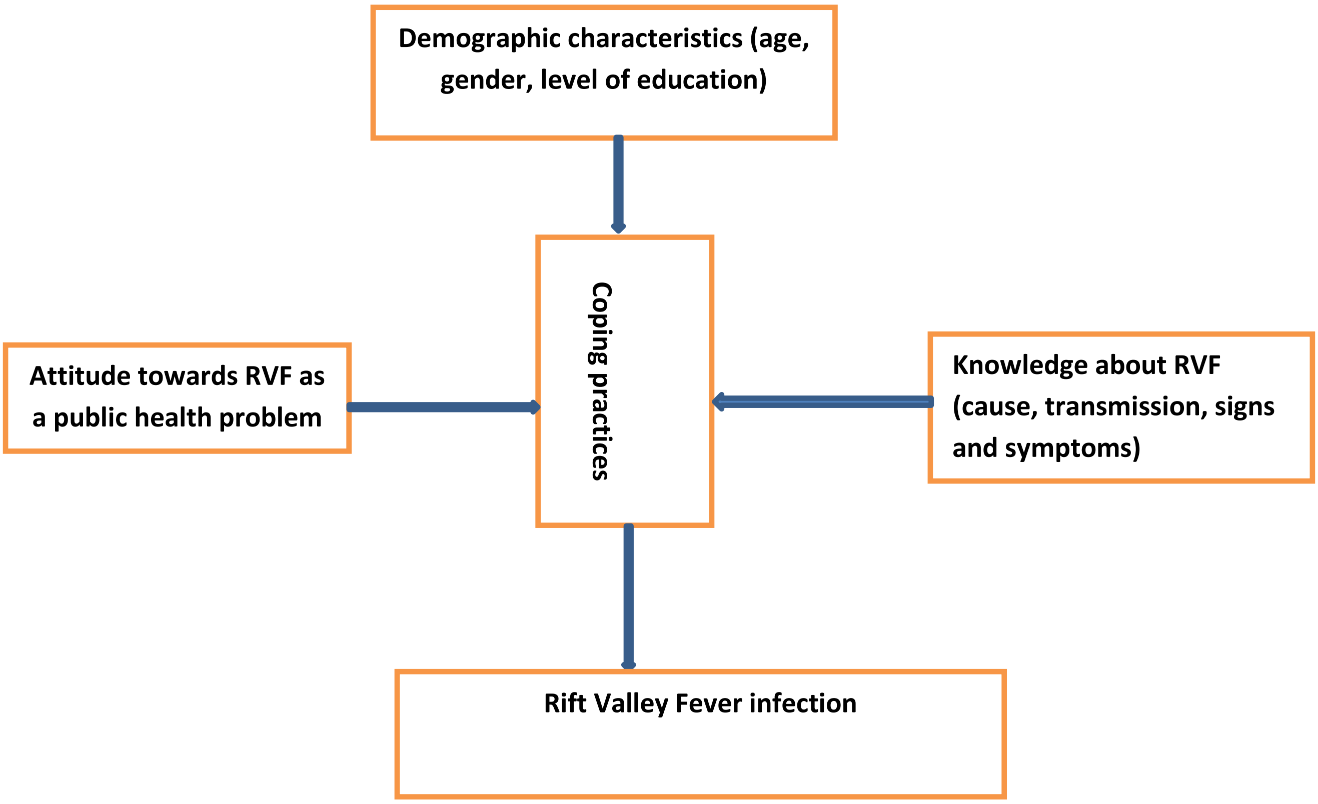


Figure 2.1: Conceptual framework indicating factors related to RVF prevention and control

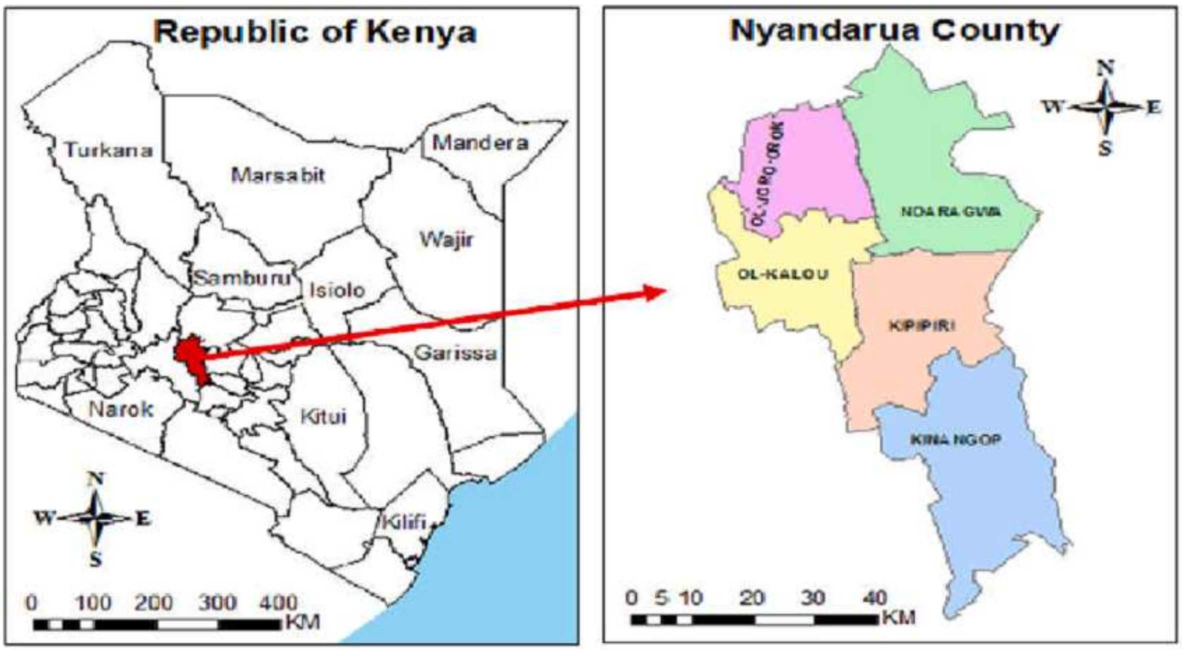
CHAPTER THREE: MATERIALS AND METHODS

3.1 Study area

The study was conducted in Nyandarua County. Geographically, it is bordered by Laikipia County to the north and north east, Nyeri County and Muranga County to the east, Kiambu County to the south and Nakuru County to the south west and west (MoALF, 2016). It is home to approximately 638,289 people (2019 census) covering an area of 3,108 KM^2 (Nyandarua, 2024). Administratively, the county is divided into 6 sub counties namely; Kipipiri, Ndaragwa, North kinagop, South Kinagop, Oljoro orok and Olkalou. The main economic activity is crop production and dairy farming (Nyandarua, 2024).

Dairy farming is a significant commercial activity in Nyandarua County with a substantial contribution to household incomes. The county's dairy sector is dominated by small holder farmers utilizing different production systems including intensive production (zero grazing), semi-intensive and open grazing systems. Crossbreeds mainly the Holstein-Friesian and Ayrshire are commonly raised for milk production.
The county has a temperature ranging between 2 ^{0}C during the cold months (June to July) and 25 ^{0}C during the hot months (January and February). It receives rainfall between 700mm and 1500mm annually. The region has two rainy seasons with the long rains falling between March-April while the short rains falling in November (MoALF, 2016).

Nyandarua County was chosen for this study because it had recently reported RVF outbreak for the first time in history (Wanjama *et al.*, 2022). The disease occurring in a non-endemic region during the dry period is untypical and can be due to the effect of climate change (Wanjama *et al.,* 2022).



Map showing the research study site area in Nyandarua County. Source: http://www.maphill.com/kenya/central/nyandarua/

3.2 Study design

This was a cross sectional study conducted between July 2020 and September 2020 in Nyandarua County.

3.3 Target population

The target population consisted of livestock farmers, 18 years and above, both male and females.

3.4 Sample size determination

The following formula was used to calculate the sample size (Cochran 1977)

$$n = \frac{Z^2 p(1-p)}{d^2}$$

Where n is the estimated sample size, Z is the Z-score at 95% confidence interval (1.96), P is the expected proportion of livestock farmers knowledgeable on RVF (38.5%) based on findings by (Abdi et al., 2015) and d is the margin of error set at

7%. This gave a total of 186 livestock farmers. However, the sample size was increased by 10% to account for non-response and hence 205 livestock farmers were sampled.

3.5 Sampling technique

Three sub-counties within Nyandarua County were purposively selected based on reports evaluated from the county veterinary department. The regions targeted had reported high rates of abortions and neonatal mortalities in animals. Further, laboratory investigations on samples collected from these animals had confirmed Rift valley fever disease outbreak. The regions selected included; Olkalou, Ndaragwa and Kipipiri Sub- counties. One ward from each sub-county was randomly selected giving a total of 3 wards. Five villages were then randomly selected from the 3 wards. Table 3.1 outlines the sample size allocation within the five villages.

Table 3.1*: Allocation of estimated sample of 205 participants distributed by sub-counties*

Sub county	**Ward**	**Village**	**Livestock farmers**	**Sample size allocation**	**N**
Olkalou	Rurii	Mukindu	875	(875/3591)×205	50
		Mugathika/Gikumbo	499	(499/3591)×205	28
Kipipiri	Wanjohi	Mishore	639	(639/3591)×205	36
		Ndemi	860	(860/3591)×205	49
Ndaragwa	Shamata	Kirima	718	(718/3591)×205	42
		Total	**3591**		**205**

Source: (KNBS 2019)

Systematic sampling was applied to identify the households to be enrolled in the study. A starting household in each village was randomly selected and subsequent households were identified at a sampling interval of 18, calculated as; k=N/n where k is the systematic sampling interval, N is the population size (3591) and n (205) is the sample size.

Household heads were interviewed. Participation in the study was voluntary and a written consent was sought from study participants before commencing the research activities.

3.6 Data collection

Before data collection, a research assistant was trained by the principal investigator on the purpose and procedures of data collection in the study.

3.6.1 Knowledge, attitude and practices

An interviewer administered questionnaire was used to record data. Information gathered included; demographic characteristics (age, sex, level of education, occupation, marital status, herd size), knowledge (vector spreading RVF, signs and symptoms in animals and humans, mode of transmission in humans and domestic animals) and attitudes towards rift valley fever (perceived seriousness and risk of contracting RVF) and prevention practices against RVF (handling of sick and dead animals, avoiding mosquito bites).

3.6.2 Assessment of knowledge on RVF

Participant's knowledge about RVF was assessed using 8 questions that consisted of general knowledge about RVF. Question 1, 2, 3, 5 and 7 had a value of 1 or 0 (1 for a correct response and 0 for incorrect or don't know response). However, the value of question 4, 6 and 8 depends on the number of choices correctly chosen. In these questions, multiple responses were allowed. For a correctly chosen choice a score of 1 was awarded and 0 was awarded for an incorrect or don't know the answer. The cumulative score of the responses in question 4, 6 and 8 was then determined for each participant. The sum of scores for all the 8 questions on the knowledge section ranged from 0 to a maximum of 24 points. The sum of scores obtained by each participant was transformed into percentage score. Participants overall level of knowledge was categorized using Blooms cut off point; low knowledge (less than 60%; 0-14 points), moderate knowledge (60-80%; 15-19 points) and high knowledge (80-100%; 20-24 points).

3.6.3 Assessment of practices related to RVF prevention

Questions were asked concerning precautionary measures taken against RVF. A score of 1 was given for a correct practice and 0 for a wrong practice. Sums of scores were then obtained and transformed into percentages. These were dichotomized into “bad” and “good” practices; a person was classified to have good practice if he/she obtained a score of 50% and above on the sum of scores and of bad practice if below 50%.

3.6.4 Assessment of attitude and perceived risk of RVF

Participants’ attitude and perceived risk towards RVF was assessed using 7 questions. Responses towards the questions were graded on a five-point likert scale system as: “Strongly agree”; “Agree”, “Don’t know”; “Disagree”; “Strongly disagree”. Numerical scores of 5,4,3,2 and 1 were given to categories “Strongly agree”; “Agree”, “Don’t know”; “Disagree” and “Strongly disagree” respectively. A sum of scores was obtained and transformed into percentages. Overall level of attitude was categorized using Blooms cut off point as positive attitude (80-100%), neutral attitude (60-80%), and negative attitude (less than 60%).

3.6.5 Collection of economics data

To estimate the economic cost of Rift Valley Fever in the study area, a questionnaire was designed to generate data on two components: loss of production (mortality, abortions, milk production) and cost of control.

- Losses due to mortality were estimated as: The number of dead animals in infected farms × slaughter value of an animal
- Losses due to abortion were computed as: The number of abortions × the value of an animal at birth. Dairy farmers have a common practice of disposing off bull calves at birth and hence their selling price was used to estimate the value of a newborn calf among the community members.
- Milk production losses were computed as: (Actual milk production before the outbreak × the value of the milk) - (Average milk production during the outbreak × Value of the milk). The price of milk per liter remained constant before and during the outbreak.
- Cost of control (vaccine cost) was computed as: Number of animals vaccinated × Price of one unit the vaccine)

The economic impact at the farm level was determined as the combined loss of production and the cost of control.

3.7 Pilot study

A pilot study was carried out using 10% of the calculated sample size (n=21) at Ol' Kalou ward within Ol'Kalou Sub-County. The pilot study helped in testing the validity of the questionnaire and estimated the interview time. All the necessary amendments were carried out on the data collection plan before conducting the main study.

3.8 Data management processing and analysis

At the end of each day of data collection, the principal investigator reviewed all the questionnaires to ensure that all variables were filled correctly. Data was entered and cleaned in Microsoft excel and imported to Statistical Package for Social Scientists (SPSS) software for statistical analysis. Descriptive statistics was used to summarize data using frequency tables, bar graphs, pie charts and mean where applicable. The relationship between demographic factors and communities' knowledge, attitude and practices regarding RVF was estimated using a multiple linear regression.

3.9 Ethical Consideration

The study commenced after approval was granted to conduct the study by the institutional research ethical committee of Moi University (IREC) under reference-IREC/2020/31, approval number 0003613. The study got authorization to collect data from the Ministry of Agriculture, Livestock and Fisheries of Nyandarua County. The objectives of the study were explained to the study participants and written consent sort before commencing the interviews. Data was handled in a confidential manner. No names were filled in the forms. Only the researcher was allowed access to the information.

CHAPTER FOUR: RESULTS

4.1 Introduction

In this study, 205 participants were interviewed during data collection and 9 questionnaires were dropped from the study due to incompleteness. Therefore, a total of 196 questionnaires, a response rate of 95.6% passed for analysis.

4.2 Social demographic characteristics of the study participants

4.2.1 Distribution of the study participants by gender

Out of 196 study participants, 43.4% were male while 56.6% were females (Table 4.1).

Table 4.1: Distribution of study participants by gender

Gender	Frequency	Percentage
Male	85	43.4%
Female	111	56.6%

4.2.2 Distribution of the study participants by age group

Majority of the participants (33.7%) were above 60 years, 23% were between 40-49 years, 20.4% were between 30-39 years, 17.9% were between 50-59 years while 5.1% were between 18-29 years (Figure 4.1).

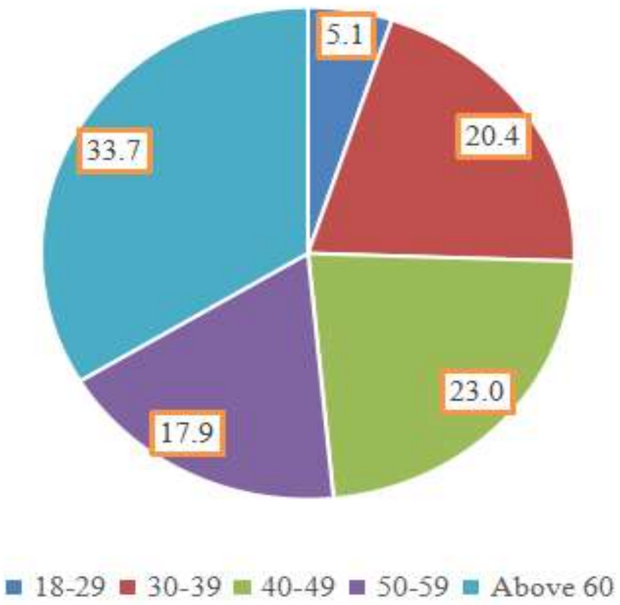


Figure 4.1: Distribution of study participants by age

4.2.3 Distribution of study participants by place of residence

The findings indicated that 50% of the respondents were from Olkalou Sub County, 31.1% were from Ndaragwa Sub County while 18.9% were from Kipipiri Sub County (Table 4.2).

Table 4.2: Distribution of study participants by place of residence

Sub-County	Frequency	Percentage
Kipipiri	37	18.9%
Olkalou	98	50.0%
Ndaragwa	61	31.1%

4.2.4 Characterization of study participants by level of education

Majority of the respondents 62.8% had completed primary education, 17.3% had completed secondary education, 7.7% had completed tertiary education while 12.2% had not gone to school (Figure 4.2).

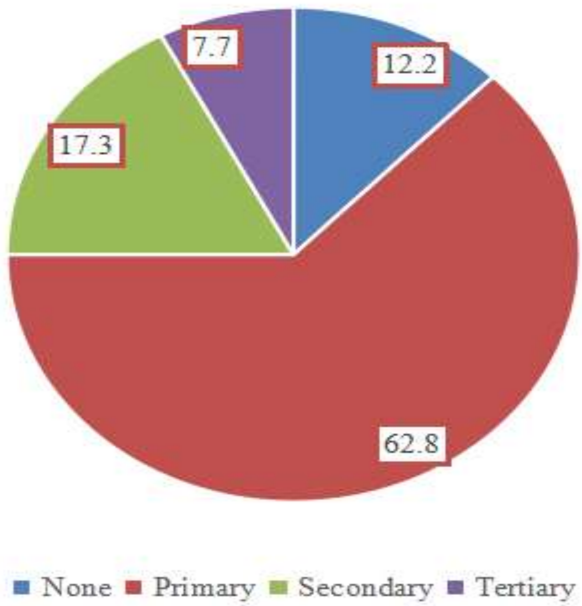


Figure 4.2: Distribution of study participants by the level of education

4.2.5 Characterization of study participants by occupation

Majority of study participants (95.9%) were self-employed with livestock keeping and crop production as their main economic activity. Only 3.6% were employed. One respondent (0.5%) was a student (Table 4.3).

Table 4.3: Distribution of study participants by occupation

Occupation	Frequency	Percentage
Employed	7	3.6%
Self employed	188	95.9%
Others	1	0.5%

4.2.6 Characterization of study participants by marital status

As the result revealed, 78.1% of the respondents were married, 13.3% were either widowed or divorced while 8.7% were single.

4.2.7 Livestock ownership by study participants

Out of the participants that were interviewed, 96.4% owned cattle, 69.4% owned sheep and only 13.8% owned goats. Further, 12.2% participants kept both cattle, sheep and goats.

4.3 Knowledge of Rift Valley Fever

4.3.1 Respondents who knew about RVF disease

Out of 196 study participants, 60.7% knew about rift valley fever disease (Table 4.4).

Table 4.4: Participant's knowledge of RVF disease

Knowledge of RVF disease	Frequency	Percentage
No	77	39.3%
Yes	119	60.7%

4.3.2 Sources of information

Majority (46.2%) of the respondents had heard about the disease from neighbors and friends, 28.6% from veterinary officials, 15.1% from the radio, 5% from the TV, 3.4% from posters/brochures while 1.7 % from medical officials.

4.3.3 Knowledge on RVF transmitting vector

Majority (94%) of the respondents did not know the cause of Rift Valley Fever disease (Table 4.5). Only 6.1% knew mosquitoes as the vector that transmits the disease. Further, 4.1% thought that the disease was bacteria related, while 3.1% and 2.6% mentioned ticks and tsetse flies as the vectors of the disease, respectively (Table 4.5).

Table 4.5: Participants knowledge about Rift Valley Fever transmitting vector

Vectors	Frequency	Percent
Mosquitoes	12	6.1
Tsetse fly	5	2.6
Ticks	6	3.1
Bacteria	8	4.1
Unknown	165	84.2
Total	196	100.0

4.3.4 Knowledge on RVF symptoms

Majority of the respondents did not know the signs and symptoms of Rift Valley Fever in animals (Table 4.6). Only 20.9% mentioned abortions, 9.2% anorexia, 8.2% diarrhea and 2.6% high fever. None of the respondent knew neonatal mortality as a sign of rift valley fever disease in animals. Additionally, 14.3% mentioned incorrect signs such as skin nodules and red eyes (Table 4.6).

Table 4.6: Knowledge on animal symptoms

Symptom		Frequency	Percentage
High fever	No	191	97.4%
	Yes	5	2.6%
Anorexia	No	178	90.8%
	Yes	18	9.2%
Neonatal mortality	No	196	100.0%
	Yes	0	0.0%
Abortion	No	155	79.1%
	Yes	41	20.9%
Nasal discharge	No	195	99.5%
	Yes	1	0.5%
Diarrhoea	No	180	91.8%
	Yes	16	8.2%
Other signs	No	168	85.7%
	Yes	28	14.3%

4.3.5 Knowledge on human symptoms

Majority (90.8%) of the respondents did not know the sign and symptoms of RVF in humans (Table 4.7). They were not aware that the disease was zoonotic. Few participants (5.6%) mentioned joint and muscle pain, 4.6% fever, 4.1% headache, 2% diarrhoea while other signs were mentioned by less than 1% of participants. Further, 2 respondents mentioned that they had recently been diagnosed with RVF disease in a nearby health center (Table 4.7).

Table 4.7: Participant's Knowledge of human symptoms

Symptoms	Knowledge	Frequency	Percentage
Fever	No	187	95.4%
	Yes	9	4.6%
Headache	No	188	95.9%
	Yes	8	4.1%
Muscle/joint pain	No	185	94.4%
	Yes	11	5.6%
Blurred vision	No	196	100.0%
	Yes	0	0.0%
Bleeding	No	195	99.5%
	Yes	1	0.5%
Diarrhoea	No	192	98.0%
	Yes	4	2.0%
Jaundice	No	195	99.5%
	Yes	1	0.5%
Coughing	No	195	99.5%
	Yes	1	0.5%
Chills	No	191	97.4%
	Yes	5	2.6%
Vomiting	No	192	98.0%
	Yes	4	2.0%

4.3.6 Knowledge on transmission

Most common (9.2%) mode of transmission mentioned was through drinking raw milk (Table 4.8). This was followed by eating meat from infected animals (8.2%), touching aborted fetuses (4.6%), touching infected body fluids (1.5%) and through mosquito bites (1%) (Table 4.8).

Table 4.8: Participant's knowledge of RVF disease transmission

Transmission	Knowledge	Frequency	Percentage
Mosquitoe bite	No	194	99.0%
	Yes	2	1.0%
Touching aborted fetus	No	187	95.4%
	Yes	9	4.6%
Touching infected body fluids	No	193	98.5%
	Yes	3	1.5%
Meat from infected animals	No	180	91.8%
	Yes	16	8.2%
Drinking raw milk	No	178	90.8%
	Yes	18	9.2%

4.3.7 Knowledge score about RVF

Out of a maximum score of 24 points on RVF knowledge, sum of scores of study participants ranged from 0-14 (0-58.3%) with a mean score of 8.8% (Table 4.9). Further, 35.7 % of the respondents scored 0%. Under blooms cut off, the respondents had low level knowledge on RVF at score less than 60% (Table 4.9).

Table 4.9: Overall knowledge based on bloom's cutoff point

Knowledge level	Frequency	Percentage
Low level knowledge	196	100.0%
moderate level knowledge	0	0.0%
High level knowledge	0	0.0%

4.3.8 Factors associated with knowledge of Rift Valley Fever

The study investigated the association between socio-demographics and knowledge. The dependent variable, mean score on knowledge was regressed on predicting variables of age, gender, occupation, marital status, place of residences, livestock ownership and history of RVF outbreak. Each coefficient was assessed to ascertain the influence on the mean score on knowledge about RVF. Factors with p value < 0.05 were considered significant.

The study revealed that significant factors associated with knowledge about RVF were marital status, age, cattle ownership and whether the participant experienced RVF outbreak (Table 4.10). Single participants had an average knowledge score that was 7.04 points lower than widowed/divorced participants (B = -7.04, p = 0.039), and each one-unit increase in age was associated with a 5.75 point decrease in knowledge score ($B = -5.75$, $p = 0.01$). Additionally, cattle owners had a higher knowledge score by 0.657 points compared to non-owners ($B = 0.657$, $p = 0.02$), and those who had experienced an RVF outbreak on their farms were 8.432 points more knowledgeable than those without such experience, a difference that was highly statistically significant ($p < 0.000$). These findings suggest that marital status, age, cattle ownership, and direct experience with RVF significantly impact knowledge levels, highlighting the need for targeted educational interventions and tailored communication strategies to address these disparities. (Table 4.10). These results suggest further that direct experience with RVF, either through cattle ownership or dealing with an outbreak, enhances knowledge about the disease. This underscores the importance of practical exposure and direct involvement in livestock farming as critical factors in increasing awareness and understanding of RVF. Public health strategies should consider leveraging the experiences of those directly affected by RVF to educate and inform broader populations who may be less aware.

Table 4.10: Factors associated with Knowledge of RVF

Coefficients[a]

Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	-2.211	5.679		-.389	.697
	Gender	-1.864	1.479	-.084	-1.261	.209
	Single	-7.038	3.392	-.180	-2.075	.039
	Married	.611	2.338	.023	.262	.794
	Occupation	6.909	3.977	.125	1.737	.084
	Kipipiri	1.391	2.153	.050	.646	.519
	Olkalou	1.047	1.632	.048	.642	.522
	Old	-5.752	1.782	-.228	-3.227	.001
	Primary	1.777	2.452	.078	.725	.470
	Secondary	-.789	2.956	-.027	-.267	.790
	Tertiary	6.994	3.653	.169	1.915	.057
	Experienced RVF oubreak recently	8.432	1.466	.375	5.751	.000
	Number of Cattle	.657	.212	.244	3.099	.002
	Number of sheep	-.030	.084	-.025	-.358	.721
	Number of goats	-.163	.458	-.026	-.355	.723

a. Dependent Variable: Mean scores on knowledge

4.4 Attitude and perceived risk of Rift valley fever

4.4.1 Attitude on the seriousness of RVF disease

Majority (41.8%) of the respondents did not know that Rift Valley Fever is a dangerous disease with a public health importance (Figure 4.3). Moreso, 37.2% and 18.9% of the respondents strongly agreed and agreed that the disease is dangerous, respectively. One of them mentioned that the disease is dangerous due to the huge animal mortality it causes. However, 1% of the respondents strongly disagreed and 1% others disagreed that the disease is dangerous (Figure 4.3).

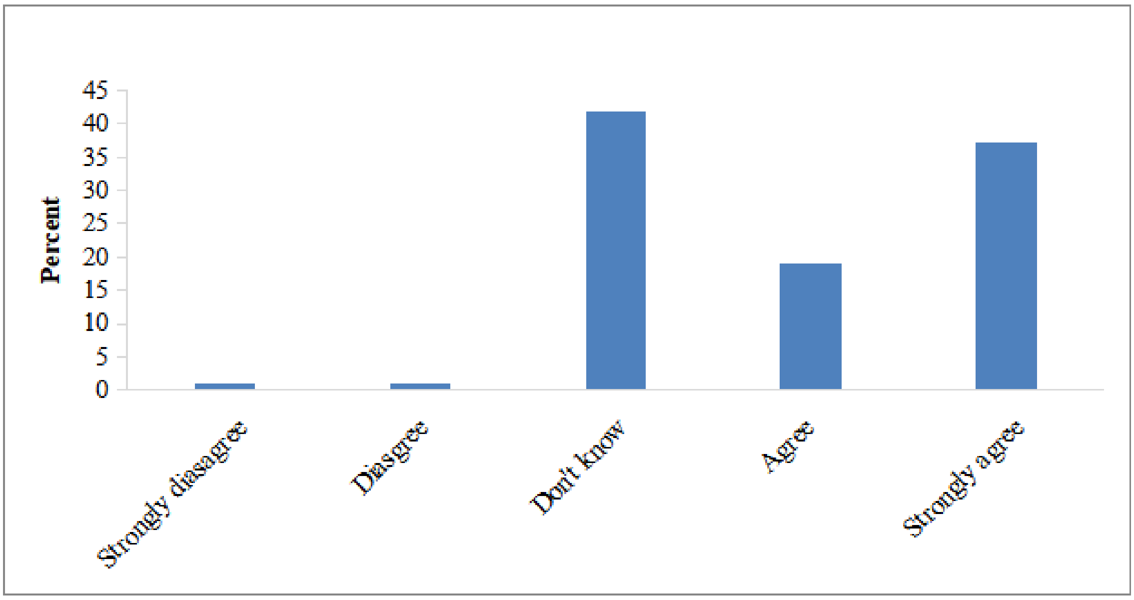


Figure 4.3: Participants' attitude on the danger of Rift Valley Fever

4.4.2 Attitude about the risk of contracting Rift Valley Fever

Majority of the respondents (60.7%) did not know that they were at risk of contracting RVF disease when working closely with animals (Figure 4.4). Only 19.4% agreed and 10.7% strongly agreed that they were at risk of contracting RVF. Further, 4.1% strongly disagreed while 5.1% disagreed that they were at risk of contracting the disease. One respondent reported that she could not contract the disease because RVF is an animal disease. Another respondent mentioned that she could not believe a cow can make her sick (Figure 4.4).

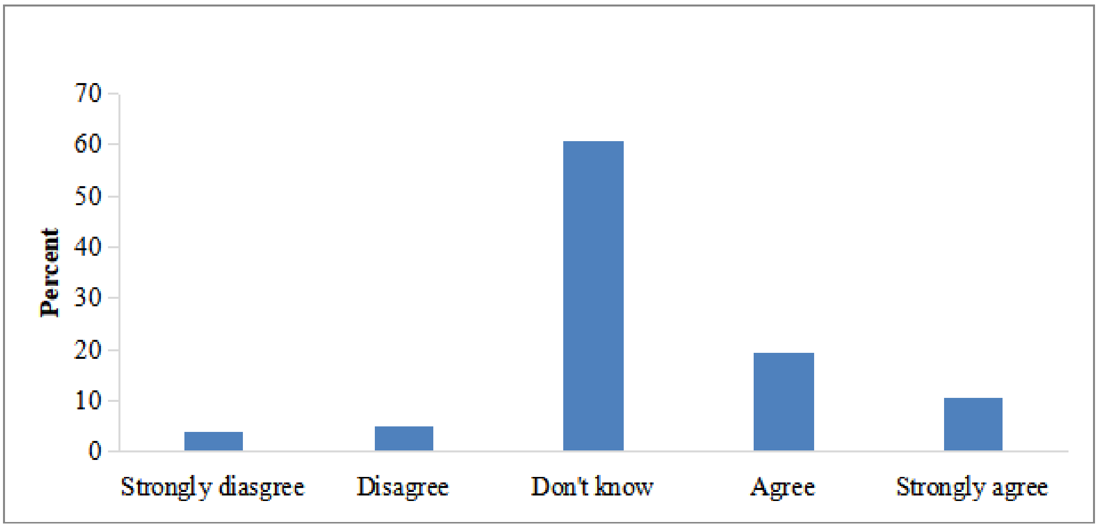


Figure 4.4: Participants attitude on the risk of contracting Rift Valley Fever

4.4.3 Attitude on the curability of RVF

Majority of the respondents 146 (74.5%) mentioned that they did not know if RVF was curable. 35 (17.9%) respondents agreed while 7 (3.6%) strongly agreed that there was a cure for RVF. Only 4(2%) strongly disagreed and other 4(2%) disagreed that there was a cure for RVF. 3 respondents mentioned that there were no medicines to treat RVF in humans. Another respondent mentioned that only first aid help was available for RVF treatment. One respondent added that the disease could only be curable if special medicines to treat it were developed.

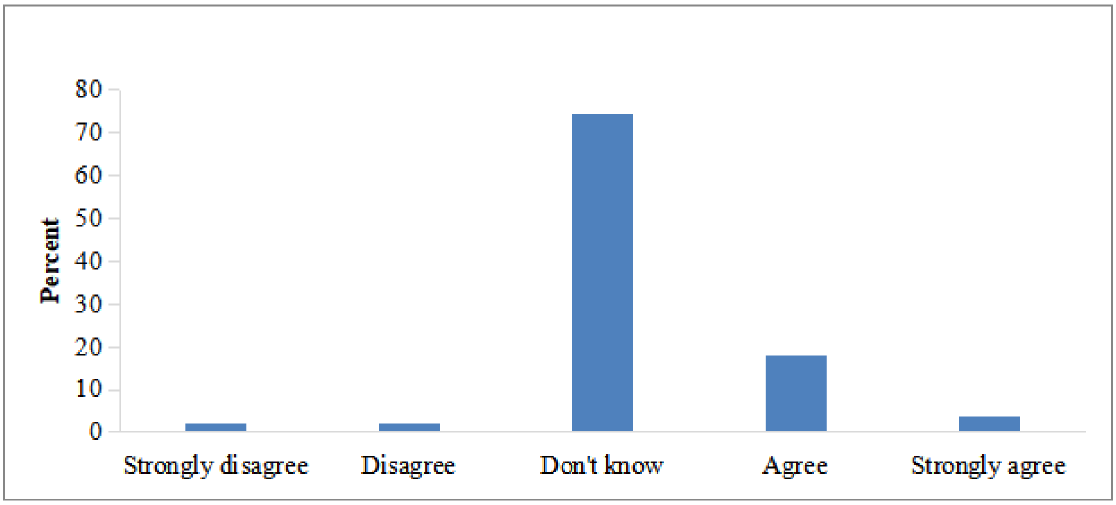


Figure 4.5: Participant's attitude on the curability of Rift Valley Fever

4.4.4 Attitude about RVF prevention

When asked if the disease transmission from animals to human was preventable, majority (66.8%) did not know (Figure 4.6). Only 25% agreed and 2.6% strongly agreed. Further, 3.6% strongly disagreed while 2% disagreed. Additionally, 2 respondents mentioned that they were always in contact with animals through milking, feeding and general care, hence they believed it was impossible to prevent contracting the disease from animals. One responded mentioned that if taught how to prevent contracting the disease then they would apply the measures to protect himself (Figure 4.6).

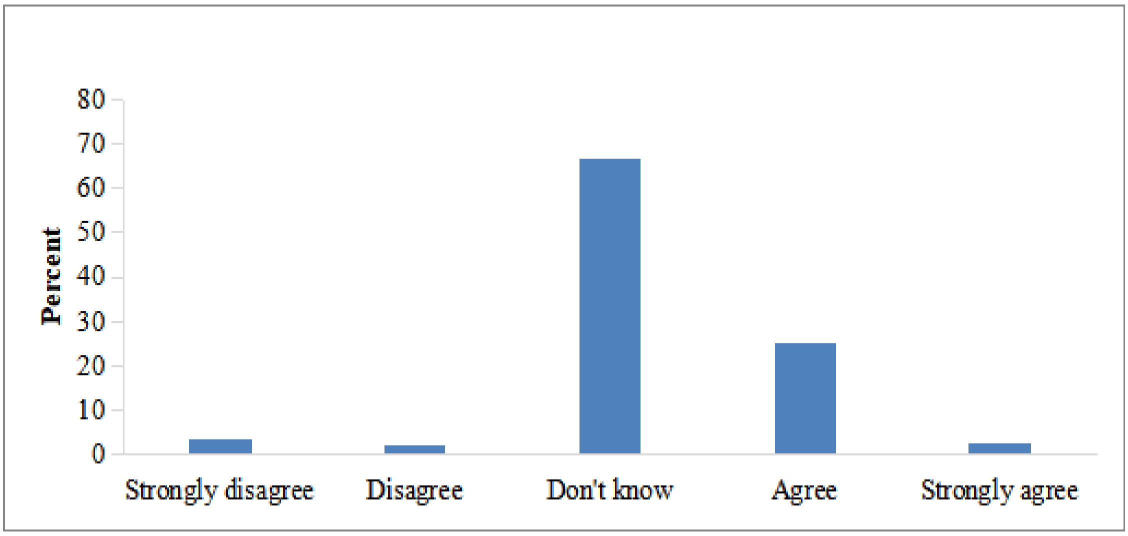


Figure 4.6: Participants attitude on the prevention of RVF transmission from animals to humans

4.4.5 Attitude about animal vaccination as a preventive measure of RVF

Majority of the respondents (57.7%) were not aware that the disease could be prevented by vaccinating animals (Figure 4.7). However, 34.2% agreed while 6.1% strongly agreed that the disease could be prevented by vaccinating animals. Further, 1% strongly disagreed and 1% disagreed that the disease could be prevented by vaccinating animals (Figure 4.7).

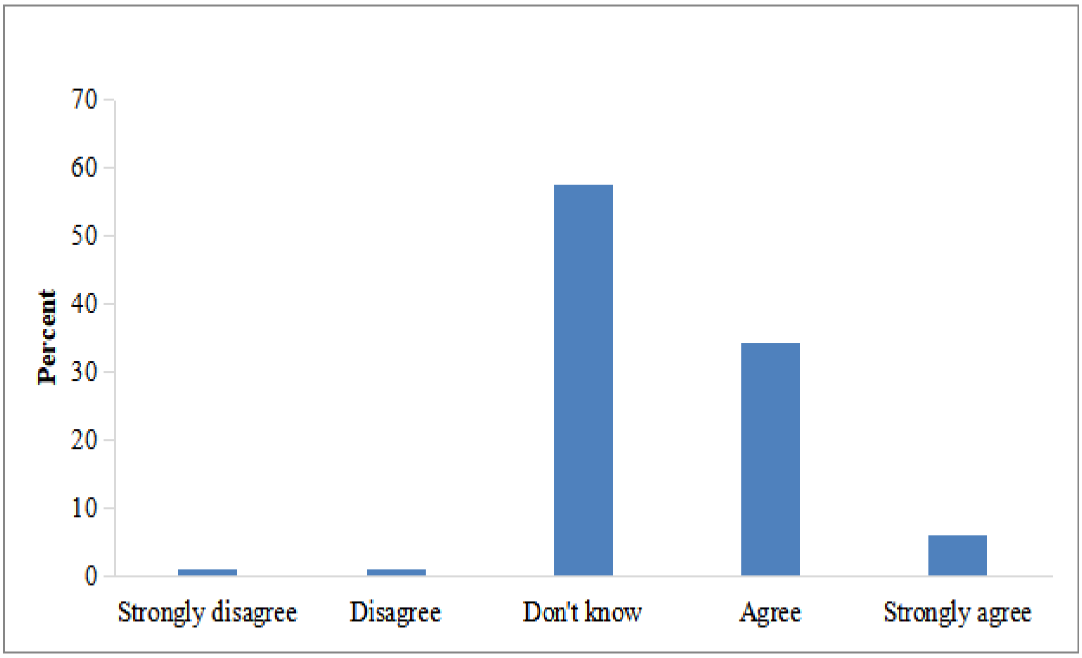


Figure 4.7: Participants attitude on RVF prevention by vaccinating animals

4.4.6 Attitude on the need to quarantine animals with RVF

Majority of the respondents (51%) did not know that there was need to quarantine animals with RVF (Figure 4.8). Moreso, 33.2% agreed while 9.7% strongly agreed that there was need to quarantine animals with RVF. The finding indicated that 4.1% strongly disagreed while 2% disagreed that there was need to quarantine animals with RVF (Figure 4.8). One of the respondent mentioned that the disease spreads like wind hence quarantine had no use in the control.

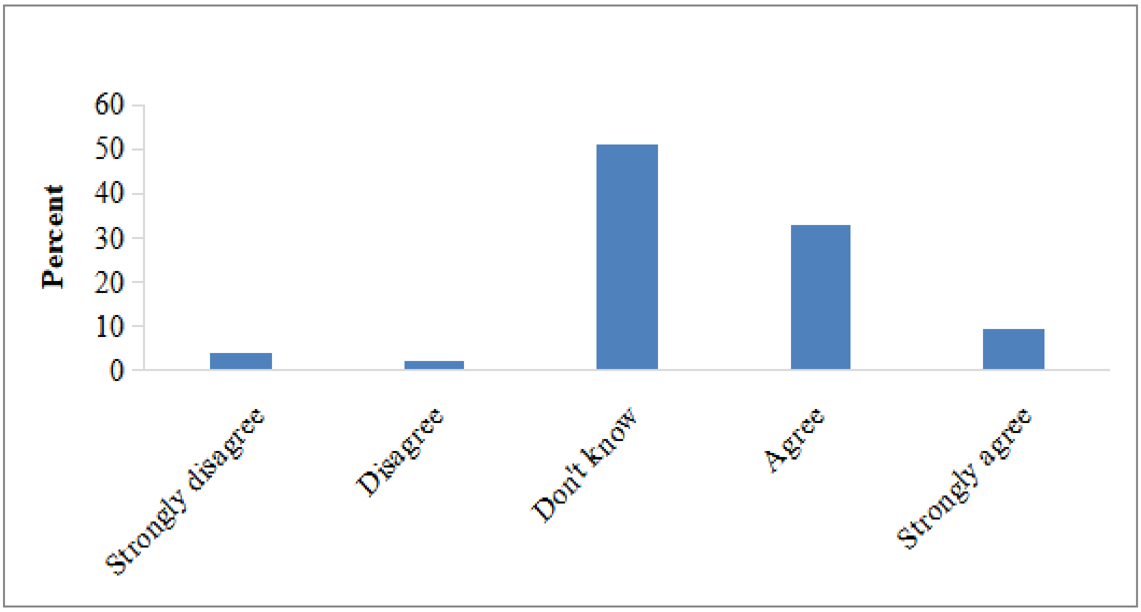


Figure 4.8: Participants attitude on need to quarantine animals with Rift Valley Fever

4.4.7 Health facilities ability to handle RVF outbreaks

When asked if the health facilities within the region could effectively handle RVF outbreaks, majority (59.7%) did not know (Figure 4.9). Additionally, 25% agreed while 2% strongly agreed that the health facilities could effectively handle RVF outbreaks. Findings indicated that 7.1% of the respondents disagreed while 6.1% strongly disagreed that the health facilities could effectively handle RVF outbreaks (Figure 4.9). Some of the reasons given were that the doctors within the facilities were few and that there were no medicines within the health facilities. However, one respondent strongly agreed that the health facilities could handle the outbreak as he had been diagnosed with the disease and received treatment at a nearby health facility.

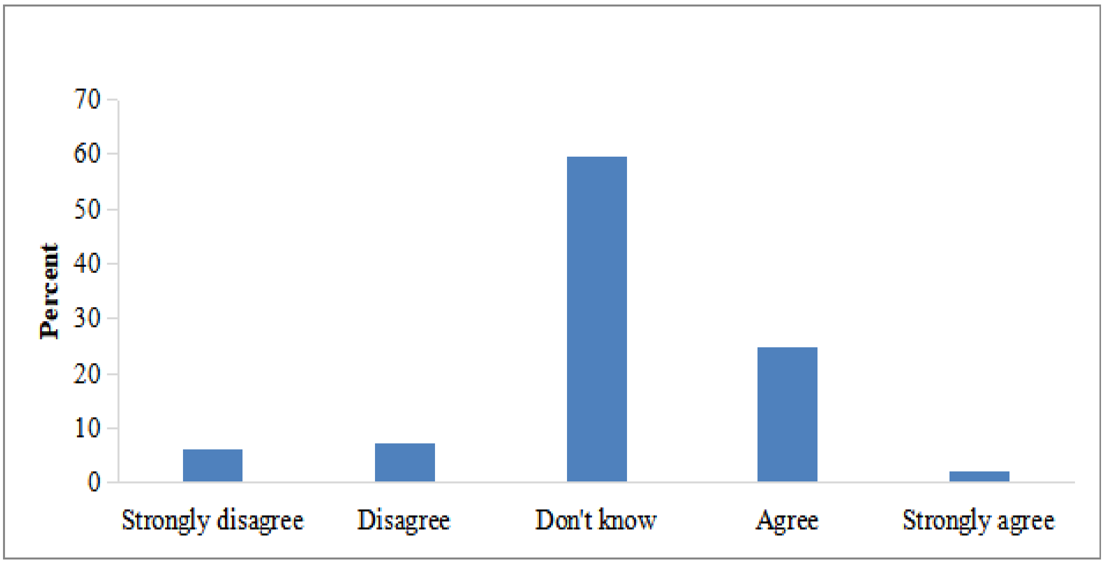


Figure 4.9: Participants attitude on the ability of health facilities to handle Rift Valley Fever outbreaks

4.4.8 Overall attitude and perceived risk of RVF

Out of maximum total score of 35 points, participants total score ranged from a minimum of 9 to a maximum of 31 with a mean score of 23.15 (Table 4.11). Only 6.6% of the respondents had a positive attitude (score between 80-100%), 48.5% had a neutral attitude (score between 60-80%) while `44.9% had a negative attitude (score less than 60%) (Table 4.11).

Table 4.11: Overall attitude and perceived risk of Rift Valley Fever

Attitude	Frequency	Percentage
Negative attitude	88	44.9%
Neutral attitude	95	48.5%
Positive attitude	13	6.6%

4.4.9 Factors associated with attitude about RVF disease

Multiple linear regression analysis was conducted to identify factors associated with attitudes towards Rift Valley Fever (RVF). The independent variables assessed included age, gender, occupation, marital status, place of residence, livestock ownership, and history of RVF outbreaks. Factors with p value < 0.05 were considered significant. Significant factors influencing attitudes towards RVF were place of residence, age, and whether the participant had experienced an RVF outbreak on their farm. There were notable differences in attitudes between regions. Participants from Kipipiri had a significantly better attitude towards RVF, with an attitude score 3.72 points higher than those from Ndaragwa (B = 3.739, p = 0.016). Similarly, residents of Olkalou had a 2.739 points better attitude score compared to those from Ndaragwa (B = 2.739, p = 0.02). Experiencing an RVF outbreak on their farms had a highly significant positive impact on participants' attitudes, with those having experienced an outbreak scoring 4.36 points higher on attitude (B = 4.36, p = 0.000). Thus, participants with prior experience of an RVF outbreak had an attitude score 4.435 points higher than those without such experience.

Table 4.12: Factors associated with attitude about RVF

Coefficients[a]

Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	63.098	4.043		15.605	.000
	Gender	-1.652	1.053	-.109	-1.569	.118
	Single	-1.661	2.415	-.062	-.688	.492
	Married	1.815	1.665	.100	1.090	.277
	Occupation	-1.483	2.832	-.039	-.524	.601
	Kipipiri	3.739	1.533	.195	2.440	.016
	Olkalou	2.739	1.162	.183	2.357	.020
	Old	-2.536	1.269	-.148	-1.998	.047
	Primary	.273	1.746	.018	.156	.876
	Secondary	-1.227	2.105	-.062	-.583	.561
	Tertiary	2.589	2.601	.092	.995	.321
	Experienced RVF outbreak recently	4.435	1.044	.289	4.249	.000
	Number of Cattle	.281	.151	.153	1.863	.064
	Number of sheep	.011	.060	.014	.191	.849
	Number of goats	-.289	.326	-.068	-.887	.376

a. Dependent Variable: mean attitude score

4.5 Practices related to RVF prevention

4.5.1 Presence of mosquitoes

Almost all the respondents 192 (98%) reported presence of mosquitoes within the homestead.

4.5.2 Protection from mosquito bites

When asked how they protect themselves from mosquito bites, 36.7% of the respondents reported that they had no form of protection against mosquito bites, 41.8% reported that they used mosquito bed nets, 13.3% use repellants, 7.1% rely on clothing, 7.7% rely on drainage of stagnant water while 11(5.6%) clear bushes around the homestead (Figure 4.10).

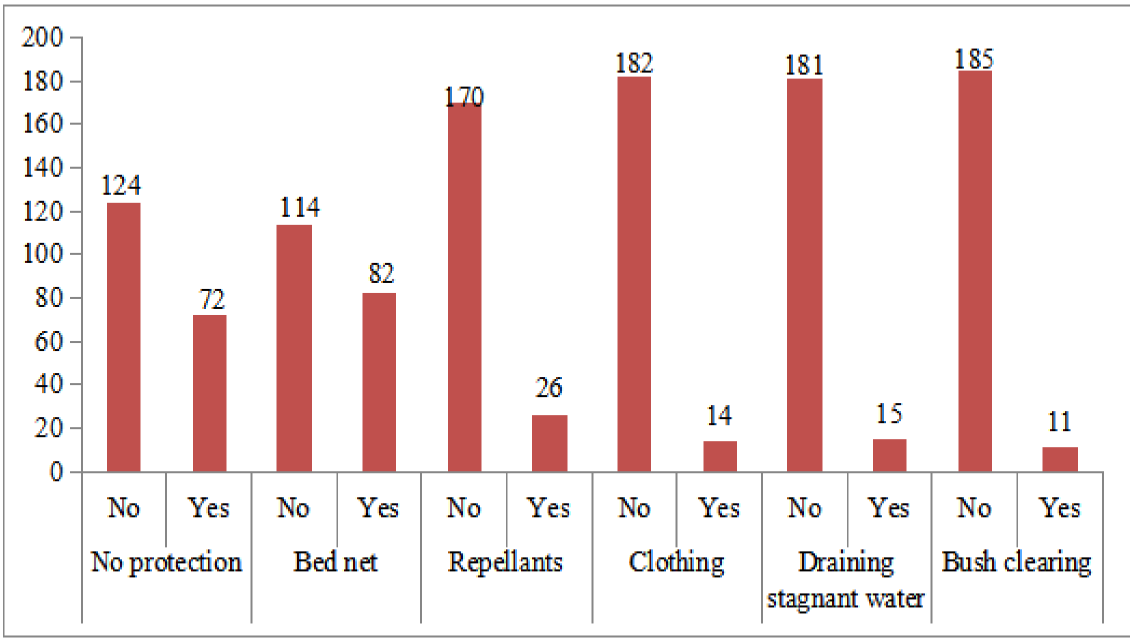


Figure 4.10: Protection from mosquito bites

4.5.3 Handling of sick animals

Majority of the respondents (98%) reported that they left sick animals and called a veterinarian to attend to them (Figure 4.11). However, 17.9% mentioned that they bought drugs from agrovets and use them to treat sick animals. Only 3.6% mentioned that they used traditional medicines to treat sick animals (Figure 4.11).

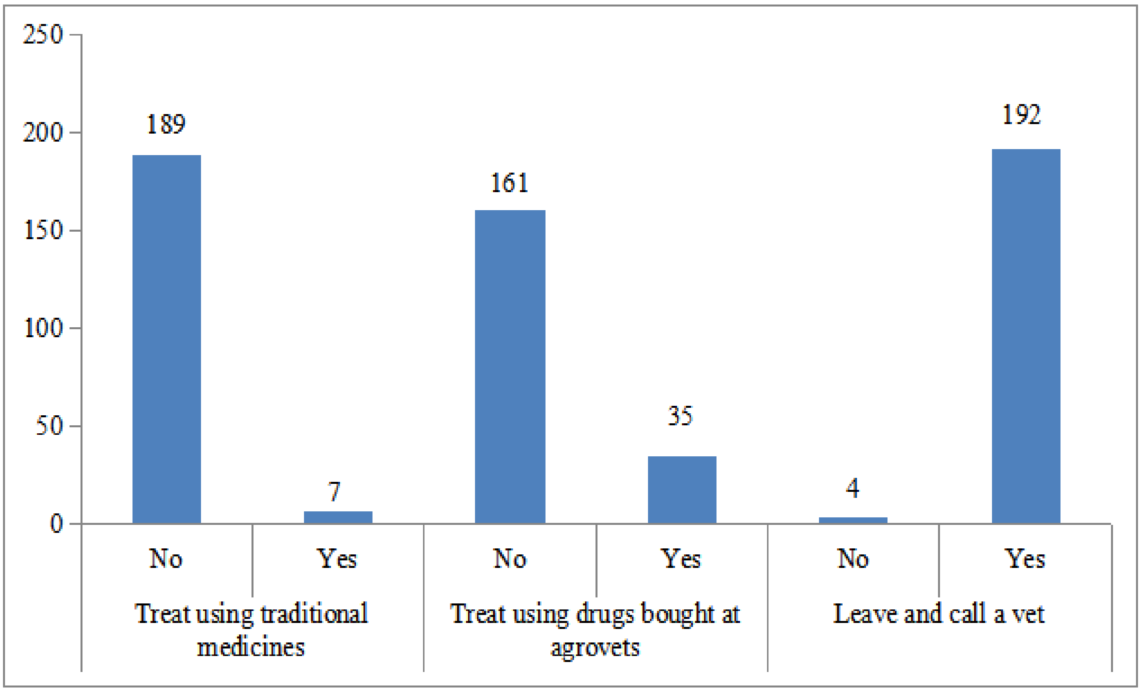


Figure 4.11: Handling of sick animals

4.5.4 Assisting animals to deliver

When asked if they assist animals to give birth, 73% of the respondents said they did while 27% said they did not.

4.5.5 Handling of aborted animals

When asked how they handled animals that aborted, majority of the respondents (65.3%) mentioned that they helped them with naked hands and without mask, 4.1% said they helped them using gloves and mask while 12.8% left them and called a veterinarian to attend to them (Figure 4.12).

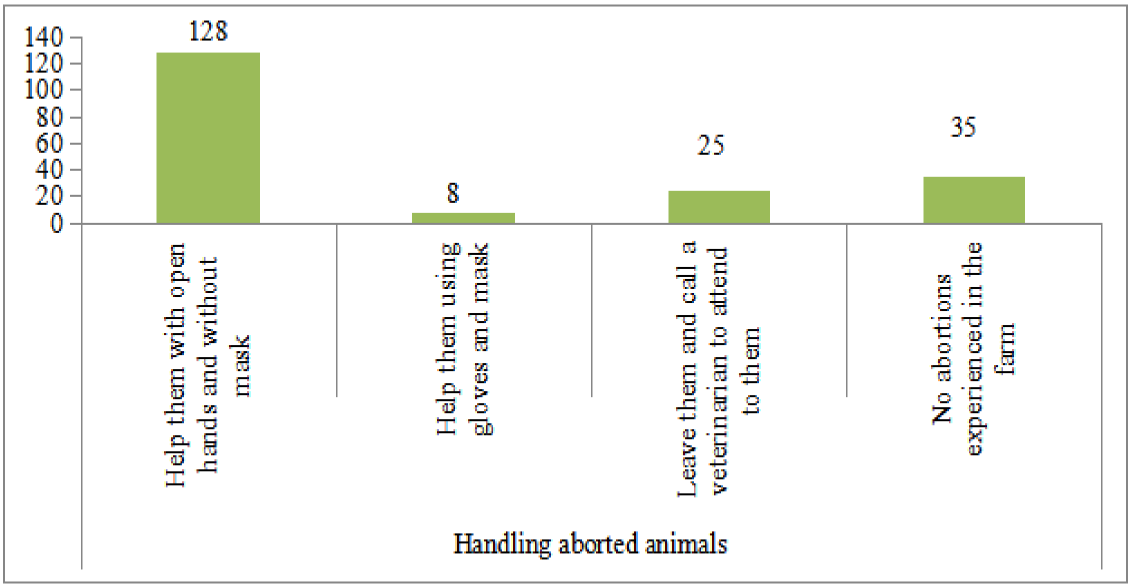


Figure 4.12: Handling of aborted animals

4.5.6 Slaughtering animals at home

Majority of the respondents (88.3%) reported that they slaughtered animals for meat at home. Of these, only 2.3% mentioned that they wore gloves when slaughtering animals.

4.5.7 Drinking raw milk

When asked if they had drunk raw milk in the past one year, majority (98%) stated they had not while 2% reported that they had drunk raw milk within the last one year.

4.5.8 Eating uncooked meat

All the respondents (100%) reported that they had not eaten uncooked meat within the past one year

4.5.9 Practices score on RVF

Out of a maximum possible score of 10 on practices related to RVF prevention, participants mean score was 5.6. Results revealed that 57.1% of the respondents scored 50% and above and were classified as having good practices on RVF prevention (Table 4.13). Further, 42.9% of the respondents scored below 50% and were classified as having poor practice on RVF prevention (Table 4.13).

Table 4.13: Overall practice score on Rift Valley fever

Practice	Frequency	Percentage
Poor practice	69	42.9%
Good practice	92	57.1%

4.5.10 Factors associated with practices related to RVF prevention

Multiple regression analysis was conducted to assess the effect of different variables on practices related to RVF prevention. Factors with p value < 0.05 were considered significant. The analysis identified that place of residence, history of RVF outbreak, and goat ownership had a positive significant impact on RVF prevention practices. Participants from Kipipiri exhibited better practices with a score 4.18 points higher compared to those from Ndaragwa (B = 4.154, p = 0.03). Additionally, participants with a history of RVF outbreak had a better practice score of 2.344 points higher than those without such an experience (B = 2.39, p = 0.013). Interestingly, among goat owners, each additional unit increase in the number of goats owned was associated with a 0.916 point increase in better practice scores on RVF prevention (B = 0.916, p = 0.002). These findings underscore the importance of place of residence, direct experience with RVF outbreaks, and livestock ownership in influencing RVF prevention practices.

Table 4.14: Factors associated with preventive practices related to RVF

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	21.313	3.626		5.878	.000
	Gender	.342	.944	.026	.362	.718
	Single	-.017	2.166	-.001	-.008	.994
	Married	1.777	1.493	.111	1.190	.235
	Occupation	-2.927	2.539	-.088	-1.153	.251
	Kipipiri	4.154	1.375	.246	3.022	.003
	Olkalou	-.097	1.042	-.007	-.093	.926
	Old	-.580	1.138	-.038	-.510	.611
	Primary	1.624	1.566	.119	1.037	.301
	Secondary	1.616	1.887	.093	.856	.393
	Tertiary	1.853	2.333	.075	.795	.428
	Experienced RVF oubreak recently	2.344	.936	.173	2.504	.013
	Number of Cattle	.102	.135	.063	.753	.452
	Number of sheep	-.069	.054	-.094	-1.277	.203
	Number of goats	.916	.292	.244	3.136	.002

a. Dependent Variable: mean score practices

4.6 Economic impact of RVF

4.6.1 Experience of RVF

Out of a total of 196 study participants, 60.7% confirmed that they experienced RVF outbreak in their farms (Table 4.15).

Table 4.15: Experience of RVF disease

Experienced outbreak	Frequency	Percentage
No	77	39.3%
Yes	119	60.7%

4.6.2 Livestock mortality from RVF

The number of animals reported to have died from RVF disease included 63 cattle and 1003 sheep. No goat was reported to have died from RVF.

4.6.3 Abortion cases in livestock

The number of animals reported to have aborted due to RVF disease included 133 cattle, 248 sheep and 11 goats.

4.6.4 Livestock value

Mature cattle, sheep and goat were valued at Ksh50, 000, Ksh 6,000, Ksh 9,000 respectively. A female calf at birth was valued at 5,000. The value increased to Ksh 15,000 on average at 3 months (after weaning). A bull at birth was valued at Ksh 3,000 increasing to 9,000 on average at 3 months. A kid of goat at birth was valued at Ksh 1,500.

4.6.5 Milk production before the outbreak

Among the farms visited, the daily milk production from the milking herds before the outbreak was an average of 6 liters per cow in the participating farms. Notably, 25 cattle and 6 heifers had died before the outbreak. The average price of a liter of milk was reported to be Ksh 30.

4.6.7 Milk production during the outbreak

Daily milk production during the outbreak was an average of 2.9 liters per cow in the participating farms.

4.6.8 History of vaccination against RVF

Majority of the participants (90.3%) did not vaccinate their livestock against RVF. Only 9.7% participants reported to have vaccinated their livestock against RVF. Vaccination was only done in cattle.

4.6.9 Price of vaccination

The mean price of the vaccine was Ksh 240 per dose

4.6.10 Loss of production

Losses due to mortality = Number of dead animals × slaughter value of an animal

Cattle: 63×50,000=3,150,000

Sheep: 1003×6,000=6,018,000

Household level losses due to livestock mortality = Total losses due to mortality in the participating farms ÷ affected households

Cattle= 3,150,000÷26= 121,153.8

Sheep= 6,018,000÷51=118,000

Losses due to abortion = Number of abortions × Value of an animal at birth

Cattle: 133×4,000=532,000

Sheep: 248×1,500=372000

Goat: 11×1500=16,500

***Household level losses due to abortion*=** Total losses due to abortion in the participating farms÷ affected households

Cattle= 532,000÷89=5,977

Sheep= 372000÷50=7,440

Goat= 16500÷2=8,250

Milk production losses = (Actual milk production before the outbreak × Value of the milk) — (Average milk production during the outbreak × Value of the milk). With the price of milk remaining constant at Ksh. 30 during the study period;

Milk production loss in cattle was estimated at: (299×30)-(141×30) = 4,740

Household level milk production losses= Total milk production losses in the participating farms÷ affected households: 4740÷48= 98.8

4.6.11 Cost of control

Vaccine cost = Number of animals vaccinated × Price of vaccine

Cattle: 125×240 = 30000

Household level cost of control= Total vaccine cost in the participating farms÷ households that vaccinated their animals: 30000÷ 19= 1578.9

4.6.12 Economic cost of RVF

Total Economic loss due to RVF was reached at by weighting losses attributable to Mortality and abortion and loss due to control costs of RVF. As shown in table 4.16, Weighted Estimated economic loss of RVF within the participating households = Ksh35, 463.02

Table 4.16: Estimated economic loss at household level

Type of Loss	Average loss per household	Households that experienced the loss	Weights	Economic Cost at household level
Cattle mortality	121,153.8	26	0.09	10,903.77
Sheep mortality	118,000	51	0.18	21,240
Cattle abortion	5,977	89	0.31	1,852.87
Sheep abortion	7,440	50	0.18	1339.2
Goat abortion	8,250	2	0.00	0
Milk production Losses	98	48	0.17	16.66
Vaccination cost	1,578.9	19	0.07	110.52
Total		285		35,463.02

The weighted estimated economic loss of Ksh 35, 463.02 reflects a comprehensive assessment of the financial impact of RVF on participating households, taking into account both the production losses and the costs incurred for controlling the disease. This figure provides a valuable measure for understanding the economic burden of RVF and for informing strategies to mitigate such losses.

CHAPTER FIVE: DISCUSSION

This study aimed at assessing community's knowledge, attitude and practices regarding RVF disease in Nyandarua County, Kenya. The disease is capable of causing serious morbidity and mortality in animal and human populations. Currently, the disease has been spreading to regions that were previously non-endemic like Nyandarua County. There is need to access knowledge, attitude and practices in order to provide the basis for health education and promotion.

5.1 Knowledge of Rift Valley Fever

From this study, 60.7% of the participants reported that they had heard about RVF disease. Majority of the participant 46.2% reported to have heard about the disease from neighbours and friends. The results are in consistent to studies by (Abdi et al., 2015) and (Hassan et al., 2017) where 46% and 54% of participants are reported to have heard about RVF from relatives and friends respectively. The high percentage of participants reporting to have heard of RVF could be attributed to sensitization messages from the veterinary department when the disease outbreak was reported. Further, findings from the study support how informal communication can be used to pass health messages within this community. It is important to understand how information flows within a community. When tailoring communication strategies, public health campaigns can be designed to leverage existing social networks. Community leaders, influencers, or trusted individuals can be trained to share accurate information about RVF.

Despite the general awareness of RVF among participants, the overall knowledge score on RVF was 8.8%. Notably, 94% of the respondents did not know the transmitting vector of RVF. These findings are similar to a study by (de St. Maurice et al., 2018) who reported low knowledge of the vector transmitting RVF. However, the findings are in contrast to a study done by (Owange et al.,2014) where pastoralists felt that mosquitoes are important risk factors for RVF spread in cattle. The finding that 94% of respondents in the study were unaware of the mosquito vector transmitting RVF reveals a critical gap in public knowledge about the disease transmission. This lack of awareness can significantly hinder efforts to control the spread of RVF. People who don't know about RVF virus vectors are less likely to take preventive measures, such as using mosquito nets or repellents. This can lead to a higher risk of infection for themselves and others. Public health initiatives rely on public cooperation to be effective. If people don't understand how RVF spreads, they may be less likely to comply with control measures, like mosquito control programs. (WHO, 2018). Educational campaigns specifically designed to raise awareness about the mosquito vector transmitting RVF are essential. By understanding how RVF spreads, people can take steps to protect themselves and their families by avoiding mosquito bites and using appropriate deterrents. Increased public awareness can empower communities to work together to implement mosquito control measures and reduce the risk of outbreaks. (CDC, 2023).

Regarding the signs of the disease in animals, only 20.9% mentioned abortions in pregnant animals while other signs were mentioned by less than 10% of the respondents. None of the respondents mentioned high neonatal mortalities. The findings are consistent with a study by (Abdi et al., 2015) and (Chengula et al., 2013) who reported low knowledge of the disease signs in animals. However, these findings differ from those reported by (Jost et al., 2010) where the Somali pastoralists provided more accurate and detailed clinical description of the livestock diseases including RVF. The low awareness (20.9%) for abortions and less than 10% for other signs regarding signs of RVF in animals, particularly the complete lack of knowledge about high neonatal mortality, highlights a critical gap in understanding this disease within the community. Unawareness of signs in animals can lead to delayed diagnosis and continued contact between infected animals and healthy ones, facilitating the spread of the virus. The RVF outbreaks can cause significant economic losses for farmers due to abortions, stillbirths, and deaths of young animals. (FAO, 2023). Livestock serve as amplifying hosts for RVF. Delayed detection in animals can lead to a larger pool of infected animals, potentially increasing the risk of spillover to humans. (Tchouassi et al., 2016). Educational campaigns highlighting the key signs of RVF in animals, including abortions, fever, weakness, and diarrhea, should be carried out to enlighten the farmers. By recognizing the signs of RVF in animals, farmers can report suspected cases to veterinary authorities promptly. This allows for early detection, isolation of infected animals, and implementation of control measures to prevent further spread. Early detection and intervention can help minimize animal deaths and abortions associated with RVF outbreaks, thereby reducing economic losses for farmers. (CDC, 2023)

Regarding the disease in humans, about 91% of the respondents were not aware that the disease could affect humans. They were not familiar with the signs and symptoms of the disease in humans as less than 10% mentioning a correct symptom of the disease in humans. Very low proportion of community members knew that the disease is transmitted by mosquito bites (1%), touching aborted fetuses (4.6%) and touching infected body fluids (1.5%). A slightly higher proportion reported transmission through eating meat from infected animals and drinking raw milk. These findings are similar to a study by (Shabani et al., 2015) where only a small proportion of participants could identify symptoms in humans. In contrast, in the study by (Abdi et al., 2015) 92% of the respondents recognized hemorrhages as RVF symptoms in humans. Similarly in the study by (Owange et al., 2014) majority of respondents identified hemorrhages as key signs followed by high fever. The finding that 91% of respondents in this study were unaware that RVF affects humans and lacked knowledge of its symptoms is a major public health concern. People who don't know RVF can infect humans might not recognize the symptoms in themselves, leading to delayed diagnosis and treatment. This can worsen the course of the illness and increase the risk of complications. (CDC, 2023). Moreover, the lack of awareness can increase the risk of contracting the disease. Unaware individuals might unknowingly engage in behaviors that increase the risk of transmission, such as handling infected animals without proper precautions. (Kainga et al., 2022). Educational campaigns specifically designed to inform people about the signs and symptoms of RVF in humans are essential. (CDC, 2023.) Educational messages should be clear, concise, and cover a range of common symptoms to enable early identification and healthcare seeking. By recognizing the signs and symptoms of RVF, people can seek medical attention promptly, leading to earlier diagnosis, treatment, and better health outcomes.(Issae et al., 2023).

Significant factors found to be associated with knowledge in this study were a history of RVF outbreak, cattle ownership, marital status and age. The findings are similar to a study conducted by (Abdi et al., 2015) which reported that being in a household with a history of RVF infection was a significant factor for Knowledge. In contrast, a study done by (Issae et al., 2023) found that gender, education levels and locality were significant factors related to Knowledge about RVF. People who have lived through an outbreak or have had family members or livestock affected are more likely to be aware of the disease, its symptoms and how it spreads. (FAO, 2023), (Bett et al., 2018). Communities reliant on livestock, particularly cattle, are more invested in understanding animal health issues.(Muga et al., 2015) It’s possible that married people, often heading households, take on more responsibility for animal care and disease prevention. Alternatively, social networks within married couples might lead to better sharing of information about RVF. (Ye & Zhang, 2019). Older individuals might have accumulated knowledge from past outbreaks. (Selvarajoo et al., 2020)

5.2 Attitude and perceived risk of RVF

From this study, 48.5% of the respondents had a neutral attitude regarding RVF disease. Although 37.2% of the respondents strongly agreed that the disease was dangerous, majority (41.8%) did not know if RVF was a dangerous disease with a public health importance. Interestingly, 61% of the respondents did not know if they were at risk of contracting the disease and could not tell if the disease was curable. The findings in this study are in contrast to those from a study by (Shabani et al., 2015) where 90% of respondents felt the disease was a serious threat to public and animal health and 67% of participants felt at risk of contracting the disease. Similarly, in another study by (Abdi et al., 2015) participants were reported to have a high positive attitude towards RVF. The low perceived risk about RVF disease in this study could be due to the region experiencing the disease for the first time and community having low knowledge about the disease. If people don't understand the severity of RVF, they may be less likely to take preventive measures or seek medical attention promptly. This can increase the risk of infection and transmission. (WHO, 2023). Uncertainty about curability can lead to fear, anxiety, and delayed healthcare seeking.(Simonovic et al., 2023), (Berrigan et al., 2023). Public health messaging should clearly explain who is most at risk of contracting RVF. (FAO, 2022) Public health messages should clearly state that while there is no specific cure for RVF, supportive treatment with fluids, medication to manage symptoms, and rest can significantly improve the chances of recovery. (FAO, 2023)

Regarding the disease prevention, majority 66.8% did not know if the disease transmission from animals to humans was preventable. This suggests a significant gap in understanding how RVF spreads. People who don't know how RVF spreads from animals to humans are less likely to take preventive measures, such as avoiding contact with infected animals or their tissues, consuming unpasteurized milk, or proper handling of meat. This can lead to a higher risk of infection. (WHO, 2018). Educational campaigns specifically designed to raise awareness about preventing zoonotic transmission (animal-to-human transmission) of RVF are essential. (CDC, 2023)

The study found that 57.7% were not aware if the disease can be prevented by vaccinating animals. Vaccination is one of the most effective ways to control RVF. It significantly reduces the number of susceptible animals in a population. This lowers the chance of the virus spreading between animals and mosquitoes, ultimately reducing transmission to humans. Further vaccination helps protect animals from RVF preventing abortions, stillbirths, and deaths in herds. This safeguards livestock livelihoods for farmers. If people don't understand the benefits of animal vaccination, they may be less likely to vaccinate their livestock. This can leave animal populations vulnerable to RVF outbreaks. Educational campaigns should clearly explain how vaccinating animals protects both livestock and public health by reducing the spread of RVF. The campaigns should address any concerns about vaccine safety or efficacy to promote trust and encourage vaccination uptake. (FAO, 2023), (CDC, 2023).

Majority of the participants (51%) were not familiar with the need to quarantine animals during outbreaks. Quarantine restricts the movement of potentially infected animals, preventing them from coming into contact with healthy animals and further spreading the virus. This can effectively contain outbreaks within a specific area. Early implementation of quarantine measures during an outbreak allows for targeted interventions like vaccination and surveillance to be applied within the quarantined zone. If people don't understand the rationale behind animal quarantine, they may be less likely to cooperate with restrictions on animal movement. This can hinder the effectiveness of control measures. Delayed implementation of quarantine can lead further spread of the virus, making outbreak control more challenging. (WHO, 2018)

Significant factors associated with attitude regarding RVF include a history of RVF outbreak, place of residence and age. People who have lived through an outbreak or witnessed its effects firsthand are likely to have a more serious attitude towards the disease. Experiencing illness or death in livestock due to RVF can instill a strong sense of the dangers it poses. (Abdi et al., 2015). People living in areas historically affected by RVF outbreaks might be more aware and concerned compared to those in low-risk region. (Chiuya et., 2023). Older individuals may have more established risk perceptions regarding RVF due to personal or community experiences with the disease (CDC 2023)

5.3 Practices related to RVF prevention

The study reported good overall practice score of participants. However, participants engaged in some practices that could expose them to Rift Valley Fever in the event of an outbreak. A high proportion of participants reported presence of mosquitoes within the homestead. However, only 41.8% reported that they used mosquito nets. These results are similar to a study by (Aliyo et al., 2023) where 47.5% of participants had used insecticide treated mosquitoe nets. Less than 20% considered other ways of controlling mosquitoes. Notably, 36.7% had no form of protection from mosquito bites. Participants sleeping under mosquito nets was partly due to malaria concerns. Mosquito nets might not be readily available or affordable in all communities

Majority of participants (98%) reported that they called a veterinarian to attend to sick animals. However, a high proportion of participants mentioned that they assisted animals to give birth. As the results showed, 65.3% reported that they handled aborted materials with bare hands and without masks. Further, majority of participants (97.3%) slaughtered animals at home and did not wear gloves when slaughtering animals. Similar findings were reported by (Chengula et al., 2013) where participants slaughtered animals at home. In another study by (de St. Maurice et al., 2018) less than 20% of butchers used gloves when slaughtering animals. The findings are similar to a study by (Affognon et al., 2017) and (Owange et al.,2014) where participants did not use protection when handling aborted fetuses. This unsafe practice could be attributed to unavailability of gloves and lack of knowledge about the risk of contracting diseases from animals through handling of aborted materials (FAO, 2024). These findings highlight the importance of educating people about the risks of zoonotic disease transmission during animal birthing and abortion events. Educational campaigns should educate people about the potential health risks associated with handling birthing materials and aborted fetuses without proper protection. (WHO, 2024). There is need to promote the use of gloves, masks, and other personal protective equipment (PPE) when assisting animals during birth or handling aborted materials. Further there is need for guidance on the safe disposal of birthing materials and aborted fetuses to minimize the risk of environmental contamination and disease spread. In the event of an outbreak, participants are at risk of contracting RVF due to contact with body and tissue fluids from infected animals. (FAO 2023, WHO 2018).

Only a small proportion of participants (2%) reported to have consumed raw milk while none of them reported to have eaten uncooked meat. These findings differ from those by (Abdi et al., 2015) and (Chengula et al. 2013) who reported high consumption of raw milk. The good practice reported in this study could be due to health education regarding milk/meat borne illness. Further, the cultural practices by the community could forbid them from consuming raw and uncooked meat.

Significant factors associated with practices include a history of RVF outbreak, goat ownership and place of residence. People living in areas with a higher frequency of RVF outbreaks might be more familiar with necessary preventive practices. This familiarity could be due to past public health campaigns. (Nanyingi et al., 2015).

5.4 Economic impact of Rift Valley Fever

A high proportion of respondents (60.7%) reported that they experienced RVF outbreak in their farms. This could be due to the study being conducted in areas that had high RVF activity within the study region. The study results confirm a significant economic impact of RVF outbreaks on livestock keepers. The overall economic loss at household level due to RVF among the participating farms was estimated at Ksh 35, 463 which includes losses attributed to livestock mortality, abortions and control costs. These findings are similar to those reported by (Seufi & Galal 2010) and (Chengula et al. 2013) who reported serious economic losses following RVF outbreak in Sudan and Tanzania respectively. In Kenya, a study by (Rich & Wanyoike 2010) estimated a total of 610 million losses from rift valley fever livestock mortality.

This direct loss of livestock through deaths represents a substantial financial blow to farmers. Animals that survive RVF infection may experience weakness and illness, leading to a decline in milk yield. This decrease in production translates to lost income and potential food insecurity for communities reliant on livestock milk. (FAO, 2023). The RVF is particularly damaging for breeding animals as it can induce a high number of abortions. This not only reduces immediate income from offspring sales but also disrupts herd dynamics and future productivity. (FAO, 2023). Governments may impose movement restrictions on livestock to control the spread of RVF. This disrupts established trade routes and marketing channels, leading to lost income for farmers who can't sell their animals. Implementing effective vaccination programs for livestock populations is crucial for preventing outbreaks and minimizing economic losses. (CDC, 2023).

CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

This study concludes that;

i. There is very low knowledge about Rift Valley Fever disease in the study area. Community members are not aware of the cause of the disease, transmission, signs and symptoms in animals. Further, there is lack of awareness of the zoonotic potential of the disease and how it manifests itself in animals and humans.

ii. Community members in the study area engaged in risky practices of handling aborted fetuses and animal tissues and therefore risk contracting RVF in the event of an outbreak.

iii. RVF caused serious economic impact by reducing production and causing loss of livestock through deaths and abortion

6.2 Recommendations

i. Community members should be educated about RVF disease. Effective control measures rely on early detection informed by a good knowledge of the disease signs and symptoms in both animals and humans. Educational programs should encourage people to use personal protective clothes when handling sick animals, slaughtering and assisting animals to give birth.

ii. Public health efforts should emphasize the importance of animal vaccination programs

iii. One health interdisciplinary collaboration bringing together experts from human health. animal health and environmental health is needed to address RVF outbreak.

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APPENDICES

Appendix 1: Consent of participation

Informed Consent Form

Informed consent form for community members in Nyandarua County who we are inviting to participate in a research titled: “Community knowledge attitude and practices regarding rift valley fever in Nyandarua County.”

Principal investigator: Catherine Karungo

Organization: Moi University

PART 1: Information sheet

Introduction: My name is Catherine Karungo, a student at Moi University. I am doing a research on a disease called Rift Valley Fever which has recently been experienced in this region. I am going to give you information and invite you to be part of this research. Your participation is entirely voluntary. This consent form may contain words you do not understand. Please ask me to stop as we go through the information and I will take time to explain.

Purpose of the research

Rift valley fever disease outbreak is causing significant losses in your community. We want to find ways to prevent this from happening. We believe you can help us by telling us what you know about Rift Valley Fever. We want to learn what people in this community know about what causes the disease, how it manifest itself among our livestock and people and how one can protect themselves from acquiring this disease. We also want to know more about your routine practices when handling livestock. This knowledge will help us to learn how to better prevent and control Rift valley fever in this community.

Participant selection: You are been invited to participate in this research because we believe that as one of the community member who keeps livestock and have lived here for more than five years, you can greatly contribute much about the community's perception regarding Rift Valley Fever.

Voluntary participation: Your participation in this research is entirely voluntary. It is your choice whether to participate or not but we will be glad if you choose to participate.

Procedure: We are asking you to help us learn more about Rift Valley Fever in your community. We are inviting you to take part in this research project. If you accept, you will be asked to answer a questionnaire. The questions will be read out loud to you and you will give the answer as we write it down for you. If you do not wish to answer any questions included in the survey, you may skip them and move to the next question.

Duration: The survey will take about 40 minutes to complete answering the questions.

Risks: There is a risk that you may share some personal or confidential information by chance or you may feel uncomfortable talking about some of the topics. However, we do not wish for this to happen. You do not have to answer any question if you feel that the question is too personal or talking about it makes you feel uncomfortable.

Benefits: There will be no direct benefits to you but your participation will help us learn more about how to prevent and control Rift Valley Fever in your community.

Confidentiality: The information recorded is confidential, your name will not be recorded in the forms, and only a code will help us identify you. No one else apart from the research team will have access to your survey.

Sharing the results: Nothing that you share with us today will be shared with anybody outside the research team and nothing will be attributed to you by name. The knowledge that we will get from this research will be shared with you and your community before being made available to the public. We will publish the results so that other interested people may learn from the research.

Right to refuse or withdraw: You may stop participating in the interview at any time. I will give you an opportunity at the end to review your remarks and can ask to modify your answers or remove portions of it if you do not agree with my notes or if I did not understand you correctly.

Who to contact

If you have any questions you can ask them now or later. If you wish to ask later, you can contact me: (Catherine Karungo: Mobile number 0726107783).

This proposal has been reviewed and approved by Institutional Research Ethics Committee (IREC) Moi University. This is a committee whose task is to make sure that research participants are protected from harm.

PART II: Certificate of consent

I have been invited to participate in a research about Rift Valley Fever. I have read the information provided/ it has been read to me. I have had the opportunity to ask questions about it and all have been answered to my satisfactory. I consent voluntarily to be a participant in this study.

Participant code………………………………………………………………………..

Signature of participant……………………………………………………………..

Date………………………………………………………………………………………

If illiterate (participant to give verbal consent, and a witness to sign)

I have witnessed the accurate reading of the consent form to the potential participant, and the individual has had the opportunity to ask questions. I confirm that the individual has given consent freely.

Witness code………………………………… Thumb print of participant [ ]

Signature of witness…………………………..

Date…………………………………………….

Appendix 2: Research Questionnaire

Study Questionnaire

Questionnaire No: …….

Name of interviewer………………………………………………………………………….

Date of interview…………………………………………………………………………….

Participant's information

Household ID…………………………………………………………………..

Sub county: ………………………………Ward………………………………….

Village……………………………….…….

Part 1: SOCIO- DEMOGRAPHIC INFORMATION

1. Age: 18-29 [ ] 30-39 [ ] 40-49 [ ] 50-59 [ ] 60+ [ ]
2. Gender: Male [ ] Female [ ]
3. Marital status: Single [ ] Married [ ] Widowed/divorced [ ]
4. Education: None [ ] Primary [ ] Secondary [ ] University/College [ ]
5. Occupation: Employed [ ] Self-employed [ ] others (specify)…………………………
6. Livestock ownership: Do you keep any of the following livestock?

Animal	Yes	No	How many?
Cattle			
Sheep			
Goats			

Part 2: KNOWLEDGE OF RIFT VALLEY FEVER

1. Do you know of a disease called Rift Valley Fever? Yes [ ] No [ ]
If yes, where did you learn about it?

Radio [ ]
Tv [ ]
Newspapers/ magazines [ ]
Bronchures/posters [ ]

Veterinary officials [ ]
Medical officials [ ]
Religious leaders [ ]
Family/ friends/ neigbours [ ]
Others (specify)……………………………………………….

2. What causes the disease?
Mosquitoes [ ]
Housefly [ ]
Ticks [ ]
Germs [ ]
Don't know [ ]

3. Do you know the signs and symptoms of Rift Valley Fever in animals? Yes [ ] No[ ]
If yes, what are the signs and symptoms of an animal with RVF?

High fever [ ]
Anorexia [ ]
Neonatal mortality [ ]
Abortions [ ]
Nasal discharge [ ]
Diarrhoea [ ]

4. Do you know the signs and symptoms of Rift Valley Fever in humans? Yes [ ] No [ ]
If yes, what are the signs and symptoms of RVF in humans?

Fever [ ]
Headache [ ]
Muscle/joint pain [ ]
Blurred vision [ ]
Diarrhoea [ ]
Bleeding [ ]
Jaundice [ ]
Coughing [ ]

5. Do you know how RVF is transmitted in animals? Yes [ ] No [ ]
If yes, how is RVF transmitted in animals?

Bites of infected mosquitoes [ ]
Bites of other biting flies [ ]
Tick bites [ ]
Aerosol of infected body fluids /blood [ ]
Others (specify)…………………………………………

6. Do you know how RVF is transmitted to humans? Yes [ ] No [ ]
If yes, how is RVF transmitted to humans?

Mosquito bites [ ]
Touching aborted fetus [ ]
Touching infected animal body fluids [ ]
Consuming meat from infected animals [ ]
Drinking raw milk [ ]
Others (specify) ………………………………………..

Part 3: ATTITUDE AND PERCEIVED RISKS OF RVF

1. RVF is a dangerous disease
   Strongly agree [ ]
   Agree [ ]
   Don't know [ ]
   Disagree [ ]
   Strongly Disagree [ ]

2. When you are in close contact with animals, you are at risk of contracting RVF
   Strongly agree [ ]
   Agree [ ]
   Don't know [ ]
   Disagree [ ]
   Strongly Disagree [ ]
3. RVF is curable
   Strongly agree [ ]
   Agree [ ]
   Don't know [ ]
   Disagree [ ]
   Strongly Disagree [ ]
4. RVF transmission from animals to humans is preventable
   Strongly agree [ ]
   Agree [ ]
   Don't know [ ]
   Disagree [ ]
   Strongly Disagree [ ]

5. RVF can be prevented by vaccinating animals.
   Strongly agree [ ]
   Agree [ ]
   Don't know [ ]
   Disagree [ ]

Strongly Disagree [ ]

6. There is no need to quarantine animals with RVF
   Strongly agree [ ]
   Agree [ ]
   Don't know [ ]
   Disagree [ ]
   Strongly Disagree [ ]

7. Health facilities efficiently handle RVF outbreaks
   Strongly agree [ ]
   Agree [ ]
   Neither agrees nor disagree [ ]
   Disagree [ ]
   Strongly Disagree [ ]

Part 4: PRACTICES RELATED TO RVF PREVENTION

1. Do you experience presence of mosquitoes in your homestead? Yes [ ] No [ ]

2. How do you protect yourself from their bites?
   Use mosquito bed net [ ]
   Use repellant [ ]
   Others (specify)……………………………………………..

3. How do you handle a sick animal?
   Treat them using traditional medicine [ ]
   Treat them using drugs bought at agrovets [ ]
   Leave them and call a veterinarian to attend to them [ ]
   Others (specify)………………………………………………

4. Do you help animals to deliver? Yes [ ] No [ ]
5. How do you handle aborted animals?
   Help them with open hands and without mask [ ]
   Help them using gloves and mask [ ]
   Leave them and call a veterinarian to attend to them [ ]

6. Do you slaughter animals for meat at home? Yes [ ] No [ ]
   If yes, do you use gloves when doing so? Yes [ ] No [ ]
7. In the past one year, have you drunk raw milk? Yes [ ] No [ ]
8. In the past one year, have you eaten uncooked meat? Yes [ ] No [ ]

Part 5: ECONOMIC IMPACT OF RVF

1. Have you experienced RVF outbreak in your farm recently? Yes [ ] No [ ]
2. Did you experience any animal deaths due to RVF outbreak? Yes [ ] No [ ]

If yes, how many died?

Deaths	Cattle	Sheep	Goats
No. Dead			

3. Did you experience any abortions due to RVF outbreaks? Yes [ ] No [ ]

If yes, how many animals aborted?

Abortion	Cattle	Sheep	Goats
No. Aborted			

4. What is the value of a mature animal?

Animal	Amount in Ksh
Cattle	
Sheep	
Goat	

5. What is the value of a calf/kid at birth?

Young	Amount in Ksh
Calf	
Kid	

6. How much milk on average did you collect in a day before and during the outbreak?
   Milk production (liters) before the outbreak [ ]
   Milk production (liters) during the outbreak [ ]
7. What is the price of a liter of milk in Ksh?
   …………………………………………………..

8. Did you vaccinate your animals against RVF? Yes [ ] No [ ]

If yes how many?

Animal	Number vaccinated
Cattle	
Sheep	
Goat	

9. How much did you pay per animal for the vaccine? Ksh
   …………………………………………

Thank you for your time

Appendix 3: Institutional research and ethics committee approval letter

INSTITUTIONAL RESEARCH AND ETHICS COMMITTEE (IREC)

MOI TEACHING AND REFERRAL HOSPITAL
P.O. BOX 3
ELDORET
Tel: 33471/2/3

MOI UNIVERSITY
COLLEGE OF HEALTH SCIENCES
P.O. BOX 4606
ELDORET
Tel: 33471/2/3

Reference: IREC/2020/31
Approval Number: 0003613

25th June, 2020

Catherine Wanjiku Karungo,
Moi University,
School of Public Health,
P.O. Box 4606-30100,
ELDORET-KENYA.

INSTITUTIONAL RESEARCH & ETHICS COMMITTEE
25 JUN 2020
APPROVED
P. O. Box 4606-30100 ELDORET

Dear Ms. Karungo,

COMMUNITY KNOWLEDGE, ATTITUDE AND PRACTICES REGARDING RIFT VALLEY FEVER IN NYANDARUA COUNTY, KENYA

This is to inform you that ***MU/MTRH-IREC*** has reviewed and approved your above research proposal. Your application approval number is ***FAN: 0003613.*** The approval period is **25th June, *2020 – 24th June, 2021.***

This approval is subject to compliance with the following requirements;

i. Only approved documents including (informed consents, study instruments, MTA) will be used.
ii. All changes including (amendments, deviations, and violations) are submitted for review and approval by ***MU/MTRH-IREC***.
iii. Death and life threatening problems and serious adverse events or unexpected adverse events whether related or unrelated to the study must be reported to ***MU/MTRH-IREC*** within 72 hours of notification.
iv. Any changes, anticipated or otherwise that may increase the risks or affected safety or welfare of study participants and others or affect the integrity of the research must be reported to ***MU/MTRH-IREC*** within 72 hours.
v. Clearance for export of biological specimens must be obtained from relevant institutions.
vi. Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. Attach a comprehensive progress report to support the renewal.
vii. Submission of an executive summary report within 90 days upon completion of the study to ***MU/MTRH-IREC.***

Prior to commencing your study; you will be required to obtain a research license from the National Commission for Science, Technology and Innovation (NACOSTI) https://oris.nacosti.go.ke and other relevant clearances. Further, a written approval from the CEO-MTRH is mandatory for studies to be undertaken within the jurisdiction of Moi Teaching & Referral Hospital (MTRH), which includes 22 Counties in the Western half of Kenya.

Sincerely,

DR. S. NYABERA
DEPUTY-CHAIRMAN
INSTITUTIONAL RESEARCH AND ETHICS COMMITTEE

cc	CEO	-	MTRH	Dean	-	SOP	Dean	-	SOM
	Principal	-	CHS	Dean	-	SON	Dean	-	SOD