

The Institute of Food Economics and Consumption Studies

of the Christian-Albrechts-Universität zu Kiel

**Ex-ante Social and Economic Impact of Rift Valley Fever control options in Pastoral and
Agro-Pastoral Livestock Production Systems of Uganda**

Dissertation

Submitted for Doctoral Degree

awarded by the Faculty of Agricultural and Nutritional Sciences of the

Christian-Albrechts-Universität zu Kiel

Submitted by

M.Sc. Marsy Asindu

Born in Arua, Uganda

Kiel, 2024

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Dean:	Prof. Dr. Georg Thaller
1. Examiner:	Prof. Dr. Awudu Abdulai
2. Examiner:	Prof. Dr. Martin Schellhorn
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Dedication

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Abstract

With a global contribution of 40% to the agricultural GDP, livestock production remains one of the most promising sectors that can be relied on to improve food security and offer a way out of poverty for over 1.5 billion people whose livelihoods depend on it. Like any other sector of the world economy, the livestock sector is faced with a myriad of challenges. Emerging infectious diseases, particularly those that are zoonotic in nature such as the Rift Valley fever disease (RVF), have rapidly emerged as a force with multiple negative economic implications on the sector. Besides infecting humans, the disease induces abortions and deaths on livestock farms thereby impacting productivity and lowering the profitability and amount of outputs that can be generated from the affected farms. In response to the alarming repercussions of the disease, policy makers are often motivated to draw up contingency plans and roll out control measures at country and transboundary levels. Unfortunately, uptake of such measures by livestock chain actors is not often straight forward and may not be aligned to the needs of the target users, leading to low uptake or outright rejection. Further, the welfare benefits that actors stand to gain from implementing such measures are often not clear. Yet, these could be the incentives that drive actors to take up the practices. This study therefore contributes to literature by examining the social and economic impact of RVF control measures on farm households' welfare outcomes livelihoods in pastoral and agro-pastoral regions of Uganda. Specifically, the study first investigates the influence of livestock chain actors' psycho-social constructs on their intentions to take up RVF control measures using a partial least squares structural equation model (PLS-SEM). Second, the impact of on-farm biosecurity on livestock farmers' food security and poverty outcomes are estimated using a dose response function model. Third, the study evaluates the impact of RVF control measures on livestock farm productivity using susceptible, exposed, infectious, recovered, and

deceased (SEIRD) compartmental model. Finally we fit a hybrid choice model to investigate livestock farmer preferences and assess the influence of heuristics on RVF vaccine choice decisions. The results reveal that positive attitudes among other behavioral constructs is essential at driving farmers intentions to take up RVF control measures. Further, social pressure within the livestock chain actors' interaction-networks boosts their uptake of available and planned RVF control measures. Increasing farm biosecurity levels are associated with higher household dietary diversity scores, household domestic asset index and a reduced poverty gap. Also, vaccination of farm animals using live vaccines averts more on farm deaths and number of infected animals thereby boosting overall farm productivity. The effect of the vaccine could be enhanced further by matching it with active surveillance. Lastly, the results show that farmers are willing to pay up to 5000 Uganda shillings (UGX) per head of animal vaccinated with any of the potential RVF vaccine options (UGX 3586 = USD 1.00), and their choice of potential RVF vaccines vary, based on perceived risk levels such as possible side effects to animals. The results overall suggest the need for policy makers to consider livestock chain actors behavioral patterns as an incentive to motivate uptake of RVF control measures, further the direct and indirect effects of existing and planned control measures on chain actors' welfare need to be considered before they are implemented. Finally, farmers' risk perceptions and attribute preferences need to be evaluated by policy makers when designing vaccination programmes.

Zusammenfassung

der vielversprechendsten und verlässlichsten Sektoren, um die Ernährungssicherheit zu verbessern und über 1,5 Milliarden Menschen, deren Lebensunterhalt von der Viehzucht abhängt, einen Weg aus der Armut zu bieten. Wie jeder andere Sektor der Weltwirtschaft funktioniert auch der Viehzuchtsektor nicht reibungslos und ist mit einer Vielzahl von Herausforderungen konfrontiert. Neu auftretende Infektionskrankheiten, insbesondere solche zoonotischer Natur wie das Rifttalfeber (RVF), haben sich rasch zu einer Bedrohung mit zahlreichen negativen wirtschaftlichen Auswirkungen auf den Sektor entwickelt. Die Krankheit infiziert nicht nur Menschen, sondern führt auch zu Fehlgeburten und Todesfällen in der Viehzucht. Dies wirkt sich auf die Produktivität und die Rentabilität aus und verringert die Produktionsmenge der betroffenen Betriebe. Als Reaktion auf die alarmierenden Auswirkungen der Krankheit sehen sich politische Entscheidungsträger häufig veranlasst, Notfallpläne zu erstellen und Kontrollmaßnahmen auf nationaler und grenzüberschreitender Ebene zu ergreifen. Leider ist die Umsetzung solcher Maßnahmen durch die Akteure der Tierhaltungskette nicht immer einfach und möglicherweise nicht auf die Bedürfnisse der Zielgruppen abgestimmt, was zu einer geringen Akzeptanz oder völligen Ablehnung führt. Darüber hinaus sind die Vorteile, die die Akteure durch die Umsetzung solcher Maßnahmen für das Wohlergehen der Tiere erzielen können, oft nicht klar ersichtlich. Die Vorteile könnten die Akteure dazu bewegen, diese Praktiken zu übernehmen. Diese Studie leistet daher einen Beitrag zur Literatur, indem sie die sozialen und wirtschaftlichen Auswirkungen von RVF-Kontrollmaßnahmen auf das Wohlergehen der landwirtschaftlichen Haushalte in pastoralen und agro-pastoralen Viehproduktionsregionen Ugandas untersucht. Konkret untersucht die Studie zunächst den Einfluss der psychosozialen Konstrukte der Akteure der Viehzuchtkette auf ihre Absichten, RVF-Kontrollmaßnahmen zu ergreifen, unter Verwendung eines partiellen Kleinstquadrat-Strukturgleichungsmodells (PLS-SEM). Zweitens werden die Auswirkungen der Biosicherheit in landwirtschaftlichen Betrieben auf die Ernährungssicherheit und die Armut der Viehzüchter mit Hilfe eines Dosis-Wirkungs-Modells untersucht. Drittens wird in der Studie die Auswirkung von RVF-Kontrollmaßnahmen auf die Produktivität von Viehzuchtbetrieben anhand des SEIRD-Modells bewertet. Schließlich wird ein hybrides Wahlmodell zur Untersuchung der Präferenzen der Viehzüchter und zur Bewertung des Einflusses von Heuristiken auf die Entscheidung für einen RVF-Impfstoff eingesetzt. Die Ergebnisse zeigen, dass positive Einstellungen neben anderen Verhaltenskonstrukten die Landwirte wesentlich dazu bewegen,

RVF-Kontrollmaßnahmen zu ergreifen. Darüber hinaus fördert sozialer Druck innerhalb der Interaktionsnetzwerke der Akteure in der Tierhaltungskette die Akzeptanz verfügbarer und geplanter RVF-Kontrollmaßnahmen. Ein höheres Biosicherheitsniveau in landwirtschaftlichen Betrieben steht in Zusammenhang mit höheren Werten für die Ernährungsvielfalt der Haushalte, dem Haushaltsvermögensindex und einer geringeren Armutslücke. Außerdem werden durch die Impfung von Nutztieren mit Lebendimpfstoffen mehr Todesfälle in den Betrieben und die Zahl der infizierten Tiere vermieden, was die Produktivität der Betriebe insgesamt erhöht. Die Wirkung des Impfstoffs könnte noch verstärkt werden, wenn er aktiv überwacht wird. Schließlich zeigen die Ergebnisse, dass die Landwirte bereit sind, bis zu 5000 Uganda-Schilling (UGX) pro Tier zu zahlen, das mit einem der möglichen RVF-Impfstoffe geimpft wird (UGX 3586 = USD 1,00). Die Entscheidung für einen möglichen RVF-Impfstoff hängt von dem wahrgenommenen Risiko, wie z. B. den möglichen Nebenwirkungen für die Tiere ab. Die Ergebnisse deuten insgesamt darauf hin, dass die politischen Entscheidungsträger die Verhaltensmuster der Akteure in der Viehzuchtkette als Anreiz für die Einführung von RVF-Bekämpfungsmaßnahmen berücksichtigen müssen. Außerdem müssen die direkten und indirekten Auswirkungen bestehender und geplanter Bekämpfungsmaßnahmen auf das Wohlergehen der Akteure in der Kette berücksichtigt werden, bevor sie umgesetzt werden. Schließlich müssen die Risikowahrnehmung und die Präferenzen der Landwirte für bestimmte Eigenschaften von den politischen Entscheidungsträgern bei der Gestaltung von Impfprogrammen berücksichtigt werden.

Chapter One

General Introduction

1.0 Introduction

As the world moves towards attaining zero hunger, improved food security and nutrition as well as eradicating poverty in all its forms by 2030 (United Nations, 2020), agriculture remains a crucial viable livelihood option for the increasing global population expected to peak at 9.7 billion by 2050 (United Nations, 2019). In particular, growth in agricultural production and productivity is reckoned to be essential if incomes are to be raised and the food and nutritional needs of the fast-growing population are to be successfully met. A highly productive agricultural sector is therefore expected to play a major role in poverty reduction and ensuring that food security and nutrition is achieved for the masses given that the world's poor live in rural areas and are largely dependent on agriculture to meet daily needs.

Among the many agricultural enterprises, livestock production is pivotal to achieving global goals of no poverty and zero hunger as livelihoods of over 1.3 billion people (about one in five of the world population) depend on it (Staal et al., 2009; Enahoro et al., 2018). Further, it constitutes over half of the value of global agricultural output and in one-third of developing countries it accounts for 40% of agricultural GDP (Upton, 2004; Grace et al., 2017). This contribution is expected to increase even further with the demand for milk and meat set to triple, especially in Africa by 2050 (Upton, 2004; ILRI, 2016). This presents a huge opportunity for hundreds of millions of poor smallholder livestock farmers, processors, and marketers to produce to meet the anticipated market demand to escape poverty. Livestock products (meat, milk) are also expected to provide essential nutrients that will eventually contribute to food and nutritional security needs of the growing population (Randolph et al., 2007; Grace et al., 2018).

Nevertheless, endeavors to harness the full potential of the livestock sector as a livelihood option for poverty eradication and ensuring zero hunger continues to be vulnerable to the emergencies and outbreaks of infectious zoonotic diseases, notably the Rift Valley Fever (RVF). Besides indirectly infecting humans' health through loss in labor hours and increased medical bills, the disease has immense direct repercussions on livestock productivity and trade. For instance, where outbreaks have previously occurred, storm abortions and animal deaths have been recorded. This reduces the overall fertility and productivity of the farms, thus retarding future stock and growth of the farms. Further, in the absence of curative measures, preventive measures established to contain the spread of the disease at regional and transboundary levels like trade ban, movement control and quarantine result into stockpile ups, and thus increases operational costs of actors along the livestock value chain. Milk and meat products are also lost due to a ban in trade and closure of slaughterhouses. Price discrepancies arising from changes in demand and supply of animal products during outbreaks also negatively impact profitability of the sector.

Under such circumstances, understanding the epidemiology of such a disease and its adverse effects on wellbeing and food and nutrition security of affected communities becomes crucial. Likewise, a careful cost-effectiveness assessment of available control measures while creating awareness is also paramount to policy and decision making if sustainability of the livestock production industry is to be guaranteed amidst the continued outbreaks of the RVF disease.

1.1 Overview of Rift Valley Fever, Impacts and control mechanisms.

Rift Valley fever (RVF) is a zoonotic, viral, vector-borne disease that represents a threat to livestock production, and human health in Africa and the Arabian Peninsula (FAO, 2012). RVF, is a World Health Organization for Animal Health (OIE) listed disease and is one of the priority diseases identified by the World Health Organization (WHO) for research and development due

to its potential to cause major epidemics in humans (WHO, 2015). The disease was first discovered in 1931 on a farm in the Great Rift Valley of Kenya (Daubney *et al.*, 1931) and has since become endemic in many countries within Africa (CDC, 2020). Outside of the African continent, RVF has also been confirmed in the Arabian Peninsula countries of Saudi Arabia and Yemen (Soumare *et al.*, 2007). Given the ubiquity of the RVF vectors and the continuous increase in international livestock trade and exchanges, RVF continues to present a constant global risk of expansion out of the current territories (Hartley *et al.*, 2011).

Outbreak of RVF disease usually tend to be cyclical and in endemic regions, infections may persist for years at a low prevalence in vectors and animals (the ‘inter-epizootic period’), then when conditions are optimal (rainfall, and an abundance of vectors and susceptible livestock) there is a dramatic increase in incidence of infections (the ‘epizootic period’). In livestock, Rift Valley fever outbreaks occur after bites from infected mosquitoes (Linthicum *et al.*, 1985). While zoonotic transmission during outbreaks occurs through mosquito-borne transmission and handling of infected ruminant carcasses (Nicholas *et al.*, 2014; Terasaki and Makino, 2015). Peaks in human RVF incidences normally coincide with outbreaks (epizootics) in livestock (Archer *et al.* 2013). Infection in humans is associated with febrile illness though affected patients may recover without long-time sequelae (Kahlon *et al.*, 2010). However, in most cases, up to 10% of the patients may develop full or partial blindness, retinitis, encephalitis, and haemorrhagic fever (Himeidan, 2016). In livestock, RVF outbreaks result in up to 100% mortality in neonatal animals, along with sweeping abortion storms in ruminants (Dar *et al.*, 2013).

Usually, in places where outbreak of the disease has been confirmed, high and detrimental repercussions on animal and public health are registered. Most of the impacts are either direct in terms of deaths of animals, abortions, loss of milk and weight loss due to disease infection or

indirect through the negative impacts of control options being implemented for instance quarantine or trade and slaughter bans. In Saudi Arabia, during the outbreak of 2000, for instance, it was estimated that around 40,000 animals including sheep, goats, camels, and cattle died whereas 8,000–10,000 of them aborted (Al-Afaleq *et al.*, 2011). The outbreaks of 2007 in Sudan led to bans in livestock trade between Saudi Arabia and Sudan, resulting in vast economic impact on the animal market in the two countries (Hassan *et al.*, 2014). Rich and Wanyoike (2010) reported that the 2007 RVF outbreak in Kenya induced losses of over Ksh2.1 billion (US\$32 million) on the economy some of which were attributed to slaughterhouse closures. In the United Republic of Tanzania, RVF outbreak led to a decline in the average price of bulls for slaughter of 33 percent, while the internal flow of marketed cattle decreased by 40 percent, and at least 75 percent of exports were not allowed to leave the country (Rich and Wanyoike, 2010; FAO, 2012). The overall economic loss in East Africa was estimated to exceed \$60 million because of disruption in trade from these recent epizootics between 2006 and 2007 (Little *et al.*, 2009).

First case of Rift Valley fever virus in Uganda was detected in mosquito samples collected from Semliki Forest, Western Uganda, in 1944 (Smithburn *et al.*, 1948). Human cases were subsequently registered during outbreaks that occurred near Entebbe in 1960 and 1962 (Williams *et al.*, 1960; Williams *et al.*, 1963). From then onwards, serological evidence of human and livestock RVFV infections in Uganda have been intermittently reported (Rodhain *et al.*, 1989; Magona *et al.*, 2013), with major outbreak experienced within 2016 to 2018 causing several animal and human mortalities in the Western part of the country (Ly *et al.*, 2017).

Following the latest (2016 – 2018) outbreak, few studies have provided evidence of risk factors for the RVF disease as well as livestock chain actors' knowledge, attitudes and practices in relation to the disease (de St. Maurice *et al.*, 2018; Nyakarahuka *et al.*, 2018), but do not show

how community knowledge and attitudes towards the disease interact to influence RVF disease control behavioral intentions. Moreso, unlike neighboring countries like Tanzania and Kenya where some quantifications of the socio-economic impacts of the disease have been conducted (Rich and Wanyoike, 2010; FAO, 2012). Unfortunately, such investigations have not yet been undertaken in Uganda to gain insights into the welfare implications, food, and nutrition security impacts of the latest outbreak on the livestock farming communities. Failure to capture these diverse impacts may have important implications on the evolution and control of the RVF disease and may accentuate impacts of the disease (Rich and Wanyoike, 2010). Within the policy dimension, a contingency plan was drafted to inform control of the disease at the national level, but this has since not been rolled out. Evaluating the costs and benefits of proposed control measures in the contingency plan through an ex-ante study could go a long way in informing policy decisions and ensuring control measures do not meet resistance from the intended beneficiaries.

1.2 Problem statement

Livestock is one of the most important assets of the poor to meet their livelihood needs (Perry and Grace, 2009). Zoonotic diseases, especially Rift Valley Fever (RVF) are a crucial constraint in the enhancement of livestock-production systems (FAO, 2002), as they pose a big threat to human health, livestock production and marketing. In the East African countries of Tanzania and Kenya for instance, economic losses amounting to over \$60 million have been reported following RVF outbreaks between 2006-2007 (Little et al., 2009; Rich and Wanyoike, 2010). These losses were attributed to decline in market value of livestock, livestock mortality, loss of milk and future animal stocks due to spontaneous RVF-induced abortions and neonatal deaths. In Saudi Arabia, an outbreak in 2000 resulted into deaths of over 4000 animals and close to 10,000 RVF induced abortions (Al-Afaleq et al., 2011). While in Sudan the 2007 outbreak resulted into livestock trade

ban between Saudi Arabia and Sudan thus impacting the animal market (Hassan et al., 2014). Where these outbreaks occur, food security and wellbeing of the livestock chain actors continue to be compromised. This is because the affected animals act as their main repository of wealth and provide valuable goods and services such as milk, meat, blood, manure, transport, draught power, and financial services (Rich and Wanyoike, 2010).

Aversion of the risk of RVF outbreak and the likely consequences involve countries carrying out surveillance which is closely followed up with vaccination programmes (Magona et al., 2013; Alhaj, 2016; Ly et al., 2017). In most other cases, trade bans, animal movement control and quarantine has been witnessed (Otte et al., 2004; Rich and Wanyoike, 2010). It should however be noted that the success and failure of such control measures are dependent on public behavior as highlighted by Bulamu et al. (2019) who showed that acceptance and utilization of a product or service depend on the extent to which it meets the needs and preferences of the target population. Farmers often consider the risk of animal diseases and adapt their behavior based on their vulnerability and ability to reduce the impact of risk (Pradere, 2014). In such cases, adherence to and acceptance of disease control practices gets anchored around the public's knowledge and attitudes towards the disease and its control mechanisms (Chirwa, 2019). Gaining deeper insights into existing public perception and practices can therefore help in identifying attributes that influence the public to adopt healthy practices and responsive behavior (Podder et al., 2019). Public knowledge, attitude, and practices (KAP) relating to zoonotic diseases among livestock farmers also supports policy development and helps in formulation and improvement of existing disease control programs (Singh et al., 2019).

Besides the need to have a clear understanding of public knowledge, attitudes, and practices in order to inform implementation of correct policy measures for the prevention of zoonotic

disease, evidence does suggest that at national and transboundary levels, implementation of disease control policies is not aligned with a comprehensive assessment of the damage caused by the disease (Otte et al., 2004). Birol et al. (2011) show that information related to the magnitude of livelihood impacts of livestock diseases is crucial for design and choice of efficient and cost-effective policies for disease prevention and control. They attest that preferably such information should be available before the occurrence of an actual outbreak so as to help policymakers efficiently allocate scarce resources and design effective contingency plans. Additionally, Otte et al. (2004); Stott and Gunn (2017), suggest that proper determination of disease control policies should involve intense examination of the potential costs and benefits associated with the implementation of available disease control options. Decision to implement a particular disease control policy should then be taken only if the benefit of implementing that particular option exceeds its associated costs.

This study will therefore contribute to the existing body of literature by examining the level of knowledge, attitudes and practices exhibited by livestock chain actors towards RVF and its control mechanisms. Quantification of the likely impact of RVF outbreak on livestock production, food and nutrition security and overall wellbeing of livestock farming households in the pastoral and agro-pastoral livestock production systems of Uganda will also be investigated. Comparisons will be drawn for the impacts of different RVF disease control policies across the livestock value chain in order to inform choice of optimal RVF control policy for implementation in Uganda. Finally, preferences and farmer demand for RVF vaccine will be assessed. Findings from the study will be imperative to policymakers as it will help in the prediction of the likely consequences of RVF disease on farmers welfare outcomes. The cost implications of future disease outbreaks in

the country, as well as the effectiveness of various control options, policies and accurate RVF control measures will also be generated for management of subsequent outbreaks.

1.3 Research questions

The overall objective of this study is to examine the ex-ante social and economic impact of Rift Valley Fever (RVF) control options in pastoral and agro-pastoral livestock production systems of Uganda. To address this broad objective, four chapters in this dissertation were dedicated for addressing the following research questions:

1. How do livestock chain actors' behavioral constructs influence uptake decisions for RVF control practices? (Chapter 2)
2. What are the impacts of on-farm biosecurity practices on livestock farmers' food security and poverty outcomes? (Chapter 3)
3. What are the likely impacts of RVF control options on farm productivity? (Chapter 4)
4. What are farmer preferences and willingness to pay for RVF vaccines (chapter 5)?

1.4 Significancy of the study

Many emerging infectious diseases are receiving an even greater attention than before following the global outbreak of covid19 and RVF is one such disease that has garnered huge interest given its ability to affect both livestock and humans. This ex-ante study premised around socio-economic impacts of RVF control options is therefore bound to offer multiple contributions to stakeholders involved in animal and human health sectors under diverse contexts. First, by determining the level of knowledge, attitudes, and practices involved in the control of Rift valley disease, policy makers can understand behavioural patterns within affected communities that are likely to motivate uptake of disease control policies. Such information can also be used to draft accurate materials for

awareness creation and plan for participatory disease surveillance and reporting programmes that involves everybody in the community.

Examination of welfare implications and the impacts of RVF outbreaks on food and nutrition security is paramount. This will help gain insights into the adverse effects of the disease and to effectively identify remedial measures towards the achievement of the countries strategic and developmental goals such as poverty eradication are being delayed by RVF.

Examining the ex-ante impact of RVF control options will enable decision and policy makers to weigh the potential losses and cost saving benefits that are likely to emerge with the implementation of each RVF control option designed in the countries contingency plan. Such an assessment will subsequently guide policy makers to make informed decisions and only pick out control options that offer optimal solution to the RVF disease outbreak.

Finally, assessing farmer preferences and willingness to pay for RVF vaccine in a country like Uganda where vaccine use against RVF is not yet approved and licenced comes handy as it will enable policy makers to identify a vaccine option that is practically acceptable and meets the preferences and needs of the target beneficiaries. This will eliminate failure in during implementation of vaccination programmes soon as the vaccines get approved for use against RVF in Uganda.

1.5 Study area and data collection

This study was conducted from six districts lying within the cattle corridor gazetted region of Uganda, which covers an estimated land area of about 84,000 km² (about 35%) of Uganda's total land area (Kiggundu et al., 2019). These districts include Isingiro, Lyantonde, Rwampara, Sembabule, Napak, and Butebo. The districts were purposively selected for the study because they

have either experienced RVF infection cases in the last outbreaks of 2016 and 2018 or they fall within list of districts with predicted high risk of RVF exposure and subsequent outbreak in the near future. Further, the districts do reasonably represent the pastoral and agro-pastoral livestock production systems that are widely spread all over the country. The diets of the inhabitants of these corridor districts largely consist of milk or meat and their livelihoods primarily depend on livestock production. Map of Uganda showing the location of study sites is presented in figure 1.

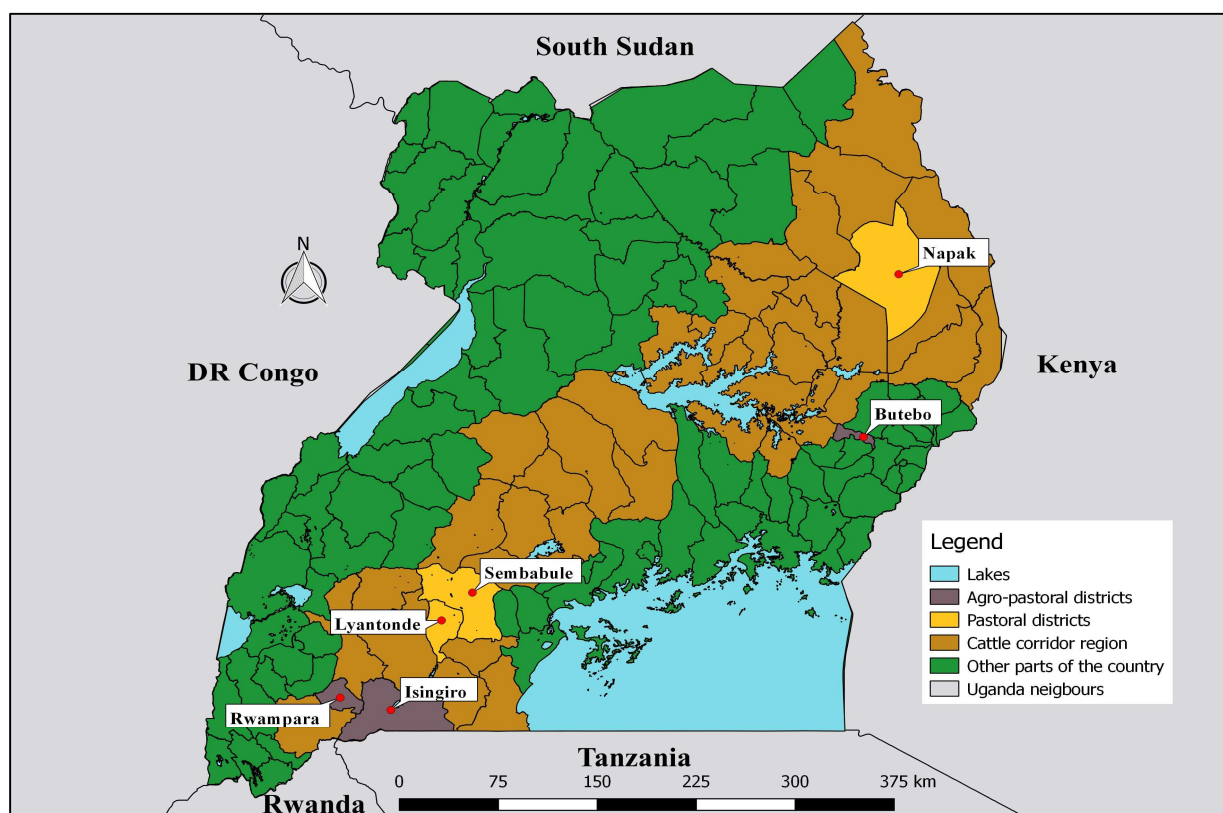


Figure 1. 1 Cattle corridor map of Uganda showing the six study districts.

A multistage random sampling procedure was used to select 444 livestock farming households to participate in the cross-sectional surveys that were conducted. In the first stage, districts were purposively selected based on historical occurrence of RVF, existing level of RVF seroprevalence and predicted risk of future occurrence. Two sub-counties were then picked up from each district in the second stage and one parish with the highest RVF spread risk identified from each sub-

county as the lowest sampling unit in the third stage. Livestock farmer lists were then obtained with the help of local council authorities and area veterinary personnel and used to draw a random sample of 37 farmers per parish (74 per each of the six districts). In addition, a snowball sampling approach was used to recruit 180 other livestock value chain actors including slaughterhouse attendants, butchers, cattle retailers, and transporters into the study. Sixteen (16) sex disaggregated focus group discussions each comprising 6 – 8 participants were also organized to identify Vaccine attributes that were included in the market study in chapter five. Lastly, six (6), key informant interviews were held with specialists in the domain of RVF epidemiology to rank on-farm biosecurity measures implemented against RVF risks. (questionnaires and related guides are attached in the Appendix).

1.6 Organization of the study

This dissertation is organised into six chapters. Chapter one presents the general introduction containing the background, an overview of RVF disease and the impacts of its control measures. The problem statement, research questions, as well as the significance of the study are also contained in this chapter. Chapters 2 to 5 contain cumulation of papers that are soon to be published or submitted to journals. Chapter two explores the influence of livestock chain actor's psycho-social constructs on intentions to take up RVF control measures. In chapter three, the study investigates the impacts of on-farm biosecurity intensification on food security and poverty outcomes. Chapter four contains an assessment of the impact of RVF control options on farm productivity. Chapter five investigates farmers' preferences and willingness to pay for RVF vaccine, and lastly, conclusions and policy implications are presented in chapter six.

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Chapter Two

Psycho-Social Constructs and Uptake of RVF Management Practices: Evidence from Uganda's Livestock Value Chain

Marsy Asindu^{1,2*}, Awudu Abdulai¹, Bernard Bett² and Emily Ouma²

¹Christian Albrechts Universitat zu Kiel (CAU), Kiel, Germany

²International Livestock Research Institute (ILRI), Nairobi, Kenya

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Abstract

Despite increasing economic, animal, and public health burden of emerging infectious diseases, little attention continues to be given to human behavioral constructs that are crucial for the uptake and scaling up of existing and newly developed counter measures against such diseases. As a result, several public health interventions have been met with rejection or even failed to meet their intended objectives when introduced to the communities at risk, thus retarding efforts towards achieving the overall global agenda of good health and well-being. This study investigates how livestock farmers' and other chain actors' psychometric constructs influence behavioral intentions towards Rift Valley fever (RVF) control and prevention practices. We use recent survey data of livestock farmers and other value chain actors from Uganda and employ the principles of partial least square structural equation models in our analysis. The results indicate that positive farmer attitudes are key to driving intentions towards participation in RVF management practices. Social pressure (subjective norms) present within the livestock chain actors' interaction networks is crucial in enforcing their uptake of RVF management practices. The study concludes that for effective promotion of RVF management practices, existing policy frameworks should consider mindset change concepts that trigger positive attitudes among livestock farmers and set out coherent social interaction networks for behavioral enforcement among farmers and other livestock chain actors.

Keywords: Psychometric, PLS-SEM, Rift Valley fever, One Health, Economic behavior.

2.1 Introduction

Emerging infectious diseases continue to hamper progress towards achievement of global health and wellbeing through its tremendous impacts on animal and public health, as well as economies of low and middle-income countries (United Nations Development Group, 2015; Malik et al., 2022). Till late, the direct annual costs attributed to emerging infectious diseases are estimated to be about US\$ 100 billion and are projected to reach several trillion dollars in the event of a pandemic such as the recent Covid19 outbreak (World Bank, 2012). Available statistics reveal that infectious diseases constitute 90% of the global health problems, account for 32% of deaths worldwide and leaves about 1 billion people chronically infected (World Health Organization (WHO), 2018). Approximately 90% of human mortalities from emerging infectious diseases occur in low and middle-income countries, with Africa accounting for about 68% of these deaths (WHO, 2018).

The increased human interface with domestic animals and encroachment into wildlife habitats for agricultural purposes has increased the tendency for cross-infections of pathogens from animals to humans (United Nations Environment Programme (UNEP) and International Livestock Research Institute (ILRI), 2020). Indeed, recent statistics show that over 60% of all emerging infectious diseases wreaking havoc across the globe are Zoonoses (Jones et al., 2008; UNEP and ILRI, 2020). It is reported that out of nearly 30 new human pathogen species that have emerged within the last three decades, 75% are zoonoses (Jones et al., 2008), that mainly originate from domesticated livestock and pets (UNEP and ILRI, 2020).

Among the numerous zoonoses impacting animal and human health, Rift Valley fever (RVF) has gained considerable global attention. The World Health Organization lists it among seven emerging infectious diseases to be prioritized for close global watch. This is because it can

potentially result in outbreaks with huge public and animal health burden, given that to date there is limited to no known medical remedies (WHO, 2015). Rift Valley fever is already endemic in over 16 African countries including Egypt, Senegal, Mauritania, and Tanzania (Center for Disease Control and Prevention (CDC), 2020). Fourteen other countries including Uganda are periodically reporting cases, and graduating to be endemic (Tumusiime et al., 2018, CDC, 2020). Outside the African continent, Saudi Arabia, and Yemen, in the Arabian Peninsula are endemic for the disease (Sindato et al., 2011; CDC, 2020). Given the increasing transmission into new territories, there is an urgent need to institute cost effective prevention and control measures against the disease before it grows into a pandemic.

Prospects for rapid spread and transmission of RVF to newer territories has been associated with changing agroecology, social (human behavior), increased interfaces with some wildlife species and climate change that is offering favorable breeding environment for RVF vectors (Nicholas, 2017; Sabin et al., 2020). Nevertheless, human behaviour remains the single most significant factor shaping RVF transmission and spread (McClymont et al., 2022, Tong et al., 2022). This implies that appropriate design of social and behavioral interventions against RVF transmission and spread under the ‘One health approach’ should consider behavioral responses of the at-risk or exposed populations (McClymont et al., 2022; Tong et al., 2022). The World Health Organization (2011) specifically emphasizes the need to focus on classified behavioral sentiments involving community’s knowledge, attitudes, risk perceptions, cultural, socio and psycho-cognitive components to set up relevant, sustainable, and cost-effective policy instruments that can be adhered to for protection against emerging infectious diseases.

Numerous studies have been conducted to demonstrate how human socio-psychological constructs motivate or demotivate participation in zoonotic disease prevention practices (Romha

and Girmay, 2020; Alemayehu et al., 2021; Castillo and Hernandez, 2023). More specifically, Shabani *et al.* (2015); Affognon et al (2017) and de St. Maurice et al. (2018) focus on RVF. These studies apply diverse statistical approaches ranging from simple descriptive statistics to complex multivariate regression models to explain how human socio-psychological characteristics (knowledge, attitudes, and perceived threats among others) affect their participation in related preventive and control practices. However, they do not show the interaction among these psycho-social constructs as a means to exhibition of intended disease control practices. Moreover, the regular statistical techniques used are only suitable for estimating the relationship between one or more independent variables and a single dependent variable (variables are treated as either dependent (DV) or independent (IV) but not both within the same analysis). Besides, the effects of latent variables often estimated through indicators cannot be identified using the above regression models without having to induce measurement errors.

Several studies have addressed this constraint by adopting behavioral theories and fitting them using Structural equation models (SEM) to predict how socio-psychological factors influence adoption behavior (Tama et al., 2020; Rezaei-Moghaddam et al., 2020; Pacho, 2020). Most of these applications are, however, restricted to understanding adoption of environmental conservation practices and other agricultural technologies with limited application in the field of human and animal health behavioral studies. The current study contributes to the literature by making use of Partial Least Squares Structural Equations Models (PLS-SEM) fitted under the extended theory of planned behavior (ETPB) framework to investigate the interaction across livestock value chain actors' psycho-social constructs and how they drive intentions towards RVF control behavior. Partial Least Squares Structural Equation Models (PLS-SEM) are useful under the current situation as they can be used in estimating relationships involving multiple independent

and dependent variables while considering measurement errors arising from the use of latent variables in equations. They also possess the ability to test theories in the form of equations involving variables that may act as both dependent and independent variables within the same analysis.

The rest of the paper is organized as follows: Section 2.2 introduces the conceptual framework and hypothesis guiding the study. Section 2.3 presents the material and methods which are structured in two parts; the first part covering the survey and data while the second part captures the empirical model estimation procedure. While the results and discussion are presented in section 2.4, the conclusions and policy implications are presented in section 2.5.

2.2 Conceptual framework and hypothesis set-up.

Multiple theories exist in the literature to explain how behavioral changes occur in the health domain. Some notable examples include the Health Belief Model (HBM) (Becker *et al.*, 1974; Shitu *et al.*, 2022), trans-theoretical (Prochaska *et al.*, 2002), the patient empowerment theory (Funnell *et al.* 1991) and the social cognitive theory (Baranowski *et al.*, 2002; Liu *et al.*, 2022). These theories, however, are associated with various shortfalls that limit their use. In particular, Funnell *et al.* (2006) identify the labor-intensive and time-consuming nature of the trans-theoretical models as a major hindrance. The patient empowerment theory in contrast does not pay attention to the role structural and environmental issues play on the ability to enact behavior and also lacks the framework to link causal components of behavioral change explained by the social cognitive theory (Denison, 1996). The HBM, unlike the other theories offers a different paradigm to explaining human health behavior and is more often used in literature (Becker *et al.*, 1974). However, like other theories, the HBM is constrained as it does not actively account for costs, benefits and factors responsible for enabling and maintaining preventive behavior over time (Janz

et al., 2002). Additionally, it does not consider the interaction effects of a complex set of behavioral determinants, rather it considers personal perceptions such as perceived risk and cost, making it too subjective for application.

Ajzen (1991) addresses the limitations in the previous theories by proposing the theory of planned behavior (TPB). Unlike other models, the TPB explains that a person's behavior is determined by the intention to perform that behavior (Ajzen, 1991; Bosnjak et al., 2020). The intention in turn is formed by attitudes towards the behavior, beliefs about what others think he/she should do (subjective norms) and perceived behavioral control. The drawback for this theory, however, is that behavioral intentions do not always lead to actual behavior, because environmental and contextual constraints come into play. Conner and Armitage (1998) reiterated this weakness by revealing that the initial three constructs of attitude, subjective norm and perceived behavioral control were not sufficient to fully explain people's intentions and actions. Ajzen (2011) in his reactions and reflections towards the critics levied against the TPB however suggested that additional predictors can be inserted with caution in cases where for intuitive or theoretical reasons are deemed relevant to the behaviour under study. Following this, the TPB has since been considered as an open framework in which other relevant constructs like knowledge and perceived threats that influence intentions can be incorporated. Further, the framework is flexible to accommodate a few demographic characteristics in the form of control variables. Based on the above arguments, this study develops a conceptual framework (See figure 2.1) that makes use of the TPB and extends it to include Knowledge and perceived threats as well as selected demographic variables like gender to predict how behavioral intentions towards control of RVF will be generated among livestock farmers and other value chain actors (slaughterhouse attendants,

cattle transporters, butchers, and cattle traders). We set up the following hypothesis as the starting point for the study.

Hypothesis 1. Attitude positively affects behavioral intentions.

Hypothesis 2. Knowledge positively affects behavioral intentions.

Hypothesis 3. Subjective norms negatively impact behavioral intentions.

Hypothesis 4. A perceived RVF threat positively influences behavioral intentions.

Hypothesis 5. Attitude mediates between knowledge and behavioral intentions.

Hypothesis 6. Subjective norms mediate knowledge and behavioral intentions.

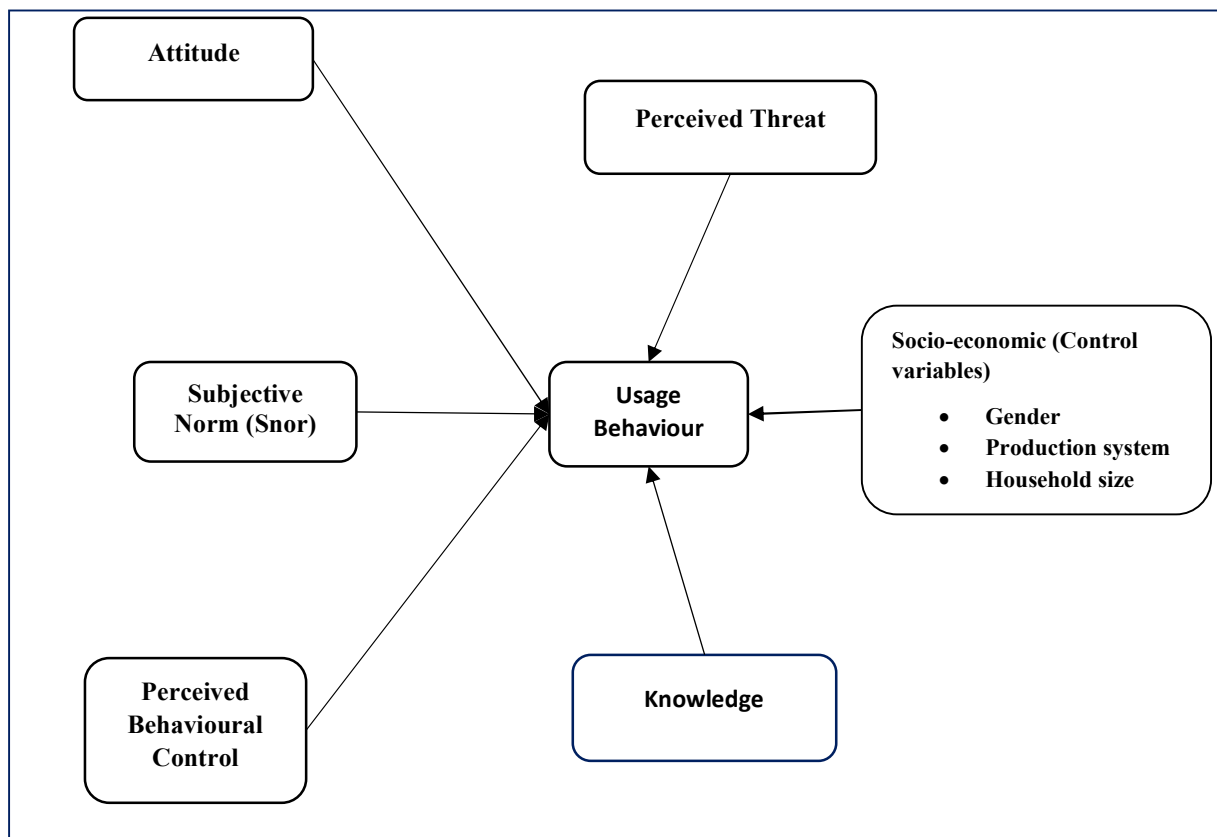


Figure 2. 1 Extended framework for Theory of planned Behaviour (TPB)

2.3 Material and Methods

2.3.1 Survey and Data

Data for this study were obtained through a survey of cattle farming households and other livestock chain actors (cattle traders, butchers, slaughterhouse attendants and cattle transporters) conducted across six districts in Uganda within the period October to December 2021. The cattle farming household sample were drawn using a multi-stage random sampling technique. In the first stage districts were purposively selected because they had either previously experienced RVF infection cases between the years 2016 and 2018, or they fall within list of districts with predicted high risk of RVF exposure and outbreak in the near future. In the second stage, the districts were categorized into pastoral and agro-pastoral based on the criteria defined by FAO. (2018). Three pastoral districts (Napak, Lyantonde and Sembabule) and three agro-pastoral districts (Butebo, Isingiro and Rwampara) were finally picked for the study based on documented RVF seroprevalence records for the respective districts. From each district, sub-counties highly at risk of RVF were identified and within the sub-counties, one parish with the highest risk level for RVF outbreak was identified and used as the lowest level of sampling unit. The choice of cattle farmers and other chain was deliberate because among all domesticated animals, the highest RVF seroprevalence has been documented in cattle. This therefore places farmers and all other chain actors whose livelihoods depend on cattle and are in constant interaction with such animals at high risk of either contracting the disease or facing the economic burden of the disease incase their animals are affected.

An exhaustive list of cattle farming households was generated from all the parishes and entered into the excel package to randomly generate a sample of 444 cattle farming households (74 per district) who were interviewed during the study. The overall sample for cattle rearing households was computed using the following formula.

$$\text{Sample size} = \frac{\frac{Z^2 \times p(1-p)}{e^2}}{1 + \left(\frac{Z^2 \times p(1-p)}{e^2 N} \right)} \dots \dots \dots (1)$$

Where N = Population size, e = Margin of error and Z = Z – Score.

In addition, a snowball sampling technique was used to recruit 180 other livestock value chain actors including slaughterhouse attendants, butchers, cattle retailers, and transporters from across the six study districts for face-to-face interviews. During the interviews with the study participants, semi structured questionnaires designed on Open Data Kit (ODK) were used to extensively capture the respondents socio-economic and demographic details, knowledge, attitudes, and perceptions related to RVF and its potential management practices as well as participants intentions to engage in the implementation of some of the potential RVF management practices.

2.3.2 Empirical model estimation

To fit the PLS-SEM using the extended TPB framework, three sequential stages are usually defined (Lohmöller 1989). First, an iterative estimation of latent variable scores is undertaken. In the second stage scores generated from the first-stage iterative process are utilized to estimate a measurement model(weights/loadings). While in the third stage, structural model parameters (path coefficients) are estimated. These three stages apply effectively when dealing with first/lower order constructs in which each latent variable represents a single theoretical concept and are unidimensional (Edwards, 2001). However, in situations of multidimensional constructs as is the case in this study, a higher-order construct is required, which pit the two-stage disjointed approach of fitting PLS-SEM model proposed by Becker et al. (2012) as the most favorable technique for analysis. To operationalize the two stage, disjoint model, principal component analysis (PCA) was first performed on individual responses to knowledge and behavioral intention statements that

were coded into five classes from strongly disagree to strongly agree (1=strongly disagree to 5=strongly agree). Table 2.1 below shows the loadings for the chain actors Knowledge sub-dimensions based on PCA. Knowledge sub-dimension loadings for the livestock farmers and behavioral intention sub-dimensions for both (livestock farmers and other chain actors are documented in the appendix; Table 2.1A, 2.2A, and 2.3A).

Table 2. 1Chain actors' RVF knowledge sub-dimensions and item loadings

Code	Knowledge statement	Mean	Factor loading	Alpha value	Knowledge dimension
KN2	Consumption of uncooked or half cooked meat can result into RVF	3.94 (0.81)	0.60	0.91	Spread and consequences
KN3	Consumption of raw milk increases risk of contracting RVF	4.01 (0.90)	0.69		
KN5	RVF in humans can only be diagnosed through medical tests	3.64 (0.77)	0.47		
KN6	Humans of all age group are susceptible to RVF infection	3.84 (0.85)	0.81		
KN8	People handling animals and related products without protective gear contract RVF	3.87 (0.84)	0.56		
KN10	Handling of aborted animal without protection spreads RVF	3.84 (0.86)	0.60		
KN11	Animals contract RVF through direct contact with infected animal	3.81 (0.75)	0.56		
KN12	Animals licking, sniffing, and eating aborted fetus contract RVF	3.71 (0.91)	0.68		
KN16	Humans get RVF infection through contact with infected animal tissues and secretion	3.81 (0.76)	0.67		
KN21	RVF can spread from one country to another	3.91 (0.82)	0.78		
KN22	RVF can spread from my district to other regions of the country	4.07 (0.74)	0.73		
KN23	RVF can lead to trade ban between regions within the country	4.04 (0.83)	0.64		
KN24	RVF can lead to trade ban outside the country	3.81 (0.90)	0.65		
KN25	Humans can get RVF incase infected mosquitoes bite them	3.73 (0.80)	0.58		
KN1	RVF disease is spread by mosquito vectors	3.43 (0.81)	0.74	0.80	Outbreak surveillance
KN9	Almost all pregnant animals abort due to RVF infection	3.38 (1.03)	0.64		
KN13	I suspect RVF if there are many sick animals and abortion on farms	3.31 (0.83)	0.66		
KN15	All calves less than 14 days of age die because of RVF	3.24 (0.84)	0.76		
KN7	Herders are the most at risk of RVF infection	3.83 (0.93)	0.78	0.81	Risk exposure and management
KN14	Only trained veterinary specialist can diagnose RVF cases	3.81 (0.83)	0.78		
KN18	Isolation of all sick animals prevents RVF spread	3.83 (0.89)	0.74		

Note: The Cronbach's alpha values for the three-knowledge dimension are above 0.70 reflecting a good measure of internal consistency and reliability of the items used to measure the three knowledge dimensions. Only items that factored above 0.4 were retained. Figures in parenthesis are standard deviations.

A scree plot was generated and used to identify the number of sub-dimensions (knowledge and behavioral intention subdimensions) to be retained and used as lower order constructs. Only sub-dimensions with eigenvalues greater than one on the scree plot were retained (Cattell, 1966) and all items with loadings of less than 0.4 on the sub-dimensions were excluded (Hair et al., 2017).

In the primary stage of the disjoint model, measurement model for all lower order constructs was fitted. Figure 2.2 below illustrates the first stage measurement model for the livestock chain actors in which the subdimensions risk management, outbreak surveillance, spread and consequences represent lower order constructs for knowledge. Meanwhile, prevention and spread control reflect the lower order constructs for chain actors' behavioral intention.

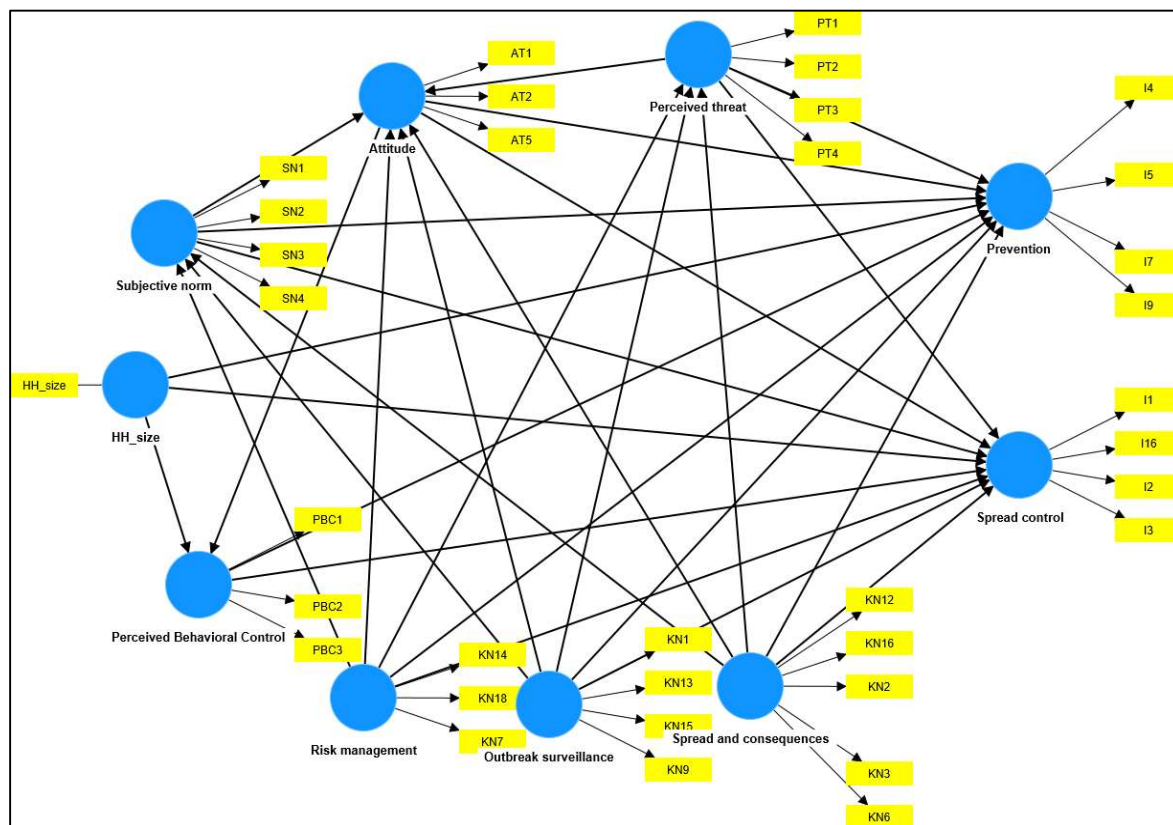


Figure 2. 2 First stage disjointed model for cattle chain actors with only lower order constructs

Latent scores for knowledge and behavioral intention subdimensions are generated from the first stage measurement model presented in figure 2.2 above. In the second stage, the measurement model for the second/higher order constructs are fitted with the latent scores generated from the primary stage being used as indicators for knowledge and behavioral intention (Figure 2.3).

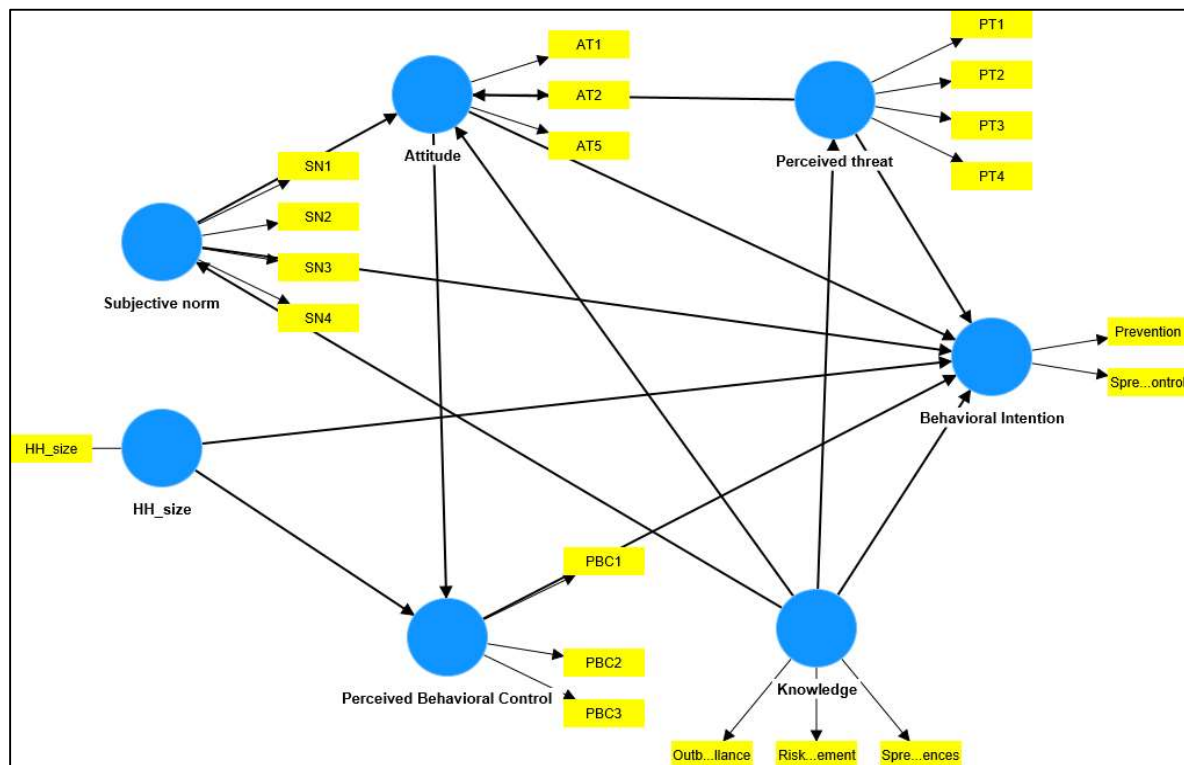


Figure 2. 3 Second stage disjointed model for cattle chain actors with latent scores for lower order constructs used as indicators for higher order constructs (Knowledge and behavioral intention)

The measurement equation for the model illustrated in figure 2.3 above can be specified as follows (Buitrago et al., 2021)

$$I = C'Y + \varepsilon \dots \dots \dots (1)$$

Where I represents the vector of all indicators (yellow colored), Y reflects the vector of latent variables (Blue colored) in the model, C is a complete matrix of loadings relating latent variables

to indicators, and ε is the residuals of all indicators used in the model specification. Following this, the structural model to evaluate the relationship between latent variables can then be expressed as,

$$Y = X_1\beta_1 + X_2\beta_2 + X_3\beta_3 + \zeta_4 \dots \dots \dots (2)$$

With the β 's representing the path coefficients that relate latent variable to each other and ζ 's are the unexplained residuals of the latent variable resulting from the corresponding exogenous latent variables. In each set of estimated structural model, X_1 , X_2 , and X_3 are exogenous variables, whereas Y is endogenous (Joreskog and Sorbom, 1984).

During the assessment of both the measurement and structural models we pay close attention to the following standard evaluation criteria. For the measurement models item loadings, Cronbach's alpha values, Composite reliability, convergent validity, and discriminant validity were considered (Henseler et al., 2016; Hair et al., 2017). The composite reliability (consistency reliability) is a measure of desirability of response patterns to the Likert scale items that study participants are subjected to. Composite reliability (CR) threshold of 0.708 is acceptable for all factors and can be specified in equation as follows (Hair et al., 2010)

$$CR = \frac{(\sum_{i=1}^n FL_i)^2}{(\sum_{i=1}^n FL_i)^2 + (\sum_{i=1}^n ME_i)} \dots \dots \dots (3)$$

where FL_i is the standardized factor loadings of measurement item i , n is the number of items in a factor, and ME_i is the measurement error of the item i .

Convergent validity meanwhile is the measure of the extent to which constructs converge to explain the variance of its items. It is commonly evaluated through the average variance extracted (AVE) and can be expressed as.

$$AVE = \frac{(\sum_{i=1}^n FL_i)^2}{n} \dots \dots \dots (4)$$

where FL_i is defined earlier in equation four (4). The acceptable threshold for the AVE is 0.50 for the constructs to be able to explain at least 50% of its items' variance (Hair et al., 2019).

The last component evaluated at the measurement model level is the discriminate validity which represents the extent to which measurement model constructs are empirically distinct from each other (Hair et al., 2019). The Fornell-Larcker criterion is a common procedure to investigate presence of discriminate validity within a model (Fornell and Larcker, 1981). In this approach, each construct's AVE is compared to the squared inter-construct correlation (shared variance) of that same construct and all other reflectively measured constructs in the structural model. Discriminate validity is then established if the shared variance for all model constructs is not larger than their AVEs (Fornell and Larcker, 1981). New evidence however suggests that reliance on the Fornell larcker criterion for assessment of discriminate validity may not be sufficient in situations where indicator loadings on a particular construct differ only slightly (Henseler et al., 2015). As a result, an additional validity measure referred to as the Heterotrait-Monotrait (HTMT) ratio of correlations (Voorhees et al., 2016) is proposed. The HTMT is the mean value of item correlations across different constructs relative to the average mean correlations for the items measuring the same construct. Under the HTMT concept, the problem of discriminant validity arises when HTMT values exceed an established threshold of 0.85 (conservative threshold) or 0.9 the upper bound (Henseler et al., 2015).

At the structural level Variance Inflation Factor (VIF), the coefficient of determination (R^2), the blindfolding-based cross validated redundancy measure Q^2 , and the statistical significance and relevance of path coefficients and PLS-predict procedure for estimating models'

predictive power (Shmueli et al., 2016). An addition analysis specifically for robustness evaluation is conducted to check for unobserved heterogeneity. A finite mixture (FIMIX-PLS) model in particular was fitted. FIMIX-PLS model assumes that data originate from several sub-samples (segments) and therefore models each of the segments separately with the overall population representing a mixture of the individually modelled segments (Sarstedt, 2008). At every data point, X_i is believed to be a fulfilment of the mixture density with S ($S < \infty$) segments, where:

$$f_{i/s}(X_i|\theta_s) = \sum_{s=1}^S \rho_s f_{i/s}(X_i) \dots \dots \dots (5)$$

With the $\rho_s > 0 \forall s$, $\sum_{s=1}^S \rho_s = 1$, $f_{s/i}(\cdot)$ representing a density function and ρ being the segment specific vector of unknown parameters for segment s . The set of mixing proportions ρ determines the relative mixing of the S segments in the mixture. Full probabilistic clustering of the data into S segments can then be obtained from the fitted posterior probabilities of segment membership.

2.4 Results and discussion

2.4.1 Descriptive statistics

Descriptive statistics for the study participants are reported in Table 2.2 The results reveal that over one third of the participants from pastoral production sites have not attended formal education and across production systems, most of the participants have only attended primary level of education. Household sizes in the pastoral production systems are smaller than those in the agro-pastoral production systems even though at least over a third of the participants from the two sites have heard about the Rift Valley fever disease. Cattle value chain actors from the pastoral production system handled more animals (14) on weekly basis than the agro-pastoral counterparts, and only a tenth of the value chain actors across the two production systems were female.

Table 2. 2 Farmers and other chain actors' socio-demographic characteristics disaggregated by livestock production system.

Variable	Farmers (N=444)		Other chain actors (N=180)	
	Agro-pastoral (222)	Pastoral (222)	Agro-pastoral (90)	Pastoral (90)
Sex = (1= Female) (n (%))	58 (26)	66 (30)	4 (4)	5 (6)
Age (years)	48	46	39	37
Marital status (n (%))	195 (88)	193 (87)	79 (88)	76 (84)
No education (n (%))	38 (17)	79 (36)	9 (10)	37 (41)
Primary level (n (%))	125 (56)	77 (35)	61 (68)	37 (41)
Lower secondary (n (%))	37 (17)	40 (18)	16 (18)	10 (11)
Upper secondary (n (%))	8 (4)	11 (5)	3 (3)	3 (3)
Vocational (n (%))	6 (3)	10 (5)	1 (1)	2 (2)
University degree (n (%))	8 (4)	5 (2)	0 (0)	1 (1)
Have heard about RVF (n (%))	78 (35)	76 (34)	29 (32)	26 (29)
Household size (Persons)	7	6	6	5
Number of animals handled weekly	-	-	5	14

Note: n represents frequency and figures in parenthesis are percentages

2.4.2 Reliability and validity of the measurement models

Table 3 and 4 report the mean scores, standard deviations and alpha values for Likert scale items that loaded significantly on the different psycho-social constructs (attitude (AT), perceived behavioral control (PBC), perceived threat (PT) and subjective norms (SN) that were used to fit the lower order measurement models. Tables 2.3 and 2.4 omit item loadings for knowledge and behavioral intentions which were treated as high order constructs with pre-existing subdimensions presented in Table1 and Tables 2.1A, 2.2A, and 2.3A in the appendix. The alpha values are above 0.7, which is a good indicator of reliability.

Table 2. 3 Farmers' mean item scores and Cronbach alpha coefficients for Likert statements.

Item code	Item statement	Mean	Alpha value
AT1	It is our role and not the government to vaccinate animals against RVF	4.17 (0.74)	0.81
AT2	Vaccination against RVF will still happen even if the vaccines are expensive	3.96 (0.95)	
AT3	Keeping our animals under quarantine during RVF outbreaks will save them from dying	4.06 (0.89)	
AT4	Meat should be recalled, and slaughters banned if RVF outbreaks occur in this community	3.93 (0.94)	
PBC1	I know how to protect myself from acquiring the RVF disease	2.77 (1.18)	0.89
PBC2	I have enough resources to enable me carry out RVF control on my farm	2.41 (1.15)	
PBC3	I am confident that I am in position to implement most RVF control measures	2.48 (1.10)	
PBC4	I do not see any difficulties in implementing the suggested RVF control measures	2.43 (1.26)	
PT1	Many animals will pick RVF infection if taken to vaccination points	2.87 (1.31)	0.72
PT2	Animals will abort if they are vaccinated against RVF	2.81 (1.10)	
PT3	Many animals will die in case they are vaccinated against RVF	2.59 (1.10)	
SN1	Patients suffering from RVF should be isolated from the community	3.35 (1.09)	0.83
SN2	If I get RVF infection, I will be stigmatized in the community	3.50 (1.01)	
SN3	Herders around will not allow my animals in the communal ground if they suspect my animal has RVF	3.67 (0.98)	

Note: figures in parenthesis are standard deviations, Alpha values for each category of statements is above the minimum threshold of 0.7

Table 2. 4 Chain actors' mean item scores and Cronbach alpha coefficients for Likert statements.

Item code	Item statement	Mean	Alpha value
A1	Livestock trade bans are good for management of RVF	3.77 (1.04)	0.76
A2	I am okay with the implementation of slaughter bans for RVF control	3.92 (1.05)	
A5	I am in support of quarantine for management of RVF	3.41 (0.98)	
PBC1	I know how to protect myself from acquiring the RVF disease	3.10 (0.94)	0.74
PBC2	I have the capacity to put in place all the necessary requirements for RVF mitigation.	3.17 (0.92)	
PBC3	I am able to continue using some of the current disease prevention measures	3.08 (1.05)	
PT1	People are likely not to eat meat and drink milk due to RVF	4.21 (0.68)	0.76
PT2	International trade restrictions will be implemented due to RVF	3.94 (0.76)	
PT3	Suppliers will increase the price of animals due to RVF	4.21 (0.69)	
PT4	RVF will greatly impact milk production	3.97 (0.80)	
SN1	My family and friends will discourage me from dealing in livestock business	3.89 (0.94)	0.72
SN2	Meat will be recalled, and slaughters banned due to RVF outbreaks	3.87 (0.95)	
SN3	All slaughterhouses will close due to RVF outbreak in this area	4.06 (0.81)	
SN4	I and my colleagues will not get animals from RVF infected areas	3.59 (1.12)	

Note: figures in parenthesis are standard deviations, Alpha values for each category of statements is above the minimum threshold of 0.7

Reliability of the measurement models revealed through cross loadings and significance of all items loaded on the latent variables for the farmer and other value chain actor models computed and reported in Table 2.4A, 2.5A, 2.6A, and 2.7A are attached in the appendices. The results show that the indicators (items) load highest for the latent variables (psycho-social constructs) they were predicting than it is for all other latent variables included in the model. Further, the individual item loadings are all significant, which indicates that the constructs used in the models explain at least more than 50 per cent of the indicator's variance, thus providing acceptable item reliability (Hair et al., 2017; Hair et al., 2019).

Results of internal consistency reliability and convergent validity for both (Farmer and other chain actors' measurement models) are presented in Table 2.5. The findings show that composite reliability (ρ_c) values for all constructs are above 0.70, which is the lowest acceptable value in any exploratory research (Jöreskog's, 1971). The alpha values are within satisfactory range of 0.6 and above (Hair et al., 2019), while the composite reliability (ρ_A) values which is an additional measure proposed to test for robustness of Cronbach's alpha and Composite reliability (ρ_c) fall in between the alpha and composite reliability (ρ_c) values obtained, and are above 0.6 threshold (Dijkstra and Henseler, 2015). The average variances extracted (AVE) for the two models are above 0.5, which is the recommended cutoff point for good internal consistency reliability to be established (Hair et al., 2019). This implies that each of the constructs included in the measurement models estimated explain at least 50 per cent of the variance of its items.

Table 2. 5 Construct reliability and validity estimates for the farmer measurement model.

Latent variables	Cronbach's alpha	Composite reliability (rho_A)	Composite reliability (rho_c)	Average variance extracted (AVE)
Farmer model				
Attitude	0.817	0.86	0.877	0.642
Behavioral Intention	0.625	0.629	0.799	0.571
Knowledge	0.691	0.694	0.866	0.764
Perceived Behavioral Control	0.894	0.896	0.927	0.76
Perceived Threat	0.729	0.867	0.837	0.634
Subjective norm	0.836	0.904	0.900	0.75
Other chain actors' model				
Attitude	0.759	0.799	0.857	0.667
Behavioral Intention	0.636	0.637	0.846	0.733
Knowledge	0.512	0.666	0.744	0.503
Perceived Behavioral Control	0.739	0.781	0.849	0.652
Perceived threat	0.768	0.772	0.851	0.588
Subjective norm	0.726	0.726	0.829	0.549

Note: All Average variance extracted (AVE) values are above the recommended 0.5 threshold, most of the rho_A values fall between alpha and rho_c values, rho_c values are all above 0.7 cutoff.

Results of the Fornell Larcker criterion measure of discriminate validity are presented in Tables 2.6 and 2.7. Comparison of each construct's AVE (diagonal elements in Tables 2.6 and 2.7) with the squared inter-construct correlation (values underneath the diagonal elements) show that each construct's AVE is larger than the values for the inter-construct correlations, which is proof that the constructs used in the models are empirically distinct from each other and therefore discriminate validity is established (Fornell and Larcker, 1981). Results of the heterotrait monotrait (HTMT) ratio correlation, which is an additional measure of discriminate validity are displayed in Table 2.8A and 2.9A for both the farmer and other chain actors' model. All values are below the lower bound (0.85) and upper bound (0.90) which is evidence that the psycho-social constructs used in the models are conceptually distinct from each other (Henseler et al., 2015).

Table 2. 6 Discriminate validity for the farmer model.

	AT	BI	Gen	KN	PBC	PT	PDE	PDN	SN
Attitude (AT)	0.801								
Behavioral Intention (BI)	0.368	0.755							
Gender (Gen)	-0.080	-0.016	1						
Knowledge (KN)	0.219	0.584	-0.031	0.874					
Perceived Behavioral Control (PBC)	-0.121	0.056	-0.023	0.18	0.872				
Perceived Threat (PT)	-0.200	-0.121	-0.06	0.024	0.336	0.796			
Previous Disease Encounter (PDE)	0.034	0.061	-0.031	-0.06	-0.148	-0.178	1		
Production system (PDN)	-0.316	-0.031	0.04	0.072	0.369	0.309	0.048	1	
Subjective norm (SN)	0.230	0.14	0.027	0.183	-0.014	-0.020	-0.043	-0.126	0.866

Note: The square root of each constructs AVE (bold diagonal figures) is larger than the squared inter-construct correlation values that are reported below the diagonal figures thus demonstrating that the constructs are empirically distinct from each other. Negative sign shows a negative correlation.

Table 2. 7 Discriminate validity for the other livestock chain actor's model.

	AT	BI	HH_Size	KN	PBC	PT	SN
Attitude (AT)	0.817						
Behavioral Intention (BI)	0.057	0.856					
Household Size (HH_Size)	-0.167	-0.06	1				
Knowledge (KN)	-0.083	0.434	0.117	0.709			
Perceived Behavioral Control (PBC)	-0.105	0.053	0.163	0.194	0.808		
Perceived threat (PT)	0.131	0.476	0.139	0.589	0.022	0.766	
Subjective norm (SN)	-0.009	0.397	0.11	0.449	0.108	0.331	0.741

Note: The square root of each constructs AVE (bold diagonal figures) is larger than the squared inter-construct correlation values that are reported below the diagonal figures thus demonstrating that the constructs are empirically distinct from each other. Negative sign shows a negative correlation.

2.4.3 Farmer psycho-social construct relationships

Results displayed in Table 2.8 show that farmers' attitudes have significant and positive effects on their intentions to take up RVF management practices. This validates hypothesis 1 of the study which postulates that attitudes positively influence behavioral intentions and implies that when farmers' attitudes become favorable towards existing and proposed RVF management practices, their intention to take up these practices is boosted. Additionally, establishment of positive attitudes results in better feeling by farmers towards existing social pressure (Subjective norm) to take up RVF management interventions. These findings corroborate with those of Hartmann et al.

(2022) who report that positive attitudes have an overall positive influence on compliance which is demonstrated through the farmers' positive intentions.

Knowledge has positive effects on subjective norms, attitudes, and intentions to take up RVF management practices. As farmers' knowledge concerning RVF and its related management practices increases, they tend to build favorable attitudes and intentions to participate in the implementation of such practices. Increased knowledge levels are also shown to promote greater feelings about social/peer pressure to take up RVF management practices.

Experience of previous livestock disease encounters encourages farmers to readily associate fewer threats to available control measures, even though they tend to feel less capable of executing the available control measures. This implies that perceived indirect effects of available RVF control measures like vaccines, quarantines, trade bans among others are generally lower than the cost of managing an infection already established on the farm, thus the fewer threats perceived by the farmers. However, due to financial constraints and the requirements to implement the practices, farmers with previous disease encounter experience may feel they don't have adequate capacity and capabilities to implement the suggested practices.

An increase in threats (Perceived threats) associated with potential RVF control measures like vaccines results into negative attitudes and lowers farmer intentions to take up the practice. Farmers rely on the animals to meet their daily needs and requirements therefore if they perceive that certain RVF management practices (vaccines and quarantines) are going to negatively impact on the animal's health and overall productivity, they will build negative attitudes, and refrain from taking up such interventions.

Farmers in the pastoral production systems have negative attitudes towards the available RVF control measures and feel negative about the influence of peer pressure much as, they show

higher capabilities to implement RVF management practices. These results can be explained by the fact that farmers in the pastoral production systems tend to associate lots of threats with RVF management options like vaccination. This prompts them to build negative attitudes, as they feel such will impact on milk production and their revenue streams. However, on a general observation, when farmers' perceived capabilities improve the more positive, they tend to consider threats associated with RVF control practices like vaccines. Increased perceived threats build negative attitudes in farmers.

Table 2. 8 Direct relationship among farmer psycho-social constructs

Farmer psycho-social construct relationship	Estimates	Standard deviation	T statistics
Attitude -> Behavioral Intention	0.247***	0.04	6.041
Attitude -> Subjective norm	0.172**	0.055	3.075
Gender -> Attitude	-0.152	0.1	1.504
Gender -> Behavioral Intention	0.04	0.084	0.459
Knowledge -> Attitude	0.242***	0.045	5.375
Knowledge -> Behavioral Intention	0.533***	0.038	14.105
Knowledge -> Perceived Behavioral Control	0.144**	0.044	3.259
Knowledge -> Perceived Threat	-0.044	0.047	0.937
Knowledge -> Subjective norm	0.153**	0.05	3.044
Perceived Behavioral Control -> Behavioral Intention	0.019	0.041	0.495
Perceived Behavioral Control -> Perceived Threat	0.236***	0.054	4.316
Perceived Threat -> Attitude	-0.121**	0.044	2.684
Perceived Threat -> Behavioral Intention	-0.084*	0.039	2.16
Previous Disease Encounter -> Behavioral Intention	0.193	0.104	1.852
Previous Disease Encounter -> Perceived Behavioral Control	-0.423***	0.116	3.653
Previous Disease Encounter -> Perceived Threat	-0.422***	0.113	3.738
Production system -> Attitude	-0.59***	0.085	6.92
Production system -> Behavioral Intention	0.041	0.08	0.523
Production system -> Perceived Behavioral Control	0.735***	0.084	8.777
Production system -> Perceived Threat	0.469***	0.094	4.984
Production system -> Subjective norm	-0.166	0.100	1.649
Subjective norm -> Behavioral Intention	-0.009	0.035	0.279

Note: ***, **, and * represents 0.001, 0.01, and 0.05 level of significance respectively

2.4.4 Chain actors' psycho-social construct relationships

Findings from the analysis of psycho-social construct relationship for the chain actors displayed in table 2.9 reveal that chain actors from larger households in terms of numbers have lesser intentions to adopt RVF management practices even though they have the needed capabilities to execute the practices. This is because larger household sizes come along with high financial requirements for maintenance. As a result, RVF management programmes like slaughter bans, trade bans, animal movement bans among others which have potential to reduce income flows for chain actors are often met with resistance.

An increase in chain actors' knowledge about available RVF management options results in negative attitudes towards RVF management interventions. This finding violates hypothesis 2 of our study which postulates that knowledge positively affects behavioral intentions and this could be attributed to the indirect negative effects of the available options (slaughter bans, quarantine etc) on the chain actors' incomes and businesses. On a positive note, however, increased knowledge levels are shown to enable actors to appreciate that RVF possess severe threats to livestock and also feel positive about the influence of peer pressure to implement or participate in RVF management practices.

Increase in perceived threats associated with RVF on livestock production and trade improves on chain actors' attitudes towards RVF control and prevention measures and builds positive intentions towards participation in RVF management practices. Lastly chain actors tend to exhibit positive intentions towards participation in RVF management practices when subjected to social pressure as revealed by the positive relationship between the subjective norm and behavioral intention psycho-social constructs.

Table 2. 9 Direct relationship among other chain actors' psycho-social constructs

Chain actor psycho-social construct relationship	Estimates	Standard deviation	T statistics
Attitude -> Behavioral Intention	0.003	0.083	0.057
Attitude -> Perceived Behavioral Control	-0.083	0.109	0.734
HH_size -> Behavioral Intention	-0.150**	0.058	2.597
HH_size -> Perceived Behavioral Control	0.158	0.084	1.774
Knowledge -> Attitude	-0.278*	0.121	2.057
Knowledge -> Behavioral Intention	0.142	0.131	1.130
Knowledge -> Perceived threat	0.600***	0.060	9.830
Knowledge -> Subjective norm	0.461***	0.068	6.655
Perceived Behavioral Control -> Behavioral Intention	0.013	0.081	0.209
Perceived threat -> Attitude	0.296*	0.115	2.374
Perceived threat -> Behavioral Intention	0.337**	0.103	3.204
Subjective norm -> Attitude	0.021	0.096	0.131
Subjective norm -> Behavioral Intention	0.235*	0.093	2.533

Note: ***, **, and * represents 0.001, 0.01, and 0.05 level of significancy respectively

2.4.5 Mediations effects of livestock farmer and other chain actors' psycho-social constructs

Mediation results for the farmer and other chain actors' psycho-social constructs are presented in Table 2.10. Only mediations between other psycho-social constructs and behavioral intentions are reported. The findings from the farmer model reveal that farmer attitudes negatively mediate the relationship between production system and behavioral intention. Farmers from pastoral production system heavily rely on livestock and related products for their livelihoods. This makes them attach higher value to the threats presented with some RVF management measures like vaccination, which they perceive can reduce milk production or even result in death of their animals. This leads to the build of negative attitudes and eventually low drive and intention to take up proposed interventions. Likewise, the effect of perceived threat on behavioral intention is negatively mediated by attitudes.

The relationship between knowledge and behavioral intention is positively mediated by the attitude psycho-social construct thus validating hypothesis 5 of the study which indicates that attitudes positively mediate between knowledge and behavioral intentions. This clearly reveals

that farmers' knowledge of RVF, and related management practices help them build positive attitudes and in turn encourages them to build positive intentions towards uptake of the available and proposed practices. Farmers' perceived threats likewise positively mediate the impact of previous disease encounter on behavioral intention. Farmers who have previously encountered diseases on their farms are conversant with the cost implications of managing diseases as such, they tend to associate more threats to occurrence of any disease such as the RVF, which prompt them to always build higher intentions to carry out timely disease prevention interventions.

Table 2. 10 Mediation for farmer and other chain actors' psycho-social constructs

	Estimates	Standard deviation	T statistics
Farmer model			
Production system -> Perceived Threat -> Behavioral Intention	-0.039	0.020	1.951
Production system -> Attitude -> Behavioral Intention	-0.146***	0.033	4.359
Previous Disease Encounter -> Perceived Threat -> Behavioral Intention	0.036	0.020	1.820
Perceived Behavioral Control -> Perceived Threat -> Behavioral Intention	-0.020	0.010	1.915
Perceived Threat -> Attitude -> Behavioral Intention	-0.030*	0.011	2.526
Knowledge -> Attitude -> Behavioral Intention	0.060***	0.015	3.977
Other chain actors' model			
Attitude -> Perceived Behavioral Control -> Behavioral Intention	-0.001	0.011	0.125
Knowledge -> Subjective norm -> Behavioral Intention	0.109*	0.049	2.177
Knowledge -> Perceived threat -> Behavioral Intention	0.205**	0.074	2.625

Note: ***, **, and * represents 0.001, 0.01, and 0.05 level of significance respectively

The mediation results for the other chain actors displayed in table 2.10 show that the relationship between knowledge and behavioral intention is successfully mediated by the subjective norm psycho-social construct thus supporting hypothesis five of the study. Perceived threat positively mediates the impact of knowledge on behavioral intention. This implies that for chain actors to successfully take up RVF interventions, there needs to be some kind of enforcement and use of established social network structures to induce uptake. Besides, adequate knowledge on the threats associated with RVF outbreaks have to be provided to ignite their participation.

2.4.6 Robustness checks

Table 2.10A in appendix presents the fit indices for the farmer and other value chain actors models obtained from analysis using varied segment sizes as a measure of unobserved heterogeneity. Overall, the results suggest that there is no substantial issue related to heterogeneity based on response patterns in the datasets used for analysis. The AIC, AIC3, AIC4, BIC and CAIC point to four segments, yet the validation criterion requires that the correct segment is one where the AIC3, AIC4, BIC and CAIC are greater than the segment indicated by the MDL5 but less than the segment indicated by the AIC (Sarstedt et al., 2019). This justifies the validity of analysis and reporting of results using aggregate data set for both the farmer and other value chain actors (Hair et al., 2016a). Further analysis of membership probabilities of belonging to the various segments (See table 2.11A in appendix) show that conducting analysis with two or more segments is not satisfactory, as the number of observations would be below the minimum sample sizes required to make sensible predictions (segment sizes from two and above constitute only a small proportion of the overall sample, which does not meet the required minimum of 109 and 98 required for inference for the farmers and chain actors, respectively).

The results in Table 2.12A in the appendices portray that with exception of the subjective norm latent variable in the farmer model whose mean value is below 0.1, all coefficients of determination (R^2 values) for the farmer and other livestock value chain actors' model are statistically significant and above the 0.1 threshold that is acceptable (Shiau et al., 2019). This implies that the exogenous constructs used in the model sufficiently explain and account for the variance in the endogenous variable used in the model (Hair et al., 2016a).

The Stone-Geisser's Q^2 test results for the farmer and other chain actors model presented in table 2.13A attached in the appendices are all none zero. This is evidence that the exogenous

variables used in the model well predict the endogenous variable under study and that in totality, the PLS-SEM path models estimated hold some adequate predictive relevance (Hair et al., 2019).

2.5 Policy Implications and conclusions

Prior assessment of the interactions across different human psychometric constructs and how they are likely to drive intentions to participate in emerging infectious disease management practices is hardly implemented when setting out policy decisions for the control and prevention of these diseases. This often leads to mass failure and rejection of interventions rolled out by authorities for the prevention and control of such diseases. In this study, using an extended theory of planned behaviour framework, we fit partial least square structural equation models to investigate how human socio-psychological constructs including knowledge, attitudes, perceived threat, subjective norms, perceived behavioral control and selected socio-economic(control) variables interact to influence farmers and other livestock chain actors' intentions to engage in planned RVF management practices in Uganda.

The findings of the study reveal that engagement in RVF risk exposing behaviors among farmers and other livestock chain actors is more prevalent in the pastoral production systems than it is in the agro-pastoral systems. Positive attitudes and previous disease encounter are the main psycho-social constructs driving farmers intentions towards engagement in RVF management practices. Knowledge of RVF disease and its related management practices positively impact participation intentions, but such effects are buffered if knowledge is supplemented with attitude change as observed through the mediation effects in the farmer model. The results also reveal that even though farmers in the pastoral production systems acknowledge that there is a high level of threat posed by RVF, they are less likely to engage in related management practices because of the negative attitudes they hold. For the other livestock chain actors, it is evident that participation

intentions towards RVF management practices are positively driven by social pressure (subjective norm), which also fully seem to mediate the effect of knowledge on their behavioral intentions.

The disclosures from the results imply that effective roll out of RVF prevention and management programmes should be preceded by sensitization and awareness programmes that trigger positive attitudes towards planned and existing RVF management practices. Moreover, a socially acceptable and logical interaction network should be established and used to enforce uptake of the management practices among the other livestock value chain actors. Lastly, while the study sufficiently attempts to explain the effects of farmer and other livestock chain actors' psycho-social constructs on their intentions to participate in RVF management practices, it is limited in scope, as it focuses only on the intra-personal concepts, thus ignoring the role played by inter-personal linkages such as social distancing and networks in disease spread and management which needs to be explored.

2. 6 References

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Appendices

Table 2.1A Livestock farmers' RVF knowledge sub-dimensions and item loadings

Item Code	Knowledge statement	Mean	Factor loading	Alpha value	Knowledge dimension
KN12	Almost all pregnant animals abort due to RVF infection	3.47 (0.92)	0.43	0.84	Husbandry practice
KN13	Handling of aborted animal without protection spreads RVF	3.70 (0.84)	0.66		
KN15	Animals licking, sniffing, and eating aborted fetus contract RVF	3.79 (0.76)	0.63		
KN16	I suspect RVF if there are many sick animals and abortion on farms	3.31 (0.94)	0.58		
KN17	All calves less than 14 days of age die because of RVF	3.46 (0.72)	0.45		
KN18	Humans get RVF infection through contact with infected animal tissues and secretion	3.64 (0.74)	0.56		
KN20	Isolation of all sick animals prevents RVF spread	3.83 (0.82)	0.75		
KN21	Isolation of aborted animals is essential to RVF prevention	3.71 (0.88)	0.73		
KN22	RVF commonly occurs in years with heavy and above average rains	3.66 (0.81)	0.46	0.83	Health & food safety
KN4	Consumption of uncooked or half cooked meat can result into RVF	3.94 (0.74)	0.82		
KN5	Consumption of raw milk increases risk of contracting RVF	4.04 (0.75)	0.78		
KN6	Animal slaughter under veterinary supervision prevents RVF	3.74 (0.78)	0.51		
KN7	RVF in humans can only be diagnosed through medical tests	3.70 (0.80)	0.43		
KN8	Humans of all age group are susceptible to RVF infection	3.75 (0.71)	0.53		
KN9	Herdors are the most at risk of RVF infection	4.03 (0.82)	0.46		
KN10	Butchers handling animals and products without protective gear easily contract RVF disease	3.89 (0.76)	0.42		
KN11	Animal blood sample is the most appropriate for testing RVF	3.73 (0.84)	0.60	0.72	Host & spread mechanism
KN1	RVF disease affects both humans and animals	3.62 (0.78)	0.54		
KN2	RVF can be spread to animals and humans through mosquito vectors	3.52 (0.78)	0.67		
KN3	One can contract RVF if he gets into contact with an infected person	3.48 (0.79)	0.73		

Note: Cronbach's alpha values for the three livestock farmers' knowledge dimensions are above 0.70 reflecting a good measure of internal consistency and reliability of the items used to measure the three knowledge dimensions. Only items that factored above 0.4 were retained.

Table 2.2A Chain actors' behavioral intention sub-dimensions and item loadings

Code	Intention statements	Mean	Factor loading	Alpha value	Behavioral Intention dimension
I4	I intend not to consume any raw milk to avoid RVF	4.31 (0.54)	0.64	0.80	Preventive practices
I5	I intend not to eat any raw or half cooked meat	4.27 (0.49)	0.68		
I7	I intend to conduct all animal slaughters away from the homestead	4.32 (0.54)	0.57		
I8	I intend to disinfect transportation facilities for meat and live animals	3.33 (1.24)	0.46		
I9	I intend to always use and sleep under mosquito net	4.34 (0.58)	0.72		
I11	I intend to only deal in meat that has been inspected by veterinary staff	3.77 (1.07)	0.54		
I18	I intend not to immediately mix animals from the market with those at home	4.10 (0.78)	0.50	0.77	Spread control practices
I1	I intend to purchase animals from only places without disease outbreak	4.27 (0.57)	0.59		
I2	I intend to restrict movement of my animals when disease breaks out	4.23 (0.59)	0.58		
I3	I intend to vaccinate all animals i keep for later slaughter	3.84 (1.09)	0.76		
I16	I intend to purchase animals that are cleared as disease free	3.49 (1.27)	0.68	0.87	Contact minimization
I10	I intend to regularly spray mosquitoes	4.16 (0.65)	0.82		
I13	I intend to always wear protective gear when handling animals	4.13 (0.68)	0.83		
I17	I intend not to slaughter animals that are sick	4.23 (0.75)	0.77		

Note: Cronbach's alpha values for the livestock value chain actors' behavioral intention dimensions are above 0.70 reflecting a good measure of internal consistency and reliability of the items used to measure the three behavioral intention dimensions. Only items that factored above 0.4 were retained.

Table 2.3A Livestock farmers' behavioral intention sub-dimensions and item loadings

	Intention statements	Mean	Factor loading	Alpha value	Category
I3	I intend to vaccinate my animals against RVF	4.47 (0.60)	0.79	0.91	prevention
I4	I intend not to consume raw milk to avoid contracting RVF	4.48 (0.61)	0.81		
I5	I intend not to consume half cooked meat to avoid contracting RVF	4.51 (0.58)	0.84		
I9	I will sleep under mosquito net to avoid mosquito bites	4.46 (0.57)	0.79		
I10	I will regularly spray mosquitoes to avoid disease spread	4.34 (0.68)	0.53		
I14	I intend to regularly monitor my animals for any suspicious disease symptoms	4.48 (0.58)	0.80		
I20	I intend not to sleep with animals in the same house	4.48 (0.59)	0.81		
I1	I intend to isolate aborted animals to avoid RVF spread	4.43 (0.59)	0.65	0.82	control
I2	I intend to quarantine my animals incase RVF breaks out	4.47 (0.57)	0.69		
I16	I intend to cull animals with suspicious diseases on the farm to reduce RVF	4.38 (0.62)	0.62		
I17	I intend not to mix my animals with others while in the grazing site	4.26 (0.75)	0.73		
I18	I intend not to mix animals from the market immediately with those at home	4.39 (0.60)	0.72		
I19	I intend not to herd in communal grounds	4.18 (0.88)	0.58		
I6	I will burn or bury all dead animals as a way of preventing RVF spread	4.49 (0.56)	0.47	0.79	Food safety
I7	I intend to slaughter animals away from my homestead	4.47 (0.65)	0.49		
I8	I intend to use protective gears while helping animals during delivery	4.16 (0.86)	0.76		
I11	intend to consume only meat that been inspected	4.48 (0.56)	0.44		
I12	I intend not to eat any meat from dead animals	4.54 (0.53)	0.50		
I13	I intend to regularly wear protective gloves when handling meat	4.14 (0.88)	0.74		

Note: Cronbach's alpha values for the three livestock farmers' behavioral intention dimensions are above 0.70 reflecting a good measure of internal consistency and reliability of the items used to measure the behavioral intention dimensions. Only items that factored above 0.4 were retained.

Table 2.4A Indicator cross loadings on the higher order latent constructs for the livestock farmers

Item code	Attitude	Behavioral Intention	Knowledge	Perceived Behavioral Control	Perceived Threat	Subjective norm
AT1	0.856	0.366	0.188	-0.23	-0.262	0.211
AT2	0.753	0.208	0.156	-0.035	-0.091	0.212
AT3	0.863	0.355	0.193	-0.029	-0.126	0.203
AT4	0.724	0.194	0.162	-0.038	-0.119	0.087
Control	0.233	0.722	0.356	0.068	-0.144	0.151
Food safety	0.303	0.8	0.443	-0.009	-0.173	0.099
Prevention	0.291	0.742	0.511	0.072	0.032	0.076
Health and Food safety	0.216	0.54	0.885	0.079	-0.074	0.213
Husbandry practice	0.165	0.479	0.862	0.243	0.125	0.102
PBC1	-0.075	0.067	0.278	0.817	0.266	0.033
PBC2	-0.137	0.024	0.108	0.893	0.299	-0.061
PBC3	-0.092	0.053	0.111	0.892	0.312	-0.019
PBC4	-0.116	0.051	0.137	0.883	0.292	-0.001
PT1	-0.215	-0.132	0.061	0.345	0.894	-0.022
PT2	-0.088	-0.051	-0.008	0.238	0.742	-0.028
PT3	-0.14	-0.083	-0.034	0.17	0.742	0.009
SN1	0.168	0.035	0.136	-0.046	0	0.828
SN2	0.206	0.089	0.088	-0.026	-0.01	0.849
SN3	0.218	0.2	0.22	0.018	-0.034	0.917

Note: Figures in bold are item loadings for latent constructs below which they are enlisted. It can be observed from the table that the items load higher for the latent constructs they were predicting than it is for other constructs which is an indicator of the reliability of the items used for the measurement. The – sign signifies negative correlation.

Table 2.5A Indicator cross loadings on the higher order latent constructs for the other livestock chain actors

Item code	Attitude	Behavioral Intention	Knowledge	Perceived Behavioral Control	Perceived threat	Subjective norm
AT1	0.825	0.015	-0.084	-0.053	0.118	0.004
AT2	0.861	0.047	-0.086	-0.142	0.11	-0.013
AT5	0.762	0.099	-0.012	-0.038	0.089	-0.015
Prevention	0.185	0.862	0.332	0.021	0.44	0.331
Spread control	-0.093	0.85	0.412	0.071	0.373	0.35
Outbreak surveillance	-0.292	0.138	0.593	0.268	0.225	0.223
Risk management	-0.057	0.319	0.586	-0.001	0.245	0.236
Spread and consequences	0.033	0.408	0.902	0.17	0.637	0.438
PBC1	-0.039	0.023	0.087	0.781	-0.041	0.107
PBC2	-0.033	0.017	0.175	0.775	0.05	-0.028
PBC3	-0.152	0.076	0.195	0.864	0.036	0.153
PT1	0.209	0.313	0.38	-0.05	0.754	0.249
PT2	0.061	0.454	0.508	0.058	0.774	0.268
PT3	0.111	0.29	0.45	-0.018	0.778	0.247
PT4	0.039	0.376	0.45	0.061	0.76	0.249
SN1	-0.064	0.267	0.367	-0.005	0.27	0.753
SN2	0.067	0.371	0.258	0.14	0.255	0.723
SN3	0.008	0.293	0.331	0.069	0.226	0.723
SN4	-0.035	0.248	0.373	0.118	0.23	0.763

Note: Negative sign signifies negative correlation. Figures in bold are item loadings for latent constructs below which they are enlisted. It can be observed from the table that the items load higher for the latent constructs they were predicting than it is for other constructs which is an indicator of the reliability of the items used for the measurement.

Table 2.6A Significancy of items loaded on the higher order latent constructs for the livestock farmers.

Items and latent constructs loaded on	Sample mean	Standard deviation	T statistics	P values
AT1 <- Attitude	0.856	0.021	41.645	0.000
AT2 <- Attitude	0.752	0.041	18.301	0.000
AT3 <- Attitude	0.862	0.019	45.095	0.000
AT4 <- Attitude	0.724	0.045	16.022	0.000
Control <- Behavioral Intention	0.72	0.042	17.103	0.000
Food safety <- Behavioral Intention	0.799	0.023	34.813	0.000
Health and Food safety <- Knowledge	0.885	0.018	49.915	0.000
Husbandry practice <- Knowledge	0.862	0.021	41.708	0.000
PBC1 <- Perceived Behavioral Control	0.816	0.023	34.971	0.000
PBC2 <- Perceived Behavioral Control	0.893	0.013	67.274	0.000
PBC3 <- Perceived Behavioral Control	0.892	0.011	84.486	0.000
PBC4 <- Perceived Behavioral Control	0.883	0.013	69.574	0.000
PT1 <- Perceived Threat	0.892	0.016	54.349	0.000
PT2 <- Perceived Threat	0.741	0.042	17.836	0.000
PT3 <- Perceived Threat	0.741	0.043	17.13	0.000
Prevention <- Behavioral Intention	0.742	0.033	22.537	0.000
SN1 <- Subjective norm	0.827	0.031	26.437	0.000
SN2 <- Subjective norm	0.847	0.03	28.558	0.000
SN3 <- Subjective norm	0.917	0.015	61.938	0.000

Note: All items loaded on the livestock farmers' higher order latent constructs are significant at $p < 0.001$ level. This signifies the reliability of the items used to measure the higher order constructs.

Table 2.7A Significancy of items loaded on the higher order latent constructs for the other livestock chain actors.

Items and latent constructs loaded on	Sample mean	Standard deviation	T statistics	P values
AT1 <- Attitude	0.809	0.087	9.505	0.000
AT2 <- Attitude	0.845	0.07	12.225	0.000
AT5 <- Attitude	0.763	0.109	6.999	0.000
Outbreak surveillance <- Knowledge	0.589	0.082	7.227	0.000
Risk management <- Knowledge	0.579	0.098	5.996	0.000
Spread and consequences <- Knowledge	0.902	0.018	48.834	0.000
PBC1 <- Perceived Behavioral Control	0.758	0.146	5.334	0.000
PBC2 <- Perceived Behavioral Control	0.758	0.145	5.363	0.000
PBC3 <- Perceived Behavioral Control	0.818	0.154	5.594	0.000
PT1 <- Perceived threat	0.748	0.054	14.058	0.000
PT2 <- Perceived threat	0.775	0.049	15.883	0.000
PT3 <- Perceived threat	0.781	0.036	21.601	0.000
PT4 <- Perceived threat	0.758	0.057	13.244	0.000
Spread control <- Behavioral Intention	0.852	0.041	20.822	0.000
Prevention <- Behavioral Intention	0.86	0.041	21.011	0.000
SN1 <- Subjective norm	0.751	0.05	15.214	0.000
SN2 <- Subjective norm	0.721	0.061	11.765	0.000
SN3 <- Subjective norm	0.723	0.06	12.122	0.000
SN4 <- Subjective norm	0.76	0.053	14.448	0.000

Note: All items loaded on the livestock value chain actors' higher order latent constructs are significant at $p < 0.001$ level. This signifies the reliability of the items.

Table 2.8A Heterotrait monotrait ratio (HTMT) for the farmer model

Latent construct	AT	BI	Gen	KN	PBC	PT	PDE	PDN	SN
Attitude (AT)									
Behavioral Intention (BI)	0.484								
Gender (Gen)	0.094	0.019							
Knowledge (KN)	0.289	0.876	0.037						
Perceived Behavioral Control (PBC)	0.121	0.094	0.03	0.236					
Perceived Threat (PT)	0.221	0.221	0.068	0.151	0.385				
Previous Disease Encounter (PDE)	0.043	0.076	0.031	0.074	0.157	0.188			
Production system (PDN)	0.332	0.053	0.04	0.144	0.388	0.321	0.048		
Subjective norm (SN)	0.266	0.177	0.048	0.221	0.059	0.048	0.047	0.137	

Note: Most of the figures are below the lower bound cut-off value of 0.85 and all are below the 0.90 upper bound mark as expected. This shows that each of the construct presented on the table is conceptually distinct from each another.

Table 2.9A Heterotrait monotrait ratio (HTMT) for the other livestock chain actors' model HTMT chain actors

Latent construct	AT	BI	HH_size	KN	PBC	PT	SN
Attitude (AT)							
Behavioral Intention (BI)	0.237						
Household size (HH_size)	0.184	0.075					
Knowledge (KN)	0.286	0.746	0.389				
Perceived Behavioral Control (PBC)	0.116	0.07	0.191	0.355			
Perceived threat (PT)	0.175	0.667	0.162	0.816	0.088		
Subjective norm (SN)	0.094	0.586	0.145	0.689	0.168	0.442	

Note: Most of the figures are below the lower bound cut-off value of 0.85 and all are below the 0.90 upper bound mark as expected. This shows that each of the construct presented on the table is conceptually distinct from each another.

The optimal number of segments used for analysis in the study were decided after conducting a post-hoc sample size calculation in the G*Power software. For both the farmer and other livestock value chain actors, the minimal sample sizes required to realize a medium effect size of 0.15, power 0.8 and alpha 0.05 were computed (109 and 98 for farmers and other value chain actors respectively). The overall sample sizes for the livestock farmers (444) and other value chain actors (180) were divided by the minimal sample sizes computed to arrive at an average of 4 and 2 segments to be used for analysis of unobserved heterogeneity for the farmers and other chain actors respectively, although in the final estimation 5 segments for farmers and 3 for other value chain actors were evaluated. Segment sizes and fit indices of Akaike Information Criterion with factor 3 (AIC3), Consistent Akaike Information Criterion (CAIC) and the Bayesian Information Criterion (BIC) were generated for each segment and used to assess if indeed individuals in the overall sample are heterogeneous in the way they evaluate the latent constructs and therefore could result into different segments with each having different drivers to RVF behavioral intentions (Hair et al., 2016b)

Table 2.10A Fit indices for the livestock farmer and other chain actors' model

Fit indices	Farmers				Other chain actors		
	seg 1	seg 2	Seg 3	seg 4	seg 1	seg 2	seg 3
AIC (Akaike's Information Criterion)	5904.12	5553.21	5296.4	5101.84	2335.27	2253.85	2151.07
AIC3 (Modified AIC with Factor 3)	5930.12	5606.21	5376.4	5208.84	2353.27	2290.85	2207.07
AIC4 (Modified AIC with Factor 4)	5956.12	5659.21	5456.4	5315.84	2371.27	2327.85	2263.07
BIC (Bayesian Information Criteria)	6010.61	5770.28	5624.07	5540.10	2392.74	2371.99	2329.88
CAIC (Consistent AIC)	6036.61	5823.28	5704.07	5647.10	2410.74	2408.99	2385.88
HQ (Hannan Quinn Criterion)	5946.11	5638.81	5425.62	5274.67	2358.57	2301.75	2223.57
MDL5 (Minimum Description Length)	6644.58	7062.60	7574.73	8149.11	2766.63	3140.55	3493.10
LnL (LogLikelihood)	-2926.06	-2723.6	-2568.2	-2443.92	-	-1089.93	-1019.54
EN (Entropy Statistic (Normed))	n/a	0.86	0.912	0.883	1149.63	0.653	0.845
NFI (Non-Fuzzy Index)	n/a	0.884	0.915	0.87	n/a	0.705	0.849
NEC (Normalized Entropy Criterion)	n/a	62.246	38.854	52.143	n/a	62.392	27.942

Note: The figures in bold show the segment indicated by corresponding fit indices.

Table 2.11A Farmer and chain actor segment sizes

Model	Segment number and sizes			
	segment 1	segment 2	segment 3	segment 4
chain actor model	0.56	0.257	0.183	
Farmer model	0.564	0.186	0.138	0.113

Note: Individuals who belong in segments 2, 3, and 4 only form a very small proportion of the overall study sample (440 farmers and 180 other livestock value chain actors) that they can not constitute the minimal sample size requirements (109 farmers and 98 other chain actors) to enable inference to be done using more than one segment.

Table 2.12A R² values for the livestock farmers and other value chain actors

Latent constructs	Sample Mean	Standard Deviation	T Statistics	P Values
Attitude	0.17***	0.03	5.26	0.00
Behavioral Intention	0.332***	0.035	8.978	0.00
Perceived Behavioral control	0.193***	0.035	5.274	0.00
Perceived threat	0.185***	0.035	4.958	0.00
Subjective Norm	0.064*	0.024	2.316	0.02
Attitude	0.135*	0.056	2.105	0.04
Behavioral Intention	0.421***	0.055	7.171	0.00
Perceived Behavioral control	0.078	0.038	1.67	0.09
Perceived threat	0.396***	0.073	5.173	0.00
Subjective Norm	0.243***	0.069	3.243	0.00

*Note: ***, **, and * represents 0.001, 0.01, and 0.05 level of significancy respectively*

Table 2.13A Q² values for the livestock farmer and other value chain actors

Latent variables	SSO	SSE	Q ² (=1-SSE/SSO)
Farmers			
Attitude	1776	1611.502	0.093
Behavioral Intention	1332	1161.209	0.128
Perceived Behavioral control	1776	1532.743	0.137
Perceived threat	1332	1205.528	0.095
Subjective Norm	1332	1278.138	0.04
Other chain actors			
Attitude	360	326.44	0.093
Behavioral Intention	540	447.817	0.171
Perceived Behavioral control	540	518.011	0.041
Perceived threat	720	579.286	0.195
Subjective Norm	720	634.629	0.119

Note: SSO refers to the sum of the squared observations while SSE is the sum of the squared prediction errors, and the last column (1 – SSE/SSO) is the

Chapter Three

Food Security and Poverty Implications of Bio-Security Measures Adopted Against Rift Valley fever.

Marsy Asindu^{a,b*}, Awudu Abdulai^a, Bernard Bett^b, Kristina Roesel^b Dan Tumusiime^c and Emily Ouma^b

^aChristian Albrechts Universitat zu Kiel (CAU), Kiel, Germany

^bInternational Livestock Research Institute (ILRI), Nairobi, Kenya

^cMinistry of Agriculture, Animal Industry and Fisheries (MAAIF), Entebbe, Uganda

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Abstract

This study examines the impact of biosecurity measures on food security and poverty, using observational data from Uganda. A dose response function model that considers adoption levels while accounting for endogeneity and self-selection effects is employed for analysis. Our results show a positive impact of biosecurity levels adopted on food security status of the livestock farmers. Household asset index and poverty gap is also shown to improve with increasing levels of biosecurity measures adopted. Overall, the empirical results demonstrate the important role biosecurity can play in reducing disease prevalence thereby enhancing food security and reducing poverty among vulnerable livestock farmers.

Keywords: Biosecurity; Food security; Poverty; Livestock; Rift Valley fever; Economic impact

3.0 Introduction

Ending poverty in all its forms and achieving food security with improved nutrition remains one of the topmost daunting tasks to be achieved by policy makers by 2030 (United Nations, 2015). Luckily, livestock production, especially cattle, is among the important contributors to this agenda with over 40% of the global agricultural gross domestic product projected to be originating from the sector (Grace et al., 2017). Further, greater positive strides towards achieving food security and poverty reduction have been observed in countries that have succeeded in improving livestock productivity, with a reverse scenario being recorded where growth in livestock production has been constrained (Pradere, 2014). The Food and Agricultural Organization (FAO) also proclaims that continuous growth and transformation of the livestock sector is bound to offer substantial opportunities for agricultural development, poverty reduction, food security gains and improved human nutrition (FAO, 2018). More specifically, for the over 50 million pastoralists within Africa, livestock raising constitutes the primary economic activity (Kratli et al., 2013). In sub-Saharan Africa, majority of households engaged in agriculture keep one or more livestock species, this not only represents wealth, income, and protection against economic shocks but also are a major source of high protein nutrition (Black et al., 2013; Mosites et al., 2015).

Despite the notable contribution of livestock and role played in improving food and nutrition security and reducing poverty. The sector continues to grapple with outbreak of livestock diseases that are fast contributing to decreased livestock productivity and fertility, livestock death and impeded herd growth (FAO, 2012; Fitzpatrick, 2013; Kraay and McKenzie 2014). More worrying is the emergency of zoonotic diseases, in particular the Rift Valley fever which not only threatens livestock production and safe utilization of animal products but also affects human health. Over the past years for instance, studies have demonstrated that economic loss exceeding

\$ 60 million were registered during 2006-2007 RVF outbreak in the East African region (Little et al., 2009; Rich and Wanyoike, 2010). The bulk of these losses were attributed to decline in the market value of livestock during outbreaks, slaughterhouse closures, abortions, animal, and human deaths. Far reaching negative impacts emanating mainly from trade bans and quarantine restrictions were equally registered in countries outside the East African region including Egypt, Sudan, Somalia, Madagascar, South Africa, Saudi-Arabia, Yemen among others (FAO, 2008; Magona; 2013). In absence of timely containment measures the ultimate consequences of these continued outbreaks will therefore immensely derail efforts towards attaining food security and reducing poverty among vulnerable households (Santos and Barrett, 2016).

With no clear and known curative measure against the RVF disease, preventive measures such as mobility restrictions (trade bans, quarantines, and movement restrictions) and vaccination at national and transboundary levels are often deployed to curb the disease during outbreaks (Hassan et al., 2014; WHO, 2018). While credible, the overall impact of these preventive measures remains highly debatable. For instance, numerous studies point out that livestock mobility restrictions result in disruptions to domestic and international livestock markets/supply chains, which could rather increase the incidence of the epidemics within the restricted communities, if additional sanitary measures are not implemented (Espinoza et al., 2020; Houser and Karali, 2020). There is also evidence that in the presence of such measures, illegal trade (black markets) in livestock and related products becomes rampant, arising from supply and demand discrepancies created by the restrictive measures. Thus, reducing transparency and making regulation of trade in livestock and related products difficult which ends up increasing the risk of disease spread rather than reduce it (Roe and Lee, 2021). Cross border movement on the other hand is hard to control due to the existence of porous borders and the high facilitation costs due to the enforcement officers

thus exacerbating the spread and transmission of the disease (WOAH), 2018). To sum it up, all the measures presented are considered public goods, with the government responsible for their implementation. However, the high cost of investment required to comprehensively execute such measures at national level is prohibitive (FAO, 2012). Furthermore, these measures tend to offer inadequate protection against the numerous RVF risk factors which occur at herd/farm level. Something that has increasingly drawn the attention of policy makers and pushed for the need to have livestock farmers take up biosecurity measures in response to the ever-evolving local risks at herd/farm level especially in endemic countries (Kobayashi and Melkonyan, 2011; Ugochukwu and Phillips, 2019).

Biosecurity refers to the sum of management and physical measures designed to reduce the risk of introduction, development and spread of diseases to, from and within an established animal population (WOAH, 2023). The Food and Agriculture Organization of the United Nations (FAO, 2010) describes it as the implementation of measures that reduce the risk of the introduction and spread of disease agents at the farm level, with a particular focus on either reducing the risk of entry of new pathogens (external biosecurity) or reducing the internal dissemination of pathogens (internal biosecurity). Besides minimizing the risk of disease spread across the farm, biosecurity increases productivity, allowing for efficient input to output conversion by reducing disease prevalence, deaths, abortions, product (milk and meat) loss, veterinary costs and improving livestock growth by enhancing feed conversion rate (McInerney, 1996; Weyori et al., 2019; Hennessy and Rault, 2023). Although Promising, adoption levels of biosecurity measures against RVF risks at farm level remains low. Additionally, the benefits that livestock farmers derive from implementing such interventions at farm level in terms of food security and poverty reduction remains largely unquantified.

In this paper, we investigate the impact of on-farm biosecurity levels adopted against RVF risk factors on livestock farmers' food security and poverty status. Few studies have attempted to investigate the factors driving adoption of biosecurity measures and their welfare impacts at farm level (Weyori et al., 2018; Weyori et al., 2019; Msimang et al., 2022). A major limitation of these studies is the frequent definition of adoption of biosecurity measures as binary (adoption vs non adoption) or categorical (based on combination of practices adopted) (Weyori et al., 2018; Weyori et al., 2019). And counts of the numbers of biosecurity measures adopted (Msimang et al., 2022). The implicit assumption of this approach is that the different biosecurity measures adopted carry similar weight. In reality, however, these biosecurity measures offer different levels of protection (Can and Altug, 2014; Doring et al., 2019). Further, treating adoption of biosecurity measures as a binary or categorical variable ignores the effect of the varying levels of biosecurity measures (dose) adopted by the individual farmers (Cerulli, 2015). Our study therefore contributes to the current empirical literature by utilizing a dose response function model to investigate the impact of varying levels of biosecurity measures adopted on food security and poverty status of livestock farmers. The approach is relevant as it allows for adoption of biosecurity measures to be captured as a continuous treatment variable (dose) against which impact can be measured while accounting for endogeneity and self-selection bias (Cerulli, 2015). Overall, the results of the study will generate knowledge that can be used for policy recommendations in the fight against RVF and improvement of food security and poverty status of farmers earning livelihoods from the affected livestock species.

3.1 Conceptual Framework

In this section, the conceptual mechanism by which adoption of biosecurity measures impacts food security and poverty is discussed. The ultimate goal of any livestock farmer is to maximize

productivity using minimal inputs and resources. However, when RVF is introduced into the herd, the rate of transmission in the absence of preventive measures becomes very high. This subsequently results in a high prevalence of disease within the herd. Under such conditions, productivity is impacted as many pregnant animals develop a high tendency to abort. Farmers also lose out on animal products because either milk products become highly contaminated or the level of milk produced drastically declines following infection (Rich and Wanyoike, 2010; Sindato et al., 2011; Mutua et al., 2019). Mortality rates on the farm likewise spike up with neonatal animals being the most vulnerable thereby impacting future stock levels. The efficiency of the production process may also be compromised as fertility, growth and feed conversion rates are negatively impacted by disease infection thereby increasing farm input costs yet returns/net earnings decline at the same time (Chi et al., 2002). In extreme situations, farmers are forced to dispose off their animals at lower prices due to the fear of losing their animals. These eventualities may seriously affect the availability and quality of food as well as negatively impact their purchasing power, rendering them food insecure. With revenues lost, accompanied by declining expenses, farmers eventually enter into poverty traps (Mahmud and Riley, 2020).

In the contrary, when farmers adopt biosecurity measures, they are likely to contain the progression rate of the disease on the farm and thus maintain a low prevalence level. This eventually boosts productivity through reduced animal deaths, less abortions and product loss including milk and meat and an enhanced input to output conversion rate. In the long run the overall anticipated economic loss or damage from the disease outbreak would have been minimized (Layton et al., 2017; Sok and Fischer, 2020; Baldwin and Effland, 2022). The end benefit is that farmers are able to accumulate more wealth due to the reduced death rates and the fast growth and fertility levels on the farm. Further, output levels (meat and milk) are maintained

or even improved thereby supplying adequate nutrition to the farmer's household (Smith et al., 2013). Surplus outputs (Meat, milk and accumulated live animals) can be sold or exchanged and the proceeds used to acquire food or invested in other productive assets like land and businesses that eventually helps to stir the adopting farmers out of poverty and ensure they have adequate dietary supply (Barrett and Carter, 2013; Wodajo et al., 2020). Figure 3.1 summarizes the mechanisms through which RVF outbreak impacts the level of food security and poverty.

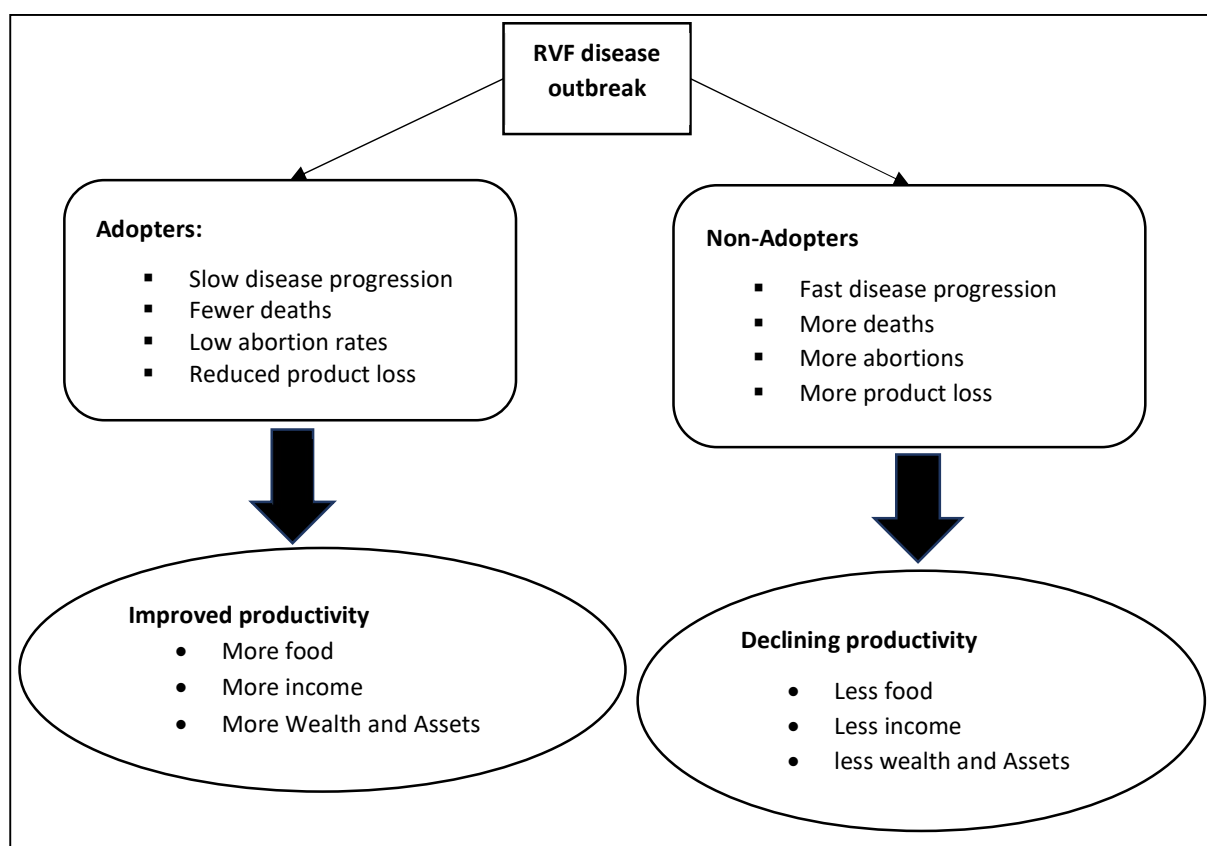


Figure 3. 1 Conceptual framework illustrating food security and poverty implications of adopting on-farm biosecurity measures against RVF disease.

3.2 Background/context for biosecurity interventions

Rift valley fever is a vector borne zoonotic disease of significant importance to the livestock sector in Uganda. The disease is mainly transmitted by mosquito species of the genus *Aedes* and *Culex*.

It was first detected in mosquito samples collected from Semliki Forest, Western Uganda, in 1944 (Smithburn et al., 1948). Afterwards human cases were subsequently registered during outbreaks that occurred near Entebbe in 1960 and 1962 (Williams et al., 1960; Williams et al., 1963). From then onwards, serological evidence of the disease has been intermittently reported with major outbreaks observed between the years 2016 and 2018, causing several human and livestock mortalities (Magona et al., 2013; Ly et al., 2017). Though not quantified, the overall economic impact of the disease is far reaching as outbreaks are often characterized by storming abortions in livestock, neonatal deaths, lost productivity, reduced milk production and weight loss due to infections among others (Dar et al., 2013; Tumusiime et al., 2018; Mutua et al., 2019). In the absence of timely containment measures, the continued productivity losses orchestrated by the high prevalence levels of the disease could eventually culminate into food insecurity and increased poverty levels among livestock farmers who largely depend on the animals to meet their nutritional needs and build wealth.

The recurrent outbreaks coupled with the risk that Uganda is likely to transition into an RVF endemic country (CDC, 2020), has resulted in a number of investigations to be conducted around the disease and related risk factors (de St. Maurice et al., 2018; Nyakarahuka et al., 2018) to inform policy decisions. Indeed, quite a number of RVF predisposing risk factors have been revealed in these studies with a sizeable proportion found to be occurring on the farms. On-farm biosecurity measures are therefore seen as a potential tool for mitigating the risk of introduction or rapid spread of the disease within and across farms in the absence of a licensed vaccine or clearly laid out disease management plan at the national level, pending its inclusion on the list of state-controlled diseases (Tumusiime et al., 2018).

On-farm biosecurity measures such as helping livestock delivery using protective equipment, vector control through spraying, isolating aborted animals and burying off aborted fetuses, isolation of sick animals among others not only reduce risk of RVF transmission but lowers the overall prevalence levels on the farm thereby boosting productivity. However, despite the demonstrated results that farmers stand to gain from implementing biosecurity measures against RVF, adoption levels of the biosecurity practices remain low in Uganda. Further the impacts of adopting such biosecurity measures on farmers' food security and poverty status, which ideally could be an incentive to propel further adoption, is largely unknown in literature.

3.3. Materials and Methods

3.3.1 Data

The study utilizes recent survey data of 444 livestock farming households from Uganda, collected within the period spanning January to March 2022. A multi-stage sampling approach was used to randomly recruit participants into the study. In the first stage, six districts were purposively selected based on evidence of RVF seroprevalence. The second stage involved identifying two sub-counties with the highest RVF seroprevalence and RVF risk levels from each of the six districts purposively picked. Within each sub-county, a parish each with the highest risk level for RVF outbreak was singled out as the lowest sampling unit in the third stage.

The fourth and final stage involved listing all the livestock farming households within the selected parishes with the aid of local council authorities and veterinary personnel available in the area. Thirty-seven (37) livestock farming households were randomly selected from each of the lists obtained from the 12 parishes and considered for interviews. A structured questionnaire programmed in the Open Data Kit (ODK) Platform was used to interview farmers in the study area. Information obtained from the farmers included, asset and land ownership, herd structure,

food and non-food expenses, 7-day and 24-hour recall of daily food and nutrient consumption, on-farm biosecurity practices, agricultural production activities for the 2021 calendar year, group memberships, access to facilities and information among others.

3.3.2 Outcome variables

Descriptive statistics and definition of outcome variables included in the analysis are presented in this section. Three outcome variables (Household dietary diversity scores (HDDS), poverty indices and household domestic asset indices were considered for analysis). Household dietary diversity score (HDDS) was calculated based on questions on household consumption of food items from 12 different food groups in the previous 24 hours (Swindale and Bilinsky, 2006; Bilinsky and Swindale, 2010).

The household domestic asset index was computed for all movable assets including livestock. Each asset captured was assigned a weight (w) which was later adjusted for age during analysis to obtain an index for each household sampled (BMGF, 2010, Alary et al., 2011). Lastly, we estimated the per adult equivalent (PAE) consumption expenditure based on a formula demonstrated by Deaton and Zaidi. (2002); and Regier et al. (2018)

$$PAE_i = \frac{X_i}{(A_i + \alpha K_i)^\theta} \dots \dots \dots (1)$$

where X represents expenditures, or any other financial welfare measure, and the parameters α and θ lie between 0 and 1, while A is the count of adults. This approach accounts for economies of scale when computing poverty measures. Following the Foster, Greer and Thorbecke (FGT) approach, three poverty indices (Poverty headcount, poverty gap and poverty severity) were computed, using the per adult equivalent consumption expenditures generated (Foster, Greer and Thorbecke, 1984). Although currently revised to US\$ 1.77 per day (Uganda Bureau of Statistics

(UBOS, 2021), the national poverty line of US\$ 1 per adult equivalent per day that was official at the time of field survey was considered for analysis (UBOS, 2018). The summary of outcome variables by adoption status are presented in table 3.1.

Table 3. 1 Summary of outcome variables by biosecurity practice adoption status

Variable	Pooled sample (N=444)	Adopters (n=378)	Non-adopters (n=66)	T-value
Household Dietary Diversity Score (HDDS)	6.29 (2.12)	6.58 (2.09)	4.59 (1.41)	7.45***
Poverty headcount	0.48 (0.50)	0.45 (0.50)	0.62 (0.49)	2.55**
Poverty gap	0.23 (0.30)	0.21 (0.29)	0.34 (0.33)	3.20***
Poverty gap-squared	0.14 (0.23)	0.13 (0.22)	0.22 (0.26)	2.90***
Household domestic asset index	278.32 (336.88)	303.09 (355.53)	136.50 (127.77)	3.76***

3.3.3 Treatment variable (adoption intensity of on-farm biosecurity practices)

In this study, the intensity of on-farm biosecurity practices adopted were measured by assigning technical weights to each biosecurity practice a farmer adopted. These weights were generated through six Key informant interviews (KIIs) conducted with experts specializing in the field of RVF epidemiology. Each of the six key informants were asked to score a set of 18 biosecurity practices on a scale of 1 – 3 (1= low protection, 2= medium protection, and 3= high protection against RVF risk factors). The average scores for each practice were then computed and attached as a technical weight to each biosecurity practice a farmer adopted (Can and Altug, 2014; Doring et al., 2019). Biosecurity scores were then derived by summing up weights for each biosecurity practice adopted by individual farmers. The biosecurity index (adoption intensity) was obtained by dividing the biosecurity score for each farmer by the highest possible biosecurity score in the dataset with the resultant value, multiplied by 100 (Cerulli, 2015). Table 3.2 shows the frequency of farmers adopting biosecurity practices and their respective weights.

Table 3. 2 Frequency of farmers adopting biosecurity practices and technical weights

Biosecurity practice	Frequency (%)	Technical weight
<i>Restraint and movement restriction</i>		
Isolation of sick animals	80 (18.02)	2.50
Isolation of newly acquired animals	30 (6.76)	2.50
Isolation of leftover stock from the market	8 (1.8)	2.00
Herd movement restriction	78 (17.57)	2.50
Quarantine	294 (66.22)	2.70
No selling animals during outbreaks	14 (3.15)	2.80
<i>Vector control</i>		
Spray mosquitoes	84 (18.92)	2.50
<i>Regular farm husbandry</i>		
Disinfection feeding and watering utensils	71 (15.99)	1.20
No immediate mixing of market stock with home animals	216 (48.65)	2.70
Non mixing of herds from communal grazing sites	256 (57.66)	2.00
Helping animal delivery with protective gear	10 (2.25)	3.00
Burn and bury carcass from dead animals	24 (5.41)	2.20
Isolate recently aborted animals	250 (56.31)	2.80
Slaughter animals away from homestead	291 (65.54)	1.70
<i>Food safety</i>		
Consume only pasteurized milk	344 (77.48)	2.50
Consume only thoroughly cooked meat	361 (81.31)	3.00
Does not consume meat from dead animals	274 (61.71)	3.00
Handle meat with protective equipment	137 (30.86)	2.70

3.3.4 Dependent and explanatory variables

The definition and descriptive statistics of variables used in analysis are presented in Table 3.3 below. The results indicate that 85 percent of livestock farmers adopted biosecurity measures on their farms. We also observed an average biosecurity intensity of 45% with about 35% of farmers being aware of RVF, and 16 % using farm animals for draught power.

Table 3. 3 Descriptive statistics and definition of dependent, treatment and explanatory variables

Variables	Variable description	Mean	Std Dev
Dependent variable			
Adopt	Adoption of biosecurity practices (1 = Yes, 0 = No)	0.85	0.37
Treatment variable			
Bio_int	Adoption intensity of biosecurity practices (0 - 100)	41.77	24..01
Explanatory variables			
PCE	Daily per adult equivalent consumption expenditure (USD)	2.00	3.09
Hausind	Housing Index	13.68	5.46
vaccination_info	Received vaccination information (1 = Yes, 0 = No)	0.59	0.49
adv_herd_mgt	Received advice on herd management (1 = Yes, 0 = No)	0.15	0.36
HHsize	Household size in number of persons	6.49	2.59
AGE_RESP	Age of the Respondent in Years	47.41	14.67
Cropinc	Annual income from crop sales in Ugandan shillings (UGX)	3213301.00	930618.00
Draught_power	Used animal for draught power (1 = Yes, 0 = No)	0.16	0.02
RESP_EDN	Level of completed education	3.57	2.66
Vetcosts	Annual veterinary costs in UGX	210021.80	397609.70
Insecurity	Household faced insecurity (1 = Yes, 0 = No)	0.05	0.22
saving_grp	Membership to a savings group (1 = Yes, 0 = No)	0.31	0.46
RESIDE_2016	Respondent was resident in the area by 2016 (1 = Yes, 0 = No)	0.98	0.12
RVF_aware	Respondent is aware of RVF (1 = Yes, 0 = No)	0.35	0.48
Dist_Ext	Distance to the extension center (km)	7.34	8.83

*Note: Exchange rate 1 USD is equivalent to 3585.78 Ugandan shillings (UGX).

3.3.5 Analytical framework/strategy

In this study, the impact of the intervention (biosecurity measures adopted), does not solely depend on the binary adoption status (adopters vs non adopters), but rather relies on both the adoption status and level of biosecurity measures adopted. Further, the adoption decision and level of biosecurity measure adopted is nonrandom which induces a self-selection bias. The varying levels of biosecurity measures adopted together with the significant differences in the outcomes of adopters and non-adopters relayed in Table 3.1, also suggest a potential heterogeneity constraint. To ensure consistent estimates of our parameters, a dose response function model proposed by

Cerulli (2015) was used for the analysis. This approach has an edge over other dose response function approaches (Adorno et al., 2007; Bia et al., 2014), as its able to address the potential treatment endogeneity problem through instrumentation, while accounting for observed heterogeneity and can be used even when data is not normally distributed (Cerulli, 2015).

We commence the set-up of the model by assuming that livestock farmer decision to adopt biosecurity measures is a binary treatment indicator denoted as (d_i) , with y_{i1} and y_{i0} representing potential outcomes (HDDs, Household domestic asset index and poverty gap) of the livestock farmers when treated and untreated respectively. x represents the confounders (exogenous and observable characteristics) of livestock farmer $i = 1, \dots, N$. Where N is the total number of livestock farmers (treated and untreated). We then express two discrete functions, $g_1(x)$ and $g_0(x)$ to signify livestock farmer's responses to the vector of confounding variables x , when treated and untreated respectively. We further denote α_1 and α_0 as constants with ε_1 and ε_0 being the random disturbance term with zero mean and a constant variance. Lastly, we state t which is a continuous treatment indicator representing the intensity of biosecurity measure adopted by each livestock farmer with its values ranging from 0 – 100 and define $h(t)$ as a non-zero response function of intensity t . Using the notations generated prior, we specify the two potential outcomes as follows.

$$\begin{cases} d = 1: \alpha_1 + g_1(x) + h(t) + \varepsilon_1 \\ d = 0: \alpha_0 + g_0(x) + \varepsilon_0 \end{cases} \dots \dots \dots (2)$$

where $h(t)$ is a function different from zero only in the treated group ($d = 1$). The treatment effect (TE) is thus expressed as $TE = (y_1 - y_0)$, with the causal parameters of interest (ATEs) conditioned on x and t specified as follows:

$$\begin{aligned}
ATE(x, t) &= E(y_1 - y_0 | x, t) \\
ATET(x, t > 0) &= E(y_1 - y_0 | x, t > 0) \dots \dots \dots (3) \\
ATENT(x, t = 0) &= E(y_1 - y_0 | x, t = 0)
\end{aligned}$$

Where ATE represents the overall average treatment effect, ATET indicates the average treatment effect on the treated and ATENT implying the average treatment effect on the untreated. Assuming a linear parametric form for $g_0(x) = x\delta_0$, and $g_1(x) = x\delta_1$, the ATE conditional on x and t is re-written as:

$$ATE(x, t, d) = d * [\alpha + x\delta_1 + h(t)] + (1 - d) * [\alpha + x\delta_0] \dots \dots \dots (4)$$

where $\alpha = (\alpha_1 - \alpha_0)$ and $\delta = (\delta_1 - \delta_0)$.

The subsequent generic regression model for fitting parameters of interest ($\alpha_1, \alpha_0, \delta_1, \delta_0, ATE, ATET$ and $ATENT$) is specified as:

$$y_i = \alpha_0 + d_i * ATE + x_i\delta_0 + d_i\delta * (x_i - \bar{x}) + d_i * \{h(t_i) - \bar{h}\} + \eta_i \dots \dots \dots (5)$$

where $\eta_i = \varepsilon_0 + d_i * (\varepsilon_1 - \varepsilon_0)$ represents the error terms, \bar{h} is the sample mean of $h(t_i)$ and \bar{x} is the vector of observed covariate for individuals in the sample. Since adoption decisions for biosecurity measures are non-random in the current study, and therefore d and t are endogenous in nature, we rewrite the generic regression as follows to include instrumental variables, thus addressing the endogeneity issue to obtain consistent estimates.

$$y_i = \alpha_0 + x_i\delta_0 + d_iATE + d_i\delta * (x_i - \bar{x}) + d_iK_{1i} + bd_iK_{2i} + cd_iK_{3i} + \eta_i \dots (6.1)$$

$$d_i^* = x_{id}\beta_d + z_{id}\omega_d + \epsilon_{id}, \quad d_i = 1, \text{ if } d_i^* > 0 \dots \dots \dots (6.2)$$

$$t_i = x_{it}\beta_t + z_{it}\omega_t + \epsilon_{it} \dots \dots \dots (6.3)$$

where d^* is an unobserved latent variable that represents expected benefit, a farmer derives from adopting biosecurity measures. t_i is observed only when $d_i = 1$. The notation x_{id} and x_{it} are a set of observed covariates, $x_{id}\beta_d$ and $x_{it}\beta_t$ are a vector of instrumental variables for adoption and

biosecurity intensity respectively. ϵ_{id} and ϵ_{it} are the error terms for the selection model (equation 6.2) and biosecurity intensity (equation 6.3) respectively.

The notations d_i , K_{1i} , K_{2i} , and K_{3i} in equation 6.1 are endogenous terms with the later three being functions of the endogenous t_i . With two endogenous variables in the model (d_i^* and t_i), two instrumental variables (z_{id} and z_{it}) are introduced for proper identification. The two instruments are directly correlated with d_i^* and t_i but not y_i and are uncorrelated with ϵ_{id} , ϵ_{it} , η_i . For the adoption decision (d_i^*), we use peer effects as an instrument following Mumin and Abdulai (2022), while distance to the extension center is used as an instrument for the biosecurity intensity (t_i).

Biosecurity adoption decision and the biosecurity intensity equations presented in equations 6.2 and 6.3 respectively are then jointly modelled using a two-step Heckman procedure with the assumption that the errors are jointly and normally distributed. The equation in 6.1 is further re-estimated using a two-stage least squares (2sls) approach, with the predicted values of d_i^* and t_i from the Heckman model being used as instruments to ensure that correct and consistent estimates of $\alpha_0, \delta_0, ATE, a, b, c$ and δ are obtained in equation 6.1. These estimates are then utilized to fit a dose response function specified as:

$$\hat{ATE}(t_i) = d_i(\hat{ATE} + \hat{a}(t_i - \hat{t}) + \hat{b}(t_i^2 - \bar{t}^2) + \hat{c}(t_i^3 - \bar{t}^3) + (1 - d_i)\hat{ATE} \dots \dots \dots (7)$$

where \hat{a}, \hat{b} and \hat{c} are coefficients of the estimated polynomials, \hat{t}, \bar{t}^2 and \bar{t}^3 and the sample means of the polynomial functions related to biosecurity intensity. Finally, a bootstrapping procedure is carried out to elicit the standard errors and confidence intervals for ATET and ATENT.

3.4 Empirical results and discussion

3.4.1 Drivers of biosecurity intensity and adoption

The results of factors that influence adoption and level of biosecurity intensity are presented in Table 3.4. The findings show that the level of biosecurity decreases with increase in distance to extension centers. Further, as farmers' age increases, the intensity of biosecurity measures adopted decreases, suggesting the tendency for risk aversion among the elderly. Increase in years of education increases adoption intensity. This is expected as increased level of education improves conceptualization and more educated farmers are therefore able to realize the benefits of additional disease risk mitigation measures and implement them. The results also reveal that farmers who received herd health management advice had higher intensities of biosecurity measures implemented on their farms. This is expected as farmers are able to learn about multiple biosecurity measures through the health herd management trainings as opposed to those who do not attend. We further, observe that increase in annual veterinary costs due to the farmer comes with higher levels of biosecurity measures. This suggests that farmers with high veterinary costs try to counter the costs by implementing additional biosecurity measures on farms. Farmers who use their animals for draught power have increased biosecurity levels on there farms. This could be a mechanism to keep the draught animals healthy throughout the season. Lastly, we observe that increase in peer effect drives adoption of on farm biosecurity measures by farmers. Implying that the people farmers interact with influence them to adopt biosecurity measures on their farms.

Table 3. 4 Determinants of adoption and intensity of biosecurity measures adopted.

Variables	Variable definition	Bio_int	Adopt
Dist_ext	Distance to extension center (km)	-0.26*** (0.14)	
adv_herd_mgt	Received advice on herd management 1 = Yes, 0 = No	7.91*** (2.44)	0.11 (0.28)
HHsize	Household size in number of persons	-0.29 (0.33)	0.01 (0.03)
AGE_RESP	Age of the Respondent in Years	-0.16** (0.06)	0.13 (0.01)
lnCropinc	Annual income from crop sales in Ugandan shillings (UGX)	-0.45 (0.14)	0.21 (0.01)
Draught_power	Used animal for draught power (1 = Yes, 0 = No)	6.67*** (2.59)	-0.16 (0.49)
RESP_EDN	Years of education	0.63** (0.35)	0.02 (0.03)
lnVetcost	Annual veterinary costs in UGX	0.54*** (0.17)	0.01 (0.02)
Insecurity	Household faced insecurity (1 = Yes, 0 = No)	9.30 (4.22)	0.44 (0.54)
saving_grp	Member of household belongs to savings group (1 = Yes, 0 = No)	-0.17 (1.90)	0.03 (0.19)
RESIDE_2016	Respondent resided in the area by 2016 (1 = Yes, 0 = No)	6.25 (7.54)	0.16 (0.60)
Peer_eff	Peer effect		3.72*** (0.49)
Cons	Constant intercept	50.75 (8.52)	1.70 (0.70)
X test of instrument		53.89	99.51
p value of instrument		0.00	0.00

Note: values in parentheses are standard errors. ***, **, & * statistical significance at 1%, 5%, and 10%, respectively

3.4.2 Determinants of HDD, HHassetindex and Poverty depth

Table 3.5 presents results of the determinants for household dietary diversity score (HDD), household domestic asset index (HHassetindex) and Poverty depth (povty_depth) in columns 3, 4 and 5 respectively. The results show that farmers access to vaccination information increases HDD and decreases poverty gap. This could be because access to such information is followed up by actual vaccination of their animals thereby offering protection to their animals against diseases and boosting overall productivity thus increasing food availability and revenues on farm. Increase in age of the respondent is associated with higher HHassetindex coupled with a lower poverty gap. This is because farmers increase their resource base and assets as they age. Increase in income from crop sales is shown to increase HDD and HHassetindex and decrease poverty gap. Crop income offers extra revenue to supplement what is obtained from livestock thereby increasing

farmers purchasing power and ability to accumulate assets. Similarly, use of own animals for draught power is shown to increase farmers HDD score while decreasing poverty gap. The increase in annual veterinary costs positively affects HHassetindex and significantly reduces poverty gap. This could suggest that a high veterinary expenditure comes with improved overall livestock health thus more revenues generated from such herds, thereby moving farmers away from poverty and boosting their asset accumulation capacity.

Table 3. 5 Driving factors for HDD, HHassetindex and Poverty depth

Variables	Variable definition	HDD	HHassetindex	Povty_depth
vaccination_inf	Received vaccination information 1 = Yes, 0 = No	0.73** (0.34)	-15.73 (52.63)	-0.13*** (0.04)
adv_herd_mgt	Received advice on herd management 1 = Yes, 0 = No	0.40 (0.56)	-101.58 (87.94)	-0.06 (0.03)
HHsize	Household size in number of persons	-0.14 (0.09)	8.42 (13.71)	0.63 (0.54)
AGE_RESP	Age of the Respondent in Years	0.01 (0.01)	1.47*** (1.78)	-0.01*** (0.02)
lnCropinc	Annual crop sales in Ugandan shillings (UGX)	0.03** (0.00)	0.21* (0.00)	-0.02*** (0.01)
Draught_power	Used animal for draught power (1 = Yes, 0 = No)	0.92* (0.51)	-44.70 (79.72)	-0.18*** (0.18)
RESP_EDN	Level of completed education (counts)	0.04 (0.07)	-3.47 (11.42)	-0.01 (0.11)
Invetcosts	Annual veterinary costs in UGX	0.38 (0.00)	0.07** (0.00)	-0.11** (0.00)
Insecurity	Household faced insecurity (1 = Yes, 0 = No)	-14.37 (13.39)	-740.90 (2098.97)	-0.30 (0.02)
saving_grp	Membership to savings group (1 = Yes, 0 = No)	-0.24 (0.40)	-72.18 (62.70)	-0.25 (0.01)
RESIDE	Resided in the area by 2016 (1 = Yes, 0 = No)	2.13 (1.63)	-293.64 (256.03)	-0.31 (0.02)
Cons	Constant intercept	-0.49*** (2.15)	-25.66 (337.61)	0.68 (0.20)

Note: values in parentheses are standard errors. ***, **, & * statistical significance at 1%, 5%, and 10%, respectively

3.4.3 Impact of Biosecurity measure adoption

The benefits livestock farmers derive by deciding whether to adopt or not to adopt biosecurity measures on their farms against RVF are presented in Table 3.6. The results show a positive and significant Average Treatment Effect (ATE), for HDD and HHassetindex. Suggesting that for any randomly selected livestock farmer within the pool, adoption of biosecurity measures against RVF increases HDD and HHassetindex by 1.9 and 0.3 respectively. The ATET are 2.0, 0.5 and -0.1 for HDD, HHassetindex and Poverty depth respectively. Implying that farmer participation in

biosecurity measures against RVF increases HDD and HHassetindex while decreasing the overall poverty gap. Lastly the results show a negative and significant ATENT for HHassetindex, which suggests that non adoption of biosecurity measures against RVF significantly reduces livestock farmers' asset index. This could be due to the lost productivity resulting from infections.

Table 3. 6 Impact of Biosecurity adoption on HDD, HHassetindex and Poverty gap

Parameter	HDDs	HHINDEX	Poverty gap
ATE	1.865*** (0.224)	0.256*** (0.100)	-0.074 (0.048)
ATET	1.946*** (0.203)	0.492*** (0.101)	-0.111*** (0.039)
ATENT	1.400 (1.118)	-1.097*** (0.360)	0.134 (0.187)

Note: values in parentheses are standard errors. ***, **, & * statistical significance at 1%, 5%, and 10%, respectively

3.4.4 Impact of biosecurity intensity on outcomes

The dose response function illustrating the effect of increasing biosecurity levels on HDD, HHassetindex, and Poverty depth are presented in figure 3.2. The HDD plot in figure 3.2a, for instance, shows a positive and significant effect of biosecurity intensity on HDD from a dose of 20 up to 80. In figure 3.2b, increasing intensity of biosecurity is shown to have a significant effect on HHassetindex from a dose of 60 to 85 percent. Lastly increasing intensity of biosecurity measures is shown to significantly reduce poverty depth from a dose of 65 to 80% (Figure 3.2c).

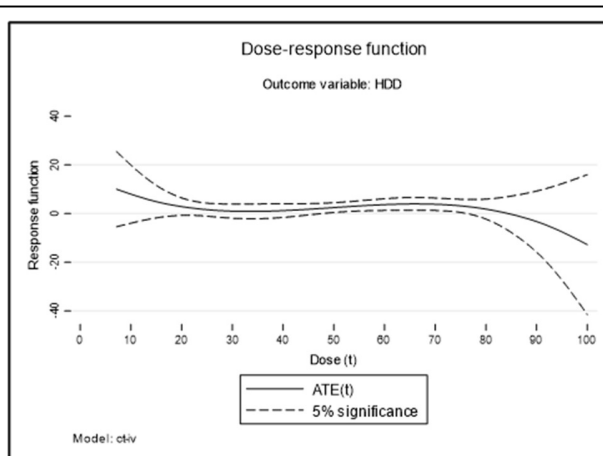


Figure 3.2a: HDD equation

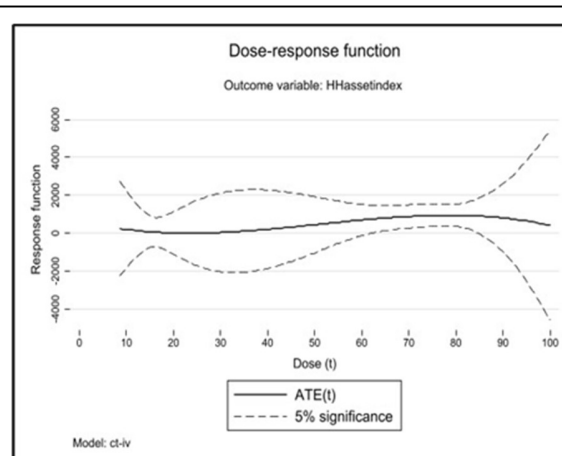


Figure 3.2b: HHassetindex equation

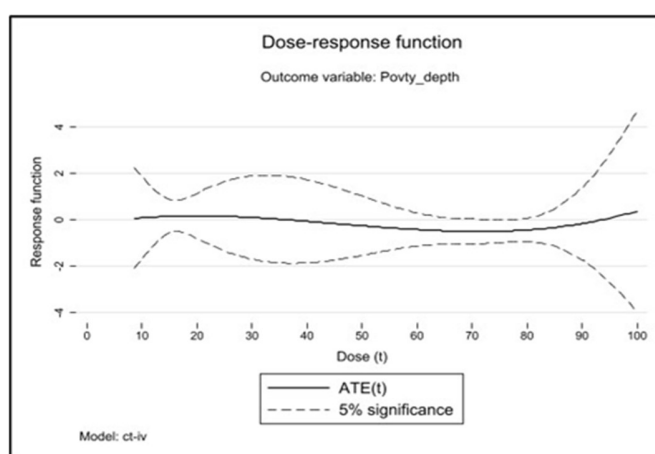


Figure 3.2c: Poverty gap equation

Figure 3. 2 Dose response function estimates for livestock farmer outcomes

3.5 Conclusion and policy recommendations

This paper deployed a dose response function model to investigate the impact of adoption and level of biosecurity measures adopted against RVF disease on food security and poverty outcomes of livestock farmers in Uganda. The results of the study provide relevant information to policy makers and stakeholders within the One-Health forum that can be used to incentivize uptake and increase levels of biosecurity measures adopted by livestock farmers at farm level against the diverse RVF risk factors that are in existence. Thus, improving farmers' welfare and food security

situation in the long run. Generally, the results suggest that the intensity of biosecurity measures implemented on the farms is dependent on whether the livestock farmers have received herd health management advice and use their animals to offer draft power. The decision to adopt or not to adopt biosecurity measures on the farm is driven mainly by peer influence. Adoption of biosecurity measures against RVF is shown to have positive impacts on livestock farmers' HDD and HHassetindex and also plays a huge role at reducing poverty gap among adopters. The dose response function results do reflect a heterogeneous effect of increasing biosecurity intensity on HDD, HHassetindex and poverty depth outcomes. The overall implication of the results to policy, is that biosecurity measures against RVF can be promoted at farm level to reduce overall prevalence and transmission of RVF disease, thereby enhancing farm productivity and improving overall farmers' welfare.

3.6 References

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Chapter Four

Ex-ante impact of Rift Valley Fever Control Strategies on Livestock Productivity

Marsy Asindu^{a,b*}, Awudu Abdulai^a, Bernard Bett^b, Kristina Roesel^b Dan Tumusiime^c Karl Rich^d
and Emily Ouma^b

^aChristian Albrechts Universitat zu Kiel (CAU), Kiel, Germany

^bInternational Livestock Research Institute (ILRI), Nairobi, Kenya

^cMinistry of Agriculture, Animal Industry and Fisheries (MAAIF), Entebbe, Uganda

^dOklahoma State University, Stillwater, Oklahoma, United States

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Abstract

Faced with the enormous intricacies of infectious diseases, policy makers are always at dilemma to quickly offer cost-effective disease prevention measures. However, in the absence of an efficient cost-effectiveness assessment strategy, such policies often fail as they may add to the burden presented by the disease through its direct and indirect effects. In this paper, a stochastic dynamic programming model based on the Susceptible, Exposed, Infected, Removed and Deceased (SEIRD), compartmental structure is used to simulate the implications of various RVF control policies on livestock farm productivity. The results show that livestock vaccination with live vaccines is effective at averting animal deaths on farm compared to the killed vaccines. Overall vaccines perform better if implemented along with surveillance programs though this comes with extra costs linked to continuous participatory surveillance.

Keywords: Rift Valley fever, dynamic programming, SEIRD, Productivity, Cost-effectiveness

4.0 Introduction

The emergence and re-emergence of zoonoses and their potentially disastrous impact on animal and human health are a growing concern around the globe (Woolhouse and Sequeria, 2005). The significance of zoonotic diseases is expanding, and their health and socioeconomic impacts are increasingly being experienced by many countries, particularly the developing ones. Zoonotic diseases continue to burden public health systems as well as undermine efforts to boost the livestock industry and the production of safe foodstuffs of animal origin to satisfy national needs and exports (WHO, 2005). Rift Valley Fever (RVF) is one of the many emerging zoonotic diseases with severe negative socio-economic impact on people's livelihoods. Once the virus is introduced in a country, it becomes endemic and causes periodic epidemics every four to ten years, resulting in extensive morbidity and mortality among livestock and humans, and extensive economic losses associated with loss of livestock and prolonged restriction in livestock trade.

RVF epidemics are normally separated by long inter-epidemic periods (IEPs) characterized by low disease activity in livestock and humans (Njenga and Bett, 2019). The disease causes serious impacts on rural food security and household nutrition, as well as direct and indirect losses to livestock producers in affected countries (FAO, 2012). Where it occurs, RVF is known to first impact pastoral livelihoods since livestock is the basis of human subsistence and prosperity, as well as of cultural life and social organization (Davies, 2010). Livestock also represents the main repository of household wealth and serves an important livelihood function, providing valuable goods and services such as milk, meat, blood, manure, transport, draught power, and financial services. Any risk imposed around livestock keeping by outbreak of RVF is thus a fundamental driver of food insecurity, health, and overall vulnerability of populations dependent on livestock for their livelihoods.

The drawbacks inflicted onto livestock production systems by outbreaks of RVF often pressurize countries and decision makers to quickly implement various control measures without conducting an accurate assessment of the potential losses and cost savings associated with each of the interventions. Haphazard implementation of disease control interventions not only results in use of less cost-effective disease management options under prevailing conditions but aggravates the impact of the disease on the affected population as well. In the case of RVF for instance, the 2007 outbreak in Sudan was followed by bans in livestock trade between Saudi Arabia and Sudan. This eventually resulted in a vast economic impact on the animal market in the two countries (Hassan et al., 2014). In the United Republic of Tanzania following the 2007 RVF outbreak, cattle trade ban was implemented. This ban ensured that 75 percent of potential exports was unable to leave the country consequently, the average price of bulls for slaughter in the domestic market dropped by 33 percent forcing the internal flow of marketed cattle to decrease by 40 percent (Rich and Wanyoike, 2010). This eventually encouraged stock piling, forcing farmers to take up extra livestock management costs. The government also had to spend more than 4.798 billion Tanzanian shillings (US\$3 million) on surveillance and control of RVF (FAO,2012).

More of concern, during the 2007 RVF outbreak in Kenya and Tanzania, large-scale sales of animals by farmers were prevented because of quarantines on movement and slaughter. Even those who afforded to sell received lower prices than those prevailing before the outbreaks. Traders on their part were forced to involuntarily incur maintenance costs of animals they purchased before the movement bans. Slaughterhouses remained closed for up to 3 months until the ban was lifted. This idling of slaughterhouses resulted in economic losses ranging from US\$ 812 to US\$ 2,917 per month. On the other hand, sales of butchers fell by 95% resulting in losses averaging US\$ 1169 – 1923 (Rich and Wanyoike, 2010).

Vaccinations on the other side have been conducted following most outbreaks. However, Kamal (2011) reveals that this should not be deployed on clinically sick animals and for pregnant animals as abortions may be induced. In the event that this is not followed, losses in terms of milk and future stock due to vaccine induced abortions may occur. There may also be time lags created before operations involving marketing of livestock products return to normal following implementation of some RVF control interventions. Kamal (2011) for instance shows that livestock should not be slaughtered until after 21 days following vaccination against RVF.

Based on this, it is evident that even though the different RVF control interventions may be beneficial in terms of mortality savings (Deaths prevented) in the event of RVF outbreaks, proper choice of interventions should always involve simulation of the effects of different interventions considering (1) the spread of the disease, (2) the direct cost of prevention and eradication, and (3) the indirect effects of the disease prevention intervention on markets and supply (Houben and Dijkhuizen, 1990; Van der Kamp et al., 1990). Published work in this field is scarce and hardly goes beyond the first two stages. Some efforts have been placed of recent to simulate all three dimensions, however, most of the models used in the estimation are static in nature, short run or non-spatial thus ignoring the dynamic interface between the epidemiology of most diseases and their socio-economic construct (Rich et al., 2005; Rich *et al.*, 2013; Rich, Roland-Holst, and Otte, 2013). Our study therefore adds to literature by fitting a dynamic SEIR model for evaluating the effects of RVF control options on livestock productivity. Deployment of such integrated epidemiology-economic models is crucial as it enables policy and decision makers to identify disease control interventions that offer optimal solutions against the disease at hand.

4.1 Conceptual framework for measuring the impact of RVF disease control interventions.

The theory of production economics is utilized to conceptualize this study. Following Rasmussen (2012), we assume that under ideal conditions, the sole objective of the livestock farmer is to minimize use of available resources to attain maximum gains in the form of profits and improved farm productivity. The livestock farmer uses available input (vaccine) to maximize productivity by reducing animal infections and averting over all case fatalities. The outputs such as meat, milk and accumulated live animals are then either consumed at home or sold in the markets to earn profits (see figure 4.1 below).

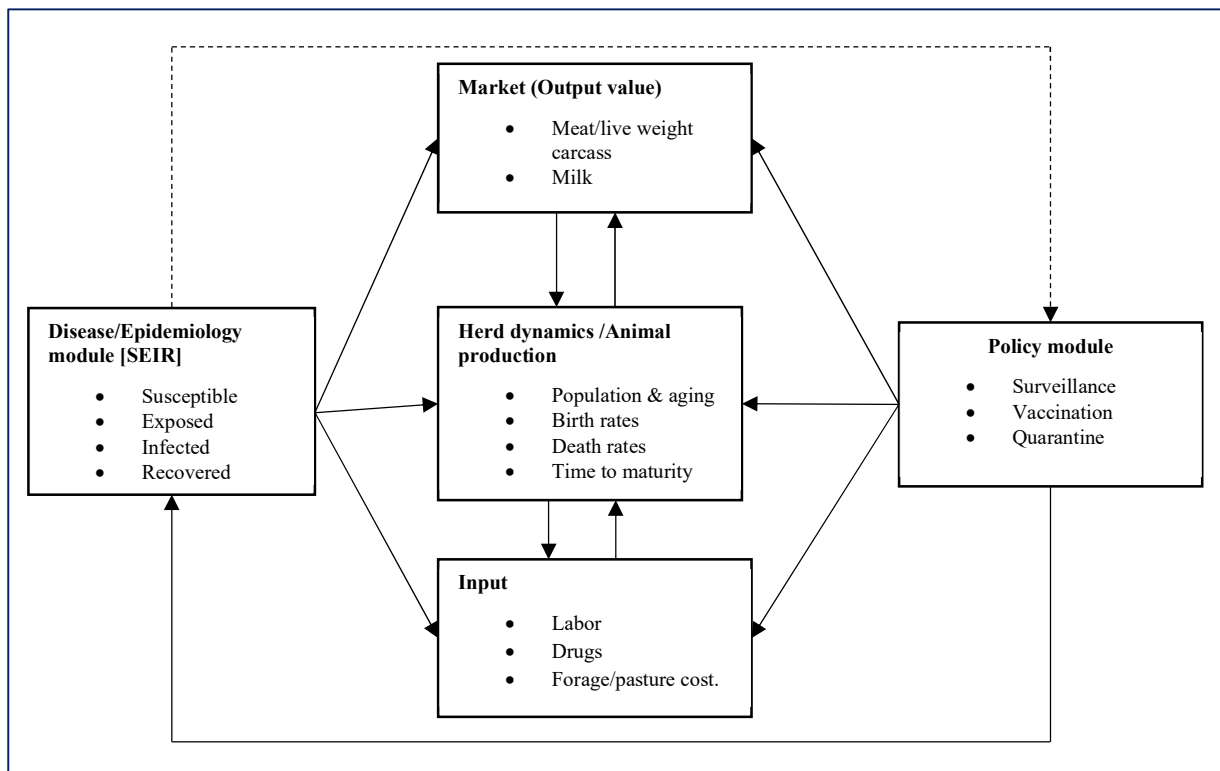


Figure 4. 1 Conceptual framework for assessing the impact of RVF disease control options.

When diseases such as RVF break out, animals in the system transition from being susceptible to exposure, then to infected and finally recovered (referred to as the epidemiology module). The impact of such disease spread is seen by the reduction in the efficiency with which animals convert

the available inputs into output (low productivity), which eventually has an impact on the supplies that enter markets and the overall profits at farm level. The realization of disease outbreak often triggers response in terms of implementation of control options which is widely informed by the disease dynamics. The chosen control options have an impact on production as expenditure on inputs are set to rise. At the production node, such control interventions for instance quarantine could lead to stock piling, thereby increasing production costs. Indirect impacts of the control options are meanwhile felt in the markets when slaughterhouses and butchers are forced to close. Alternatively, if trade bans are implemented at international level, surpluses are seen in the domestic market, and this has a huge impact on prices which in most cases decrease thus lowering farmer gains.

4.2 Analytical approaches for the impacts of the proposed RVF control interventions

4.2.1 Epidemiology model

The model content for the epidemiology of the RVF disease is structured to determine the spread of the disease right from its onset (after initial outbreak). A Markov chain model is fitted because of its ability to capture states and transitions which represent the stages of disease spread. The model also offers an extra benefit of allowing for the examination of a variety of disease control strategies (Miller, 1979). In the Markov chain model, during an outbreak, livestock are considered to belong to four mutually exclusive compartments (states) including susceptible, exposed, infectious, and recovered (referred to as the S.E.I.R model) as shown in figure 4.2 below.

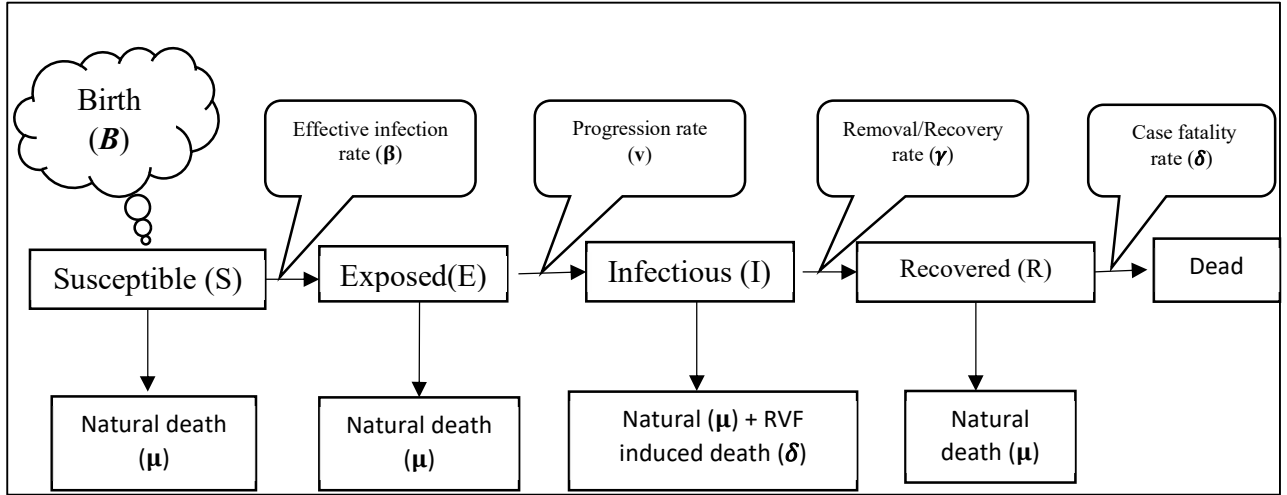


Figure 4. 2 General structure of the S.E.I.R epidemiology model.

Each week, the probability of every transition is calculated and the proportion of herds in each state during the next week is thus derived (Miller, 1979). To operationalize the model, four key assumptions are made following the incubation and transmission pattern of infectious diseases (Shah and Gupta, 2013). First, we assume that the number of infected animals increases at a rate proportional to both the number of infectious and the number of susceptible (β) also called the effective infection rate. Secondly, animals from the exposed compartment move to infectious state with a rate ν (progression rate). Third the rate of transition from infectious state to recovered is proportional to the number of infectious only (γ) also referred to as the removal rate. Lastly, animals can die at any stage due to natural death following a rate represented by (μ) and RVF induced death (δ). In addition to the assumptions, we assert that animals will be added to the system by birth with a rate represented as (B). The full expression of the model takes the form.

$$\frac{dS}{dt} = B - \beta SI - \mu S \dots \dots \dots (1)$$

$$\frac{dE}{dt} = B - \beta SI - (\nu - \mu)E \dots \dots \dots (2)$$

$$\frac{dI}{dt} = \nu E - (\gamma + \mu + \delta)I \dots \dots \dots (3)$$

$$\frac{dR}{dt} = \gamma I - \mu R \dots \dots \dots (4)$$

4.2.2 Economic model

In the economic model, cost benefit analysis based on the output from the S.E.I.R model is conducted. The cost of each potential intervention is computed and compared with the value of animal deaths averted by that particular control measure. For Quarantine measures, the value of animal deaths averted is compared with the value of business lost during the quarantine implementation period. System variables and parameters used for model estimation are presented in tables 4.1 and 4.2 respectively.

Table 4. 1 Description of system variables used for simulation

Variable	Description
S	Susceptible
E	Exposed
I	Infectious
R	Recovered/Removed
D	Deceased/Dead
V1	Vaccine one (Live vaccine)
V2	Vaccine two (killed vaccine)
Q	Quarantined

Table 4. 2 Description of parameters used for the model.

Parameter description	Value
Cattle population in study sites	874167
RVF latency period/incubation	3
Infective/infectious period	14
Case fatality rate	0.05
Reproduction rate (R_0)	2.1077
natural birth rate	0.00275
natural death rate	0.0006
Vaccine one efficacy	90%
vaccine two efficacy	70%
vaccine coverage	50
Vaccine effect	7 days

4.2.3 Scenario Analysis

In the initial case, three scenarios are simulated. The first being disease spread in the system without intervention, the second is where a live vaccine with efficacy of 90% is used as a preventive measure and the third scenario involves use of a killed vaccine with 50% efficacy. In the second case, four scenarios are compared as follow:

1. Disease spread on-farm without intervention.
2. Vaccine use as a control mechanism at the start of infections.
3. Vaccination is informed by surveillance programme.
4. Quarantine is implemented to contain RVF disease spread.

4.3 Results and Discussion

4.3.1 Case 1

Figure 4.1 below shows the number of infections under the scenarios simulated in case1, infections without any intervention (green) are shown to peak higher than it is for live vaccines (blue) and killed vaccines (red). The fewest number of animals infected are realized with the live vaccine, which demonstrates that the higher the vaccine efficacy the higher the level of protection it offers to the farms.

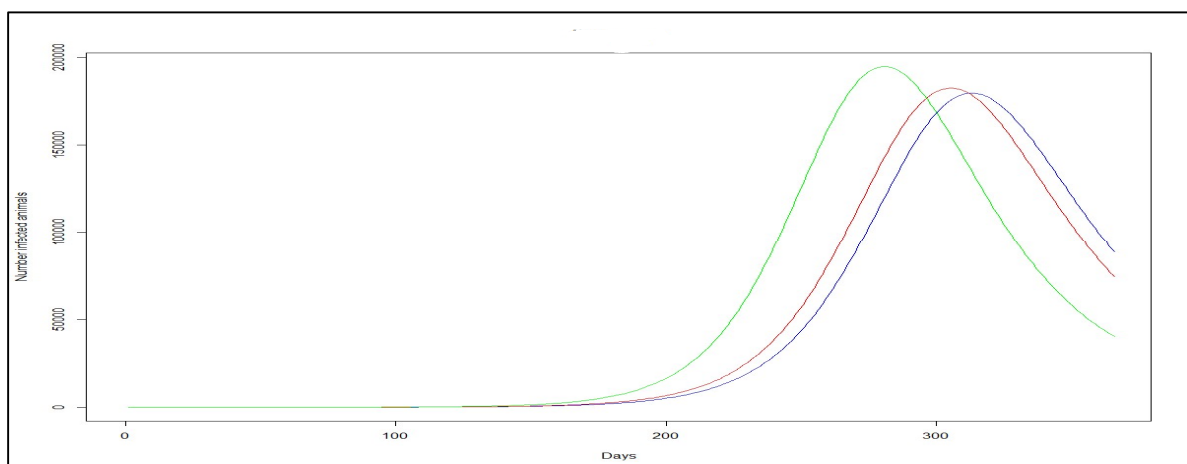


Figure 4. 3 number of farm animals infected under varied vaccine interventions.

The trend from figure 4.3 above suggest that RVF infections could be best managed by live vaccines, however, negative side effects of the vaccine, like the possibility of inducing abortions need to be considered when making decisions on its use.

4.3.2. Case 2

In case 2, simulation results of scenarios, 1 no intervention (Blue), 2 live vaccine (purple), 3 vaccine combined with surveillance (red) and 4 quarantine (green) is presented. The results in Figure 4.4 below as expected do reflect that more infections are averted when quarantine is implemented before infections set in. for the vaccination scenario, effective management of the disease is achieved if quarantine is combined with surveillance practices.

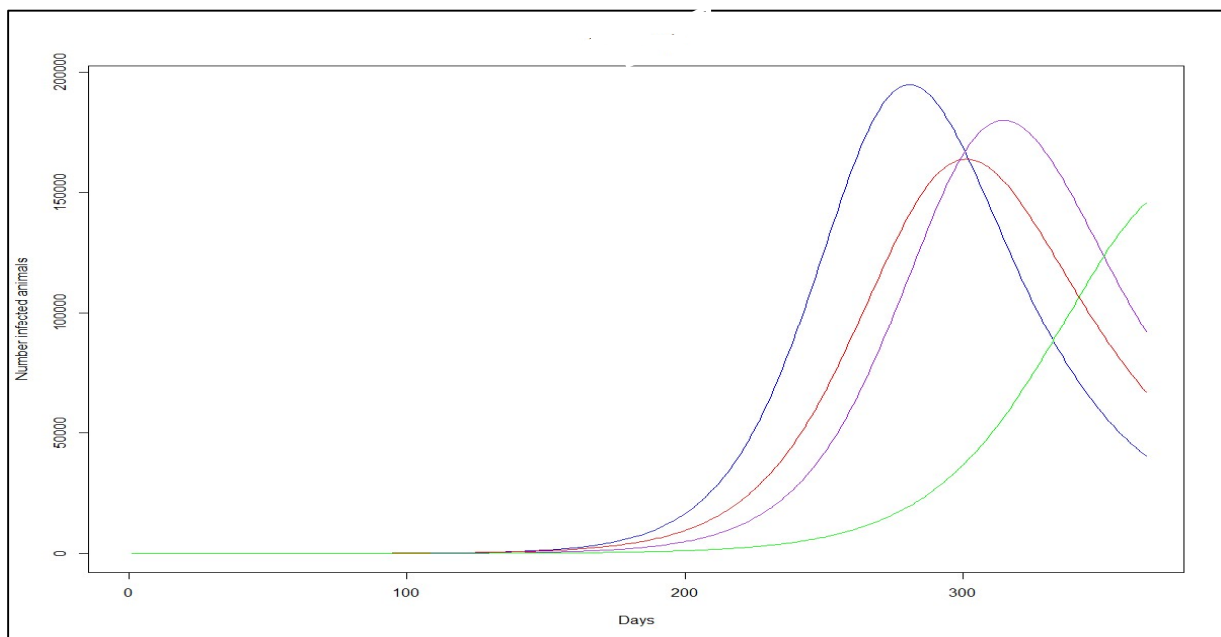


Figure 4. 4 Comparison of infections under vaccination, quarantine and surveillance

4. 4 Conclusion and policy implications

This study utilized an integrated epidemiology-economic model to simulate the impact of several RVF management strategies on livestock productivity. The results demonstrate that livestock vaccination with live vaccines averts more infections on farms thereby improving farm productivity in the long run. The effect of live vaccines can improve further when implemented alongside surveillance programs. Killed vaccines do perform fairly well as opposed to not having interventions on the ground but the overall costs may be high given that animals may have to receive repeated annual boosters to guarantee protection. Quarantine plays a great role at lowering overall disease transmission rate; however, its overall effects can be short lived if the restrictions are lifted and not immediately supplemented by other risk mitigation measures.

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Chapter Five

Choice heuristics and livestock farmers' preference heterogeneity for Rift Valley fever vaccines in Uganda

Marsy Asindu^{a,b*}, Awudu Abdulai^a, Bernard Bett^b, Kristina Roesel^b and Emily Ouma^b

^aChristian Albrechts Universitat zu Kiel (CAU), Kiel, Germany

^bInternational Livestock Research Institute (ILRI), Nairobi, Kenya

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Abstract

Rapid spread and erratic outbreaks of Rift Valley fever (RVF) disease across the African continent continues to pose serious threat to animal, public health, and regional livestock trade. Failure to institute timely control measures will have serious implications on food security and livelihoods. Among existing control options for the disease, vaccines are reported to be the most cost-effective. However, no RVF vaccines are currently registered for use in Uganda. Prior to approval, reservations exist concerning the uptake of vaccines by farmers as they have to weigh in several features and associated risks before acceptance. This study utilizes data from 444 livestock farming households in Uganda to elicit farmers' preference heterogeneity and the influence of choice heuristics on their preferences for RVF vaccines. The empirical results reveal that two livestock farmer segments exist with respect to RVF vaccine preference. The single dose vaccine attribute is the most highly valued by farmers. Further, livestock farmers' conditional perceptions and risk attitudes play a major role in vaccine choice decisions. The paper highlights the need for careful consideration of livestock farmers' preference heterogeneities and intrinsic motivations such as risk attitudes and conditional perceptions when designing policy instruments for the promotion of RVF vaccination programmes.

Key words: Choice experiment; RVF vaccine preference; heuristics; risk attitudes; health policy

5. 0 Introduction

Rift Valley fever is one of the economically important transboundary diseases that has serious implications on food security and livelihoods of livestock value chain actors (Perry and Rich, 2007; Perry and Grace, 2009). For instance, economic losses exceeding \$60 million were estimated from the 2006-2007 RVF outbreak in the East African region alone (Rich and Wanyoike, 2010; Peyre et al., 2014). The Sudan outbreak in 2007 led to bans in livestock trade between Saudi Arabia and its main supplying countries located in East Africa including Sudan, resulting in vast economic impact on the animal market estimated at a value of 600 – 900 million dollars annually (Hassan *et al.*, 2014). The ramification of the disease is further magnified by its tendency to affect humans and being transmitted by globally distributed mosquito species of the genus *Aedes* and *Culex*, thus imposing a global animal and public health burden, prompting the World Health Organization (WHO) to consider it a priority disease for research and development in emergency context across the global (WHO, 2022). As the disease continues to expand and becomes endemic in new territories, there is urgent need for cost-effective preventive measures to be implemented either singly or in combination with other measures. Some of the few RVF control measures recommended by the World Organization for Animal Health (WOAH), Center for Disease Control and prevention (CDC) and WHO for use during outbreaks include animal movement control, test and slaughter, vector control, slaughter bans, trade bans, regular surveillance, quarantine, and vaccination programmes (WHO, 2018). Mixed results have however been documented from the use of these control measures in previous RVF outbreaks that impact their choice for continued use.

Animal movement control for instance, whilst a good control mechanism, is complex to implement due the existence of “green borders” that are porous with no formal checks.

Additionally, the practice fails in pastoral production systems due to transhumance and socio-cultural practices and is even unmanageable where there is civil strife and cattle rustling (Masige et al., 1998). Test and slaughter on the other hand fails in African countries because of the reluctance of livestock owners to slaughter their animals and fear of economic losses if they report outbreaks. Likewise, there is indication of government inability to pay compensation for the slaughtered animals and sustain such schemes during outbreaks (Thomson, 2005; IOM and NRC, 2009). Slaughter bans, trade bans and quarantine have serious economic implications on livestock markets as foreign exchange is lost when livestock exports are banned (Hassan et al., 2014). Domestically, meat traders (butchers and slaughterhouses) lose out due to closures (Rich and Wanyoike, 2010). Vector control would be a formidable option but given the short breeding cycles of mosquitoes and the ability of the female to transmit the virus directly to her offspring via eggs, leading to new generations of infected mosquitoes hatching from eggs makes it less cost effective (WHO, 2018). In particular, Tmimi et al. (2018), show that efficiency of vector control as RVF prevention measure is increasingly compromised by the emergence of insecticide resistance. This therefore leaves vaccination as the most favorable option, especially for low-income countries grappling with RVF outbreaks.

RVF vaccines are already widely used in endemic countries but has not yet been licensed and approved for use in Uganda, a country that continues to experience periodic RVF outbreaks and predicted to gradually become endemic (CDC, 2020). Pending the licensing it is expected that vaccine availability and access alone may not be adequate to guarantee uptake by livestock farmers as existing empirical evidence demonstrates that farmers often consider several vaccine features and attributes before deciding to accept or participate in vaccination programs, given their circumstances (Ouma et al., 2021). Besides, they also rely on divergent intrinsic concepts such as

risk attitudes and conditional perceptions to make individual vaccine acceptance decisions, which creates heterogeneity in their vaccine preferences. Failure to account for these heterogeneities in preferences and its underlying causes when designing vaccination strategies and policy instruments will often result in low uptake or rejection of the proposed interventions. Effective introduction of a RVF vaccine will therefore require a prior and thorough understanding of farmer preferences and willingness to pay (WTP) for vaccines so that only vaccines that closely meet the interests of the intended beneficiaries are introduced.

Empirical studies on evaluation of preferences and willingness to pay for livestock vaccines mainly utilize two stated preference approaches; namely contingent valuation (Wanyoike et al., 2019; Wane et al., 2020; Jemberu et al., 2020) and discrete choice experiments (CE) (Sok et al., 2018 Ouma et al., 2021). Application of contingent valuation approach is however limited in incidences where multiple options and product attributes have to be considered prior to choice decisions (Diamond and Hausman, 1994; Stevens et al., 2000). Making CE the most preferred and commonly used approach when eliciting demand and preferences for non-market goods like the RVF vaccines in Uganda. However, the hypothetical CE which has been employed in many studies is reported to suffer from some biases. Mental information processing rules (heuristics) are a major source of biases inducing substantial deviation from rationality, if left unaccounted for in hypothetical CE (Simon, 1955; Hensher, 2008).

A number of studies have attempted to demonstrate the importance of accounting for heuristics in hypothetical CE (Scarpa et al., 2013; Bello and Abdulai 2016; Kassie et al., 2022; Colombo et al., 2022; Kassie et al., 2023). In particular, they examine attribute non-attendance as one of the heuristics with known potential to induce hypothetical biases in stated preference choice studies and highlight mitigation measures such as cheap talks, nudges, and honesty priming. While

commendable, the recent body of empirical evidence show that heuristics go beyond attribute non-attendance to include risk attitudes and perceptions (Just and Just, 2016; Gilbert and Rushton, 2016) as well as conditional operands (Balbontin et al., 2016; Igaki et al., 2019). Such heuristics are best modelled simultaneously to eliminate possible endogeneity issues within the choice responses that can result in biased policy decisions. Balbontin et al. (2016) demonstrate how the integration of multiple information processing criterion (heuristics) into utility functions can enhance decision making in the transport sector. But to the best of our knowledge no such applications have been made in livestock related research.

Our study fills this gap by using CE data collected from livestock farmers in 6 districts of Uganda to investigate preferences for RVF vaccines and assess the influence of heuristics on RVF vaccine choice decisions. We employ a latent class model to elicit farmer preference heterogeneities for RVF vaccine attributes and identify possible farmer segments based on attribute preferences. An equality constrained latent class model (ECLCM) is fitted to identify probabilities of attribute non-attendance and finally a hybrid latent class model is used to integrate three information processing strategies (i.e., attribute non-attendance, risk attitude and conditional perceptions) into a utility function for RVF vaccine choice. The study contributes to literature by integrating multiple heuristics including risk perceptions into farmers choice decision framework. This is particularly important as it informs policy makers about the observed and unobserved factors that are likely to inform farmers vaccine uptake decisions once made available. Policy makers can also draw useful information about existing farmer segments in relation to vaccine preference and use this to draft awareness creation messages that can boost overall participation in vaccination programmes.

5.2. Materials and methods

5.2.1. Survey design and data description

The primary data for this study were drawn from 444 cattle keeping households, using a multi-stage sampling approach from six districts of Uganda between the period October and December 2021. The 6 districts were purposively selected based on evidence of RVF seropositivity and the anticipated higher risk of future RVF outbreaks. Cattle farmers were specifically targeted because of the high level of RVF seroprevalence in cattle as opposed to other livestock species and the tendency to often vaccinate cattle at the expense of small ruminants and other animal species among the farming communities. Within each of the six purposively selected districts, two sub-counties with high RVF seroprevalence were identified, from which one parish each with the highest risk level for RVF outbreak was then singled out as the lowest unit for sampling. The local council authorities in each of the identified parishes were asked to provide a full list of cattle rearing households together with the number of heads of cattle kept and gender of the household heads. The lists were later compiled and used to draw a representative sample that was interviewed during the study. Before embarking on the study, ethical clearance for the study was reviewed and approved by Institutional Research Ethics Committee (IREC) International Livestock Research Institute (ILRI-IREC2021-30) and the Vector Control Division Research Ethics Committee (VCDREC133).

During the survey, face to face interviews were held with cattle farmers using semi-structured questionnaires programmed using Open Data Kit (ODK) Platform. The questionnaire featured information on cattle farmers' socio-demographics, attribute processing strategies (level of attention to vaccine attributes, ranking by level of importance vaccine attributes), risk attitudes and conditional perceptions related to RVF vaccines among others.

5.2.2 Choice experiment design

Design of the choice experiment commenced with the identification of RVF vaccine attributes together with the respective levels. This was achieved through focus group discussions (FGD) with livestock farmers, a thorough review of literature on the development and use of RVF vaccines in livestock production and consultations with Onderstepoort Biological Products (OBP) a renowned RVF vaccine manufacturer based in South Africa. Particularly for the focus group discussion, 16 sex-disaggregated focus group discussions each comprising 6 – 8 participants were held. A thoroughly drafted FGD guide was used to drive the discussions with its main aspects revolving around vaccination programmes in the communities visited, barriers to vaccination programmes and what the communities think could improve vaccine uptake by livestock farmers. The entire process was concluded with six vaccine attributes of importance being identified, each with three levels as displayed in table 5.1.

Table 5. 1 RVF vaccine attributes and levels used in the choice experiment.

Attribute	Attribute description	Attribute level
Dose regimen and effectiveness	Dosage regimen required for the animal to be fully protected against RVF.	<ol style="list-style-type: none"> 1. Single vaccination required for lifelong protection. 2. Initial vaccination + annual boosters required for full protection. 3. Initial vaccination + booster 3 - 4 weeks after the first vaccination + annual boosters required to attain full protection.
Distance and vaccination points	Vaccination points and cost associated with distance travelled.	<ol style="list-style-type: none"> 1. Vaccination done at designated communal vaccination point, No extra cost. 2. Vaccination done at farmers home within 5 km of the designated communal vaccination point + 5000 UGX extra cost per vaccination event. 3. Vaccination done at farmers home, > 5 km away from the designated communal vaccination point + 10,000 UGX extra cost per vaccination event.
Adverse effects	Advance events likely to occur following vaccination of the animals against RVF	<ol style="list-style-type: none"> 1. No reaction 2. Febrile reaction occurs on the second to fourth day following vaccination after which clears. 3. 28% chances of abortion if in-calve animals are vaccinated.
Vaccine withdrawal period	Time taken before animal products (milk & meat) can be used for human consumption following vaccination.	<ol style="list-style-type: none"> 1. One week before animal product can be consumed following vaccination. 2. Two weeks before animal products can be consumed following vaccination. 3. Three weeks before animal products can be consumed following vaccination
Exemption of vaccine use	Circumstances under which vaccine cannot be used on animals	<ol style="list-style-type: none"> 1. No exemption 2. Calves below 6 months of age from immune cows can't be vaccinated. 3. Can't be used during outbreak (epidemic period)
Cost of vaccination	Cost of vaccination per head of cattle per vaccination event.	<ol style="list-style-type: none"> 1. UGX 5700 2. UGX 8550 3. UGX 11400

**Note: At the time of the survey 1 USD was equivalent to 3585.78 Ugandan shillings (UGX). (Computation of cost per vaccination event factored in the cost per 100 ml vial of specific types of RVF vaccines already in use outside Uganda, insurance costs, freight, verification, and value added tax, transport to district of vaccination and mark-up)*

Considering the number of available RVF vaccine attributes and respective levels presented in Table 2, a total of 729 ($3 \times 3 \times 3 \times 3 \times 3 \times 3$) choice scenarios were possible following a full factorial design. However, subjecting survey participants to all the available scenarios is generally impracticable. The study therefore made advantage of the fractional factorial design to generate 24 RVF vaccine choice tasks using D-efficient design (D error 0.057 and A error 0.069). The 24 choice tasks were then assembled into three blocks of eight scenarios each to minimize respondent

fatigue during implementation of the CE, with an equal number of respondents (148) being randomly assigned to each block. A sample choice card administered to the respondents during the CE is presented in figure 5.1 below.

BLOCK 1

CHOICE SET 1













Attribute	Option A	Option B	Option C
Dose-regimen and effectiveness	 <ul style="list-style-type: none"> Single vaccination required for lifelong protection. 	 <ul style="list-style-type: none"> Initial vaccination + Annual boosters. 	Neither Option A nor Option B
Distance and vaccination points and associated transport cost for the Vet	 <ul style="list-style-type: none"> Vaccination at communal points, no extra cost. 	 <ul style="list-style-type: none"> Vaccination at farmers home, >5km away Ugx 10000 Vet transport. 	
Adverse effects	 <ul style="list-style-type: none"> No reaction. 	 <ul style="list-style-type: none"> Pregnant animal likely to abort 	
Vaccine withdrawal period	 <ul style="list-style-type: none"> No consumption of milk and meat for 7 days. 	 <ul style="list-style-type: none"> No consumption of milk and meat for 21 days. 	
Exemption of use	 <ul style="list-style-type: none"> Don't use during outbreak. 	 <ul style="list-style-type: none"> Calves below 6 months of age from immune cows can't be vaccinated. 	
Cost of vaccination	 <ul style="list-style-type: none"> UGX 11,400 / Vaccination / Animal. 	 <ul style="list-style-type: none"> UGX 5,700/ Vaccination /Animal. 	
Choice question:	Which of these vaccines do you prefer?		

Figure 5. 1 Sample choice card used with the respondents during the study.

Prior to the CE, cheap talk, and a slight nudge not adequate enough to induce choice hacking was delivered to the respondents using a script designed following Cummings and Taylor (1999). This was particularly conducted with the aim of minimizing hypothetical bias and thus making sure the choices made are as if the product was readily available for purchase in the market.

Upon completion of the choice tasks, respondents were issued with a number of follow up questions (probes) which evolved around the choice processing procedure. First, they were tasked to indicate their level of attendance to the different vaccine attributes presented during the CE on

a five-point Likert scale (1 = never to 5 = always). They were then asked to rank the vaccine attributes following the sequence of their importance from the most to least important.

5.3 Econometric framework

The discrete choice experiment approach used for this study is rooted in the Lancasterian consumer theory (Lancaster, 1966), which states that farmers derive utility by considering a bundle of product attributes and not the product itself. The farmer's decision on the choice of a vaccine is contextualized as a random utility problem, where farmer (n) makes repeated choices among j different vaccine alternatives in t choice situations. Each vaccine alternative j is represented by a random utility function expressed as:

$$U_{njt} = \beta'X_{njt} + \varepsilon_{njt} \dots \dots \dots (1)$$

where U_{njt} is the utility farmer n derives from choosing vaccine alternative j , X_{njt} is a vector of observed variables (vaccine attributes and socioeconomic characteristics) of individual farmers, β is a vector of coefficients/estimated taste parameters for each farmer, and ε_{njt} is an unobserved random term that is independent and identically distributed (iid) extreme value. Farmer n chooses the vaccine alternative that gives the highest utility, such that:

$$P_{nj} = \text{prob}(\beta'X_{nj} + \varepsilon_{nj} > \beta'X_{nk} + \varepsilon_{nk}) \forall j \neq k \in C, \text{ where } C \text{ is the choice set of } j \text{ RVF vaccine alternatives, } j = 1 \dots \dots \dots J \dots \dots \dots (2)$$

Several studies have reported marked heterogeneity in the utility farmers derive from their choices of attributes of vaccines conditional on their characteristics (Ouma et al., 2021). To account for this heterogeneity, we draw from equation 2 to fit a latent class model (LCM) that identifies farmers into heterogenous groups with farmers within the same group sharing similar preferences (Hensher et al., 2013). Under the LCM, the utility parameters, β_n , take a finite number

C of values $B_{n1}, B_{n2}, \dots, B_{nC}$ with corresponding probabilities $H_{n1}, H_{n2}, \dots, H_{nC}$ of belonging to a particular latent class, c. Under this framework, two probabilities are estimated: (i) the class probabilities of choosing alternative j in T choice situations conditional on the preferences within each class,

$$P_{njt/c} = \frac{\exp(\beta'_c X_{njt})}{\sum_{j=1}^n \exp(\beta'_c X_{njt})} \dots \dots \dots (3)$$

and (ii) the probability that farmer n belongs to a particular class, given by the following equation (Greene and Hensher, 2003; Greene and Hensher, 2013):

$$H_{nc} = \frac{\exp(\theta_c Z_n)}{\sum_{c \in C} \exp(\theta_c Z_n)} \dots \dots \dots (4)$$

where θ_c are the class-specific parameters, with Cth vector normalized to ensure model identification, and Z_n is a vector of alternative attributes and farmer's characteristics. It should be noted however that when using latent class models, the number of latent segments cannot be easily defined. In this study, we base on information criterion statistical procedures that involve use of minimal Akaike Information Criterion (AIC), and the minimal Bayesian Information Criterion (BIC) (Allenby 1990) to identify the optimal number of segments (Swait, 1994).

The welfare measure observed through farmers' willingness to pay for vaccine attributes is then computed as rate of change in the coefficient of vaccine attributes divided by the rate of change in the price coefficient, and is specified as follows,

$$WTP = - \frac{\beta_{Vaccine\ attributes}}{\beta_{Price}} \dots \dots \dots (5)$$

The use of choice simplification strategies mainly attribute non-attendance (ANA) is shown to be common in choice experiment studies. This usually helps to show the level of attention farmers pay to specific attributes while making their vaccine choices. Stated ANA and Inferred

ANA are two of the most commonly applied in empirical research. Stated ANA is an experimental approach that relies on self-assessment, where respondents are directly asked whether or not they ignored one or more attributes (Scarpa et al., 2010; Rose et al., 2012). Inferred ANA on the other hand involves inferring of ANA behaviour through the estimation of analytical models (Harrison et al., 2020). This study applies an Equality Constrained Latent Class model (ECLC) for inference of vaccine attribute non-attendance. In the ECLC model, the coefficient of attributes that have not been attended to are set to zero, while those that have been attended to take nonzero coefficient across classes (Hensher & Greene, 2010). This is particularly done to ensure that utility weights are constrained to be equal in all classes. With six (6) vaccine attributes, an eight-class model is estimated with each representing different ANA strategies used by the farmers in making RVF vaccine choice decisions. The first class represents full attendance to all the six vaccine attributes. Classes two to seven represent partial attribute attendance in which one of the six vaccine attributes is not attended to per class. The last class (class eight) represents total non-attendance in which none of the six vaccine attributes is attended to by the farmers while making their choices. The full structure for this eight-class model is presented as below:

$$\begin{pmatrix} \beta_{Vcost} \neq 0 \beta_{Dose} \neq 0 \beta_{Dist} \neq 0 \beta_{Adeffects} \neq 0 \beta_{WDraw} \neq 0 \beta_{Exempt} \neq 0 \\ \beta_{Vcost} = 0 \beta_{Dose} \neq 0 \beta_{Dist} \neq 0 \beta_{Adeffects} \neq 0 \beta_{WDraw} \neq 0 \beta_{Exempt} \neq 0 \\ \beta_{Vcost} \neq 0 \beta_{Dose} = 0 \beta_{Dist} \neq 0 \beta_{Adeffects} \neq 0 \beta_{WDraw} \neq 0 \beta_{Exempt} \neq 0 \\ \beta_{Vcost} \neq 0 \beta_{Dose} \neq 0 \beta_{Dist} = 0 \beta_{Adeffects} \neq 0 \beta_{WDraw} \neq 0 \beta_{Exempt} \neq 0 \\ \beta_{Vcost} \neq 0 \beta_{Dose} \neq 0 \beta_{Dist} \neq 0 \beta_{Adeffects} = 0 \beta_{WDraw} \neq 0 \beta_{Exempt} \neq 0 \\ \beta_{Vcost} \neq 0 \beta_{Dose} \neq 0 \beta_{Dist} \neq 0 \beta_{Adeffects} \neq 0 \beta_{WDraw} = 0 \beta_{Exempt} \neq 0 \\ \beta_{Vcost} \neq 0 \beta_{Dose} \neq 0 \beta_{Dist} \neq 0 \beta_{Adeffects} \neq 0 \beta_{WDraw} \neq 0 \beta_{Exempt} = 0 \\ \beta_{Vcost} = 0 \beta_{Dose} = 0 \beta_{Dist} = 0 \beta_{Adeffects} = 0 \beta_{WDraw} = 0 \beta_{Exempt} = 0 \end{pmatrix} \Rightarrow \begin{pmatrix} \pi_0 = \text{Full attendance} \\ \pi_1 = \text{Cost not attended} \\ \pi_2 = \text{Dose not attended} \\ \pi_3 = \text{Distance not attended} \\ \pi_4 = \text{Adverse effects not attended} \\ \pi_5 = \text{Withdraw not attended} \\ \pi_6 = \text{Use exemption not attended} \\ \pi_7 = \text{All attributes not attended} \end{pmatrix} \dots \dots (6)$$

Where $\beta_k \neq 0$ showcases vaccine attribute coefficients that have been constrained to be equal across all classes, while $\beta_k = 0$ is a scenario in which coefficients have been fixed to zero.

An important feature of focus in our study is to integrate the choice model with multiple information (choice) processing strategies also referred to as heuristics. To achieve this, a Hybrid

Choice Model (HCM) is estimated. The HCM is an integration of two models i.e., the choice model and latent variable model, with each constituting one or more structural and measurement equations. Full specification of these equations and likelihood function follows an approach proposed by (Ben-Akiva et al., 1999). First, we fit a structural equation for the latent variable model, to help in the establishment of the distribution of latent variables given the observed variables ($f_1(X_n^*|X_n; \lambda, \Sigma_\omega)$), with the full expression denoted as.

$$X_n^* = h(X_n; \lambda) + \omega_n \text{ and } \omega_n \sim D(O, \Sigma_\omega) \dots\dots\dots (7)$$

where X_n^* is the latent variable, X_n is a vector of observed characteristics of farmer n, D is a distribution function, ω is a random disturbance term, and λ is an unknown parameter to be estimated. One equation is fitted for each of the three latent variables (stated attribute non-attendance, risk attitude and conditional perception) considered in this study.

We then fit a second structural equation for the choice model to establish the distribution of utilities given the observable and latent variables ($f_2(U_n|X_n, X_n^*; \beta, \Sigma_\varepsilon)$), with the overall equation specified as

$$U_n = V(X_n, X_n^*; \beta) + \varepsilon_n \text{ and } \varepsilon_n \sim D(O, \Sigma_\varepsilon) \dots\dots\dots (8)$$

where U_n represents vector of utilities, ε is a random disturbance term and β is unknown parameter.

For the measurement equation, two models (latent variable and choice) are still fitted as is the case with the structural equations in the first stage. The latent variable model in the measurement equation establishes the distribution of indicators conditional on the values of the latent variables ($f_3(I_n|X_n, X_n^*; \alpha, \Sigma_v)$). This can be expressed as

$$I_n = m(X_n, X_n^*; \alpha) + v_n \text{ and } v_n \sim D(O, \Sigma_v) \dots\dots\dots (9)$$

where I_n represents the indicator of latent variables, α , is an unknown parameter and u_n denotes the random disturbance term. In principle, one equation is set up for each latent variable indicator (response from conditional perceptions, risk attitudes and stated attribute non-attendance statements) elicited from farmers during the CE survey. Principal component analysis (PCA) was conducted on responses to a set of 18 perception statements issued to the respondents during the CE in order to identify items (indicators) that factored well for risk attitude and conditional perception latent variables used in the model.

The overall choice probability is then presented as $P(y_n|X_n, X_n^*; \beta, \Sigma_\varepsilon)$, which is conditioned on both observable and latent explanatory variables. And to generate the likelihood function for the integrated model (HCM), we first specify a choice model without latent variables: $P(y_n|X_n; \beta, \Sigma_\varepsilon)$ (10)

Then incorporate the latent variables into the choice model in the following stage where the likelihood function is now presented as an integral of the choice model over the distribution of the latent constructs:

$$P(y_n|X_n; \beta, \lambda, \Sigma_\varepsilon, \Sigma_\eta) = \int_{x^*} P(y_n|X_n, X_n^*; \beta, \Sigma_\varepsilon) f_1(X^*|X_n; \lambda, \Sigma_\omega) dX^* \dots \dots \dots (11)$$

Finally, to improve the precision of the estimates linked to the structural parameters as well as improve on their identification, indicators to each of the latent variables used in the model are introduced.

5.4 Empirical Results

5.4.1 Descriptive statistics

Segment specific descriptive statistics based on vaccine preference heterogeneity of the farmers are displayed in table 5.2. The statistics show that vaccine enthusiasts are younger than status quo group. The majority of farmers in the two segments attained primary level education and come from households with a size of at least five people on average. Nearly half of the respondents within the “Enthusiasts” segment reported often moving their herds to new locations in search of pasture. However, among the “Status quo” segment, two out of three households reported moving their herds. With regards to farmers’ awareness of RVF, our results show that one third have heard about RVF in both segments.

Table 5. 2 Vaccine preference Segment specific descriptive statistics for cattle farming households

Variable	Enthusiasts	Status quo
Gender of the respondent:		
Female	118 (28.92)	6 (16.67)
Male	290 (79.08)	30 (83.33)
Marital status (Married)	354 (86.76)	34 (94.44)
Age (years)	47.14	50.56
Move herd to new locations often (Yes)	193 (47.30)	24(66.67)
Household size (Persons)	6.30	4.89
Have access to tarmac road (Yes)	274 (67.16)	17 (47.22)
Have access to veterinary shop (Yes)	328 (80.39)	22 (61.11)
Production system (Pastoral)	201 (49.26)	21 (58.33)
Have heard about RVF (Yes)	141(34.56)	13 (36.11)
No education (%)	108 (26.47)	9 (25)
Primary level (%)	188 (46.08)	14 (38.89)
Lower secondary (%)	69 (16.91)	8 (22.22)
Upper secondary (%)	18 (4.41)	1 (2.78)
Vocational (%)	15 (3.68)	1 (2.78)
University degree (%)	10 (2.45)	3 (8.33)

Note: with exception of the age and household size variables for which mean values are presented, the remaining variables are presented as frequencies with the percentages inserted in parenthesis.

5.4.2 Preference heterogeneity for RVF vaccines

Results of the RVF vaccine preference heterogeneity estimated with a latent class model are presented in table 5.3. The results reveal that two heterogeneous cattle farmer classes exist with

respect to RVF vaccine preference. The fitted probability of belonging to each of these two classes were 92% for class 1 (Enthusiasts) and 8% for class 2 (Status quo). The enthusiastic group were generally willing to take up any of the available RVF vaccine options rather than opt-out and this is reflected by the negative and statistically significant coefficient for the alternative specific constant (ASC3). The status quo class meanwhile preferred opting out as indicated by the positive and significant coefficient for the alternative specific constant (ASC3).

Table 5. 3 Latent class model estimates for RVF vaccine preference heterogeneity

Attribute Levels	Class 1 (Enthusiasts)	Class 2 (Status quo)
Utility function estimates		
Price	-0.0002*** (0.0000)	-0.0003*** (0.0001)
Single dose	1.1773*** (0.2214)	1.6387*** (0.5211)
Initial dose plus annual doses	0.1363 (0.2243)	1.2682** (0.5012)
Vaccination at collective central point	0.3382*** (0.0717)	0.7520 (0.5267)
Vaccination at farmers home at 5 Km radius	-0.8659*** (0.2263)	0.4426 (0.4991)
No reaction after vaccination	0.7666*** (0.0789)	0.4862 (0.6567)
Fever after vaccination	-0.1908 (0.2964)	-0.2621 (0.6180)
Withdrawal period 7 days	0.1717*** (0.0712)	-0.0359 (0.5480)
Withdrawal period 21 days	-1.2704*** (0.2812)	-0.1537 (0.4663)
No use exemption	1.0119*** (0.3644)	1.7190** (0.5705)
Not for use on calves below 6 months	0.6906*** (0.0944)	-0.1951 (0.6622)
Alternative Specific Constant (ASC3)	-3.8935*** (0.2772)	1.5130* (0.7864)
Membership function estimates (Respondent characteristics)		
Gender	1.1287** (0.5238)	
Age of the respondent	-0.0231* (0.0135)	
Previously vaccinated cattle	0.9980** (0.4786)	
Regularly move herd	-1.2748*** (0.4635)	
Household size	0.3235*** (0.0973)	
Tarmac road access	0.7544* (0.3996)	
Vet shop access	1.0902** (0.4516)	
Pastoral production system	-0.8957** (0.4310)	
constant	1.2301 (0.9972)	
Latent class probability	0.9190	0.0810
Number of observations	10656.0000	
Log likelihood	-2395.3826	

Note: values in parentheses are standard errors. ***, **, & * statistical significance at 1%, 5%, and 10%, respectively

The coefficient of the price variable in both classes were negative and statistically significant, suggesting that as the price of the vaccine increases, farmers' demand for vaccine decreases. These results are in line with the theory of demand. Farmers in both classes (1 and 2) generally obtained higher and positive utility from single dose RVF vaccine even though class 2 members exclusively derived also utility from those vaccines that involved use of repeated annual boosters. This observation could probably be attributed to the fact that having a single dose for life protection against RVF disease reduces future vaccination costs and also minimizes the risk that animals will have to be exposed or even infected as they await booster doses. The results further reveal that with exception of class 1 farmers who derived higher utility from RVF vaccine that is not useable on calves below 6 months of age and from immune cows, both classes of farmers largely gained higher utility from a vaccine with no use exemption. The result is probably due to the fact that farmers may generally want to minimize risks at the slightest opportunity available and therefore would not favor a vaccine that discriminates other categories of animals on the farm, thereby increasing risk of infection which could affect farm productivity.

We further observe that class 1 farmers had higher utility for vaccines that posed no adverse effects on the animals following vaccination and were positive as well if the vaccination exercise were conducted at a collective central point with no extra costs required to compensate for the veterinarian's transport. Disutility was however registered by the same group of farmers in the event that vaccination carried out within a radius of 5 km from the collective point with an extra charge of 5,000 UGX levied to compensate for the veterinarian's transport cost. This can partly be explained by the fact that farmers considered the radius of 5 km from the collective vaccination point to be within their grazing zone and therefore the extra charge of 5000 UGX was weighed to be more than it would require to drive the animals for vaccination at the collective point with zero

extra costs. Class 1 farmers also exhibited higher utility for vaccine with a seven-day withdrawal period, which eventually subdued when the period was up to 21 days. This was expected as higher withdrawal days meant anticipated reduced revenues from milk sales and also nutritional loss in cases where the farmers relied on animals for daily dietary needs.

Membership estimates for the model indicate that females are more likely to belong to the enthusiast's class. This closely relates to the findings of Bärebring et al. (2020), who reported that women are more health conscious than men and would therefore readily be willing to take up any measures for averting health related risks such as the RVF disease. As farmers age, they are less likely to be in the enthusiast's class. This is expected as aged people rarely take up risks and would therefore not take up innovations quickly like the younger individuals would (Albert and Duffy, 2012). Farmers who have previously vaccinated their animals against other diseases largely belong to the enthusiast's class. This could be because they easily relate the benefits of vaccines in disease prevention with associated costs and therefore would easily pick up any available vaccines for their animals. Farmers who regularly move herds and those in pastoral sites are likely to belong to the status quo class. Such farmers are often resource constrained and therefore would rarely purchase vaccines if made available but could vaccinate if the vaccines are provided by the government (Acosta et al., 2022). Farmers from large household sizes associate with the enthusiast's class. Large household sizes require ample financial resources to maintain. Any external factor like RVF infection would affect revenue streams for such families and negatively impact their livelihoods, thus their high urge to take up the vaccines. Farmers with regular access to tarmac and veterinary shops belong to the enthusiast's class. This is expected as accessibility and shortage of vet related structures are often highlighted as a barrier to uptake of veterinary services (Mutua et al., 2019).

5.4.3 Willingness to pay for RVF vaccine attribute levels

Results of the willingness to pay estimates presented in table 5.4 reveal that farmers in both classes (enthusiasts and status quo) were each willing to pay higher values (more than 5000 UGX) for a single dose RVF vaccine. The class 2 farmers specifically registered their highest willingness to pay for a vaccine with no use exemption. This is expected since the status quo group often expects vaccinations to be carried out by the government as a public good. Having a vaccine with no use restriction would therefore maximize their chances of having all their animals vaccinated in the limited window in which government often offers such related services. Class 1 farmers on their part offered high values of UGX 1674, 3794, 850 and 3418 for RVF vaccine administered from a collective central point, having no adverse effects on animals following vaccination, with a withdrawal period of up to seven days and cannot be used on calves below six months of age respectively. They, however, offered lower values under circumstances where the vaccine withdrawal period reached 21 days and the vaccination exercise was to be conducted from the farmers home within 5 km radius of the collective vaccination points, but transport refund of 5000 UGX was to be offered to the veterinarian.

Table 5. 4 Class specific willingness to pay estimates for RVF vaccine attribute levels.

Attribute Levels	Class 1 (Enthusiasts)	Class 2 (Status quo)
Single dose	5826.99***	5168.04***
Initial dose plus annual doses	674.5	3999.54
Vaccination at collective central point	1673.62***	2371.72
Vaccination at farmers home at 5 Km radius	-4285.62***	1395.85
No reaction after vaccination	3793.87***	1533.48
Fever after vaccination	-944.42	-826.57
Withdrawal period 7 days	849.75***	-113.19
Withdrawal period 21 days	-6287.28***	-484.67
No use exemption	5008.09***	5421.29**
Not for use on calves below 6 months	3418.06***	-615.35
Alternative Specific Constant (ASC3)	-19269.93***	4771.78

Note: ***, **, & * represent statistical significance at 1%, 5%, and 10%, respectively

5.4.4. Attribute non-attendance

Estimates for attribute non-attendance are displayed in table 5.5. The findings show that the probability of attending to all the RVF vaccine attributes is zero. This implies that farmers ignored at least one or more vaccine attributes when making decisions on their choices. Vaccine cost, distance to vaccination point and dose regime attributes were fully attended to as indicated by the 0.000 probability scores of ignoring them. This could be due to the cost implications associated with those attributes. Overall vaccine withdrawal attribute was the most ignored RVF vaccine attribute with a probability of 0.385. This could be attributed to the fact that farmers seem to attach greater long-term benefit to vaccinating animals compared to the value of revenue that could be lost within the few days of vaccine withdrawal. Vaccine use exemption attribute registered a 0.320 probability of being ignored while the probability of ignoring vaccine adverse effects, stood as low as 0.157. The seemingly high level of attendance to the adverse effects is probably evidence of the fears and risks farmers perceive of vaccines. We also observe that only 13.8% of the farmers ignored all the attributes when making their choices.

Table 5. 5 Attribute non-attendance probabilities

Attribute	Attribute None Attendance (ANA) Probability (%)
Probability all attributes attended	0.000
Vaccine cost ANA	0.000
Dose regime ANA	0.000
Distance ANA	0.000
Adverse effect ANA	0.157
Vaccine withdrawal ANA	0.385
Vaccine use exemption ANA	0.320
All attributes not attended	0.138

5.4.5. Hybrid choice model estimates

This section presents results of the hybrid choice model that integrates the choice model and latent variable models. Results of the principal component analysis to identify the risk attitude and conditional perception latent variables used in the hybrid choice model (HCM) are first presented. This is followed in order by the estimates of the structural equation model, measurement equation and lastly the sigma values of the measurement model.

5.4.6 Principal component analysis

The Bartlett test of sphericity conducted on the set of 16 responses to risk attitude and conditional perception statements elicited from the 444 farmers interviewed during the choice experiment survey yielded a value that was highly significant ($p < 0.001$). Further, the Kaiser–Meyer–Olkin (KMO) estimate was 0.865 which is greater than the acceptable threshold of 0.5 (Kaiser, 1974), implying that the data were adequate enough for conducting principal component analysis (PCA). The scree plot presented in figure 5.2 following PCA reveal that two components (risk attitude and conditional perception) loaded with eigenvalues greater than one and were therefore retained as latent variables for further analysis in the hybrid choice model.

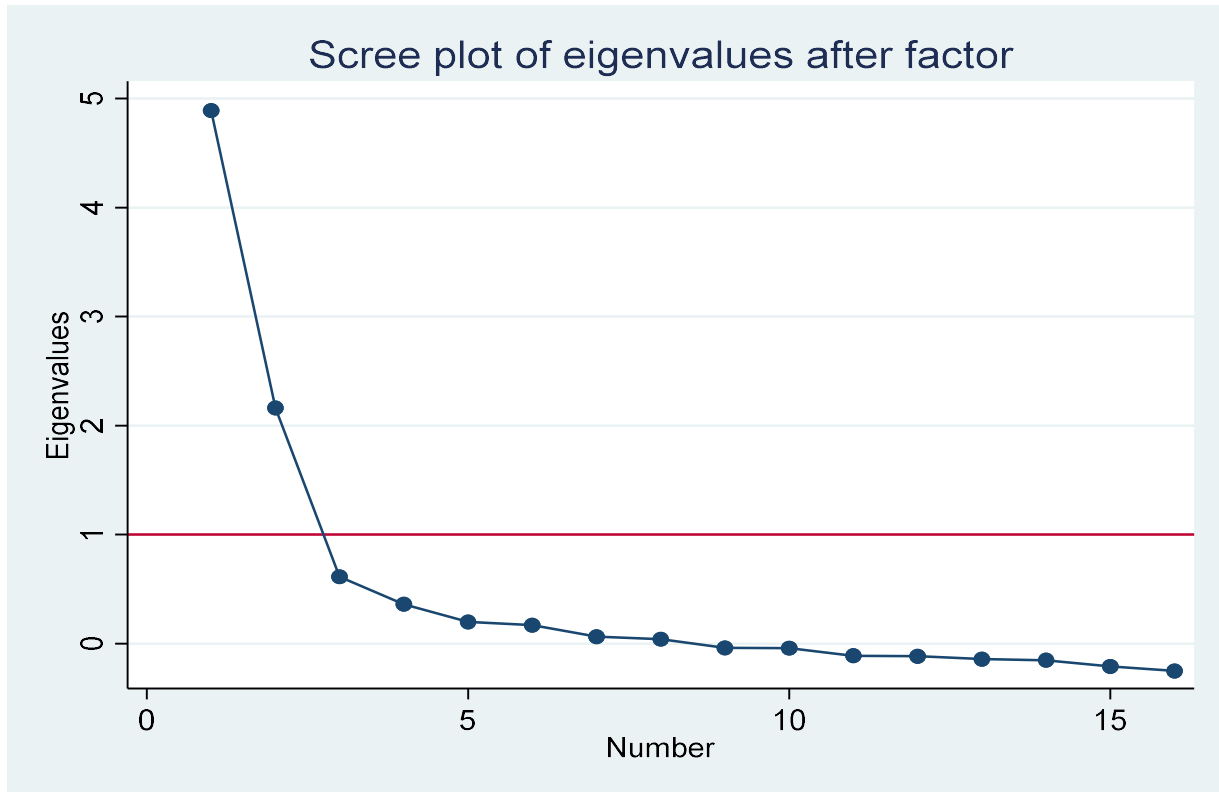


Figure 5. 2 Scree plot of eigenvalues after factoring.

Three factors were generated during the PCA process, but only two (Factors 1 and 2) were retained, as their alpha values were above the minimum possible value of 0.70, indicating homogeneity of each factor (Waltz et al., 2010). Item loadings for the retained factors (Factor 1 = conditional perception (VPC1 – VPC6), and Factor 2 = risk attitude (VRP1 – VRP6), are presented in table 5.6. Only items with loadings greater than 0.4 were retained as indicators for the two latent variables (Factor 1 = conditional perception and Factor 2 = risk attitude).

Table 5. 6 Factor loadings on risk attitudes and conditional perception statements

Item No	RVF vaccine perception statement	Factor1	Factor2
1	My pregnant animals will abort if vaccinated against RVF (VRP1)		0.654
2	I trust the veterinary doctors around my village to administer the right RVF vaccine		
3	I will vaccinate my animals only if the costs are not very high (VPC1)	0.593	
4	Government should be the one to procure vaccines and vaccinate our animals		
5	My animals are likely to die of RVF even after they get vaccinated against the disease (VRP2)		0.572
6	Rare and more dangerous type of RVF will emerge if we vaccinate our animals (VRP3)		0.571
7	I fear that there will not be enough vaccines available for all animals in this village		
8	My animals will contract other diseases from the collective vaccination area		
9	My animals' milk yield will drop if they are vaccinated against RVF (VRP4)		0.845
10	I fear, I will have to lose revenue from milk if my animals are vaccinated (VRP5)		0.857
11	The tails of our animals will fall in case we decide to vaccinate them (VRP6)		0.594
12	I will only vaccinate my animals if I see the disease has become serious in my village (VPC2)	0.793	
13	I will only accept my animals to be vaccinated if they are first diagnosed for RVF (VPC3)	0.775	
14	People in this community will vaccinate if they realise defaulters will be fined (VPC4)	0.746	
15	If market prices of animals and its products are good, I will vaccinate my animals (VPC5)	0.848	
16	I will vaccinate if my neighbours and other cattle farmers in this area vaccinate theirs (VPC6)	0.832	
Cronbach's Alpha		0.893	0.860
Overall Kaiser-Meyer-Olkin (KMO)			0.865

Note: Item loadings for factors that were not retained are not indicated on the table.

5.4.7 Parameter estimates for the utility/choice model.

Results of the choice model estimates are presented in table 5.7. The results show that farmers derive positive utility when vaccination is conducted in their homes located more than 5 km away from the central vaccination points, and they have to compensate for the veterinarian's transport costs. This result is expected as the indirect costs of labor to drive the cattle to the collective vaccination points become expensive (Mutua et al., 2019), thus the farmers' willingness to compensate for the veterinarian's transport cost to their homes. The results also portray that the utility farmers derive from potential RVF vaccines declined as withdrawal days increased from

seven to 21 days. This is partly expected as increased withdrawal period is associated with revenue loss from milk sales and loss of nutrition in terms of milk, blood, and meat for home consumption during the withholding period of the vaccine.

Table 5. 7 Parameter estimates for the structural equation model.

Variable	Coefficients	Standard errors	t-statistics
ASC3	-1.4000***	0.0601	-23.40
price	-0.0002***	1.0000	-19.80
Single dose	1.1600***	0.0627	18.50
Initial dose plus annual doses	0.1520***	0.0571	2.66
Initial dose, follow up 3 – 4 weeks and annual boosters	0.0939	0.0673	1.40
Vaccination at collective central point	0.6640***	0.0696	9.55
Vaccination at farmers home within 5 Km radius	-0.0997	0.0902	-1.11
Vaccination at farmers home, >5 Km radius	0.3300***	0.0644	5.12
Withdrawal period 7 days	0.6090***	0.0729	8.36
Withdrawal period 14 days	0.4630***	0.1020	-1.74
Withdrawal period 21 days	-0.1780***	0.0730	6.34
No reaction after vaccination	0.9400***	0.0803	11.70
Fever after vaccination	0.2870**	0.1280	2.25
28% chances of abortion in-calve animals	0.1780*	0.0908	1.96
No use exemption	0.7560***	0.1790	4.22
Not for use on calves below 6 months	0.3990***	0.0982	4.06
Can't be used during outbreak (epidemic period)	-0.2610***	0.0905	-2.88
Age of the respondent (years)	0.0006	0.0008	0.449
Previously vaccinated cattle (1= Yes, 0 = No)	0.0201	0.03	0.672
Sex of the respondent (1 = Female, 0 = Male)	-0.0387	0.0276	-1.40
Household size (Number of persons)	-0.0096	0.00636	-1.51
Regularly move herd (1= Yes, 0 = No)	-0.0094	0.0282	-0.34
Production system (1= Pastoral, 0 = Agro-pastoral)	0.1970***	0.0359	5.48
Have access to tarmac (1= Yes, 0 = No)	-0.0654*	0.0391	-1.67
Vet shop access (1= Yes, 0 = No)	0.0054	0.0368	0.147
Sample size (N)	444		
Number of observations	3552		
Final Loglikelihood	-13566.73		
AIC	27283.47		
BIC	27590.65		
No of Parameters	75		

Notes. *, **, *** denotes significance at $p = 0.1$, 0.05 and 0.01 levels, respectively.

Results in table 5.7 further reveal that farmers derive high utility from an RVF vaccine which has a 28% chance of inducing abortion in in-calve cows. The finding reflects how farmers weigh the benefits of vaccination to be more than the risks it poses. Further such risks can be easily minimized as the veterinary personnel will always have to identify the pregnant animals for exclusion before proceeding to vaccinate the rest of the animals on the herd. Disutility is however, displayed by farmers if the vaccine option available cannot be used during outbreaks.

5.4.8 Parameter estimates for the latent variable model.

The estimates for the latent variable model presented in table 5.8 shows that an increase in vaccine dose, adverse effects and vaccine cost attribute non-attendance lowers the utility farmers derive from the available RVF vaccine options. It is however evident that as farmers' conditional perceptions (VPC) and risk attitudes (VRP) improve, they tend to derive higher and increased utility from the RVF vaccine options available to them. This finding suggests that risk attitudes and conditional perception responses that underline the cattle farming household's irrational vaccine choice behavior need to be addressed if uptake of RVF vaccines is to be successful.

Table 5. 8 Measurement equation parameter estimates

Variable	Coefficients	Standard errors	t-statistics
DOSANA	-0.599*	0.359	-1.67
EFFANA	-1.47***	0.45	-3.26
EXPANA	-0.127	0.26	-0.486
VCANA	-2.1***	0.494	-4.26
WDANA	-0.0327	0.283	-0.116
VPC2	3.06***	0.379	8.08
VPC3	2.94***	0.386	7.62
VPC4	3.47***	0.43	8.08
VPC5	3.54***	0.455	7.78
VPC6	2.99***	0.369	8.1
VRP1	1.07***	0.192	5.58
VRP2	1.42***	0.196	7.24
VRP4	0.699***	0.191	3.66
VRP5	0.625***	0.183	3.42
VRP6	1.44***	0.217	6.63

Notes. *, **, *** denotes significance at $p = 0.1$, 0.05 and 0.01 levels, respectively. VPC are the indicators for conditional perception and the VRPs are the indicators for risk attitudes.

5.4.9 Standard deviations (Sigma) estimates for the latent variable model.

As evident in Table 5.9, all the sigma coefficients for the different indicators associated with the stated attribute non-attendance, risk attitudes and conditional perceptions latent variables are shown to be statistically significant (see Table 5.9). This is therefore an indication that there is heterogeneity among the interviewed cattle farming households based on the indicators to the cognitive latent variables (choice heuristics) used in the study. Taking such variations in indicators to choice processing behavior into consideration when designing an RVF vaccination policy will therefore be of significant importance to driving vaccine uptake by the target cattle farmers.

Table 5. 9 Sigma values for the measurement equation.

Variable	Coefficients	Standard errors	t-statistics
SIGMA_DOSANA	1.27***	0.082	15.5
SIGMA_EFFANA	1.36***	0.0909	14.9
SIGMA_EXPANA	1.04***	0.057	18.2
SIGMA_VCANA	1.35***	0.0837	16.1
SIGMA_WDANA	1.11***	0.0648	17.1
SIGMA_VPC2	0.467***	0.0414	11.3
SIGMA_VPC3	0.511***	0.0432	11.8
SIGMA_VPC4	0.582***	0.0655	8.89
SIGMA_VPC5	0.465***	0.0444	10.5
SIGMA_VPC6	0.417***	0.0377	11
SIGMA_VRP1	0.721***	0.0339	21.3
SIGMA_VRP2	0.639***	0.0351	18.2
SIGMA_VRP4	0.727***	0.0308	23.6
SIGMA_VRP5	0.721***	0.0299	24.1
SIGMA_VRP6	0.713***	0.0348	20.5

Notes. *, **, *** denote significance at $p = 0.1$, 0.05 and 0.01 levels, respectively.

5.5 Conclusion and policy implications

This study employed a discrete choice experiment approach to elicit cattle farmers' preferences for potential RVF vaccine attributes in Uganda. We utilized latent class model to identify the drivers of preference heterogeneity among cattle farming households. In addition, an integrated

choice model that incorporates choice to the decision-making processes, mainly heuristics into the utility function was adopted to investigate how farmer risk attitudes, conditional perceptions, and attribute non-attendance impact farmers' choice of potential vaccine options availed to them.

The results reveal that two heterogeneous cattle farmer groups exist with respect to RVF vaccine preference. The largest group, constituting over 92% of the sampled population are enthusiastic about the RVF vaccine option presented during the choice experiment. The minority group constituting 8% of the sample wish the vaccination process would be organized by the government. Farmers generally derived high utility from a single dose vaccine and a vaccine with no use case exemptions. The two segments of farmers in the latent class model were willing to pay values of over 5000 UGX per head of animal vaccinated. Similar values were attainable for a vaccine with no use case restriction/exemption. When making a choice, vaccine cost, distance to vaccination points, and dose regime attributes were accorded full attention by the farmers, but little focus in return was observed for the vaccine withdrawal attribute. The outcome of the hybrid choice model on the other hand revealed the existence of preference heterogeneity among farmers based on attribute non-attendance, risk attitudes and conditional perceptions.

The results of this study offer valuable contribution to policy in the sense that it showcases the single dose RVF vaccine as being the ideal and most preferred vaccine candidate for introduction in Uganda. Further, vaccination programs would be effective if collective vaccination points are situated within 5 km radius of farmers homes, otherwise a mechanism will have to be drawn to facilitate delivery of vaccination services to farmers homes, if the distance to the collective vaccination cattle crushes exceed 5 km. There is also the need to initiate awareness creation campaigns that address risk attitudes and conditional perceptions that are shown to be driving farmers choices and acceptance of vaccines.

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Chapter Six

Conclusions and policy implications

6.1 Concluding remarks.

The negative effects of RVF disease along the livestock value chain is already evident in endemic areas and is expected to spread even further with the rapid spread and transmission of the disease to new territories across the African continent if cost-effective and sustainable control measures are not promoted in time. Even when such measures are available at the policy makers disposal, its implementation are often met with resistance because either they do not meet the expectations of the users or the benefits of participating in such interventions are controversial. This therefore calls for a thorough understanding of behavioural patterns that motivate uptake of the control measures within the communities and a cost-effectiveness analysis on the side of policy makers prior to promotion of the practices. It is against this background that this study sought to investigate the social and economic implications of RVF control strategies on the livelihoods of livestock farmers in Uganda. First the study examined the influence of livestock chain actors' psycho-social constructs on their intentions to take up RVF control measures, showing how their attitudes, knowledge and subjective norms influence their uptake decisions for available and potential control measures.

Second, the study investigated the impact of on-farm biosecurity measures on livestock farmers' food security and poverty outcomes with specific emphasis on household dietary diversity score, household asset index and poverty gap measured through food and non food expenses. Following this, the study examined the potential impact of planned RVF control measures on livestock farm productivity with animal deaths and infections averted forming the basis for the evaluation. Finally, the study explored livestock farmer preferences and assessed the influence of heuristics on their RVF vaccine choice decisions.

6.2 Summary of empirical and econometric approaches

The greatest emphasis in most economic studies is to utilize econometric approaches that produce estimates with minimal bias and errors. This demand is even more critical in analysis involving use of observational data. As a contribution, this study arguments a series of the latest econometric approaches to generate evidence that can be used to inform policy decisions related to RVF management.

In chapter 2 for instance, the study fits a Partial Least Squares Structural Equations Models (PLS-SEM) using an extended theory of planned behaviour (ETPB) framework to examine how livestock value chain actors' psycho-social constructs interact to influence their decisions to take up current and potential RVF control measures. The use of Partial Least Squares Structural Equation Models (SEM) is novel as it offers the opportunity to investigate relationships involving multiple independent and dependent variables within a single equation while capturing possible measurement errors that could arise from use of latent variables within the equations.

Since outcomes due to technology adoption tend to vary with the intensity of adoption, this study deployed a dose response function model in chapter 3 to examine the effects of biosecurity adoption on livestock farmers' welfare. The dose response function model allows for the estimation of causal effects between livestock farmers' outcome variables and the varying levels of biosecurity measures (continuous treatment) they have adopted on their farms. The use of instrumental variables (IV) when estimating the model also helps in accounting for endogeneity and self-selection bias, thereby improving the precision and consistency of the estimates.

Causal patterns of many emerging infectious diseases such as RVF which is the focus in this study take the shape of a polycrisis. Assessing the cost-effectiveness of control strategies designed against such diseases with a focus on only one system leads to biased conclusions. Further, systems under such settings are often dynamic in nature and therefore reliance on

deterministic econometric approaches employed in many studies to evaluate the cost-effectiveness of control measures do not yield satisfactory results that can sustainably guide policy making. To counter this challenge, in chapter 4, a stochastic dynamic programming model that integrates epidemiology, herd dynamics and economic model is fitted to evaluate the impact of RVF control strategies on livestock productivity. Such models are effective as they enable proper identification of disease control strategies that offer optimal solution against the prevailing disease.

Finally in chapter 5, a latent class model is used to elicit farmer preference heterogeneities for RVF vaccine attributes and identify possible farmer segments based on attribute preferences. An equality constrained latent class model (ECLCM) is then estimated to identify attribute non-attendance probabilities and finally a hybrid choice model that integrates three information processing strategies (attribute non-attendance, risk attitude and conditional perceptions) together with the utility function for RVF vaccine choice is estimated. Following such and extensive estimation approach is particularly important as it informs policy makers on both the observed and unobserved factors that are likely to drive farmers vaccine uptake decisions. Further, policy makers can also readily draw useful information about existing farmer segments and use this draw vaccination programmes.

6.3 Summary of main findings

The findings in chapter two show that livestock farmer's intentions to take up RVF management practices are motivated by positive attitudes and previous encounter of disease cases on their farms. Farmers with knowledge of the RVF disease and its related management practices positively also displayed great intentions for management of the disease on their farms. More interestingly, the results further showed that supplementing knowledge delivery with attitude change programs resulted in an even greater desire among farmers to participate in RVF management programmes.

The results also reveal that even though farmers in the pastoral production systems acknowledge that there is a high level of threat posed by RVF, they are less likely to engage in related management practices because of the negative attitudes they hold. Among the other livestock chain actors, participation intentions towards uptake of RVF management practices is shown to be strongly influenced by social pressure (subjective norm). For instance, enforcement by veterinary personnel, meat inspectors, community health officers, and the fear that they will be isolated and stigmatized by members of the public in case they realize that they are dealing with infected animals or contaminated meat.

The empirical results in chapter three show that the intensity of biosecurity measures adopted against on-farm risks associated with RVF vary based on whether the farmer received herd health management advice and/or use their animals to offer draught power. It is also revealed that farmer adoption decisions for biosecurity measures against RVF risk factors at farm level are highly motivated by their peers. And adoption of these biosecurity measures has a positive and significant effect on livestock farmers' HDD and HHassetindex, at the same time plays a huge role at reducing poverty gap among adopters. The varying levels of biosecurity measures adopted by farmers meanwhile yields heterogeneous effects on HDD, HHassetindex and poverty depth outcomes.

In chapter four, the empirical results showed that livestock vaccination with live vaccines like Smith's 9E averts more deaths and infections on farms thereby improving farm productivity in the long run. The effect of live vaccines can be much greater when implemented alongside surveillance programs. Killed vaccines perform fairly well as opposed to not having interventions on the ground but the overall costs may be high given that animals may have to receive repeated annual boosters to guarantee protection. Quarantine plays a great role at lowering overall disease

transmission rate; however, its overall effects can be short lived if the restrictions are lifted and not immediately supplemented by other risk mitigation measures.

The results in chapter five show that there are two farmer categories in reference to RVF vaccine preference. The largest group, constituting over 92% of the sampled population are enthusiastic about acquiring RVF vaccines for their animals and are willing to meet the cost of the vaccines, up to UGX 5,000 per head of animal vaccinated with any of the potential RVF vaccine options. A minority group constituting 8% of the sample feel the government is responsible for purchasing vaccines for their animals. Most farmers preferred the single dose RVF vaccine. Farmers believe that collective vaccination points should be within 5 km radius of farmers homes to ensure maximum participation during livestock vaccination exercises. Lastly farmers choice of potential RVF vaccine are shown to vary based on their perceived risk levels such as possible side effects to animals.

6.4 Policy implications

The main focus of this study was to explore the socio-economic impacts of RVF control strategies. The analysis in the different chapters of the dissertation yielded several policy relevant paradigms that are summarized under this section. The evidence generated in chapter two for instance suggests that for RVF management programmes to be effective, policy frameworks should consider mindset change concepts that trigger positive attitudes among livestock chain actors to embrace recommended control measures. There is also the need for policy makers to set out coherent social networks for behavioral enforcement among livestock farmers and other livestock value chain actors. This is necessary as the results have shown that butchers, traders, slaughterhouse attendants and livestock traders tend to implement desired RVF prevention

strategies easily when under the watch of influential authorities such as para-vets, community leaders and other authorities within their communities of operation.

The outcomes in chapter three, do indicate that besides the cost prohibitive transboundary and country level RVF control measures that is often implemented by central and local governments, policy makers could tap into and promote the use of biosecurity measures against identified RVF risk factors to lower the overall prevalence and transmission of the disease at farm level, thereby improving productivity and farmer welfare outcomes in the long run. In chapter four, the use of live vaccines for RVF control could be emphasized as a plausible strategy, however this is subject to further risk evaluations. The dynamics of RVF vectors and environmental conditions such as temperature and rainfall variations that drive the epidemiology of the disease also need to be factored during the cost effectiveness assessments to get a more precise effect of the various RVF control strategies. The varying stages of RVF disease spread calls for the need for policy makers to consider real time interventions when managing the disease, instead of relying on a one size fits all approach. For instance, vaccines may not be feasible during outbreaks but a short term quarantine could help lower the prevalence of the disease and vaccinations resume once the quarantine is lifted.

In chapter five, its revealed that the single dose RVF vaccine is the ideal and most preferred vaccine candidate for introduction in Uganda. Further, in the setup of vaccination programmes if made available, policy may be faced with the challenge of establishing communal vaccination points within 5 km radius of farmers homes, otherwise a mechanism will have to be drawn to facilitate delivery of vaccination services to farmers homes, if the distance to the collective vaccination cattle crushes exceeds 5 km to ensure maximum participation in the programs. There

is also the need to initiate awareness creation campaigns that address risk attitudes and conditional perceptions that are shown to be driving farmers choices and acceptance of vaccines.

Appendix A: Questionnaire



Introduction and consent

PART A: Project Information

I am _____ (name of researcher) a student from the university of Kiel. We are carrying out a study to determine the social and economic impact of Rift Valley Fever control options on farm productivity, farmer welfare, food and nutrition security in pastoral and Agro-pastoral livestock production systems of Uganda. Information from this study will inform our project's interventions and activities that are aimed to strengthen the capacity of government of Uganda and other stakeholders in the livestock sector to better manage Rift Valley Fever disease. The project is funded by BMZ under the program titled BUILDUganda. I would like to invite you to participate in the study in the form of an interview. If you consider participating, you will not be compelled to answer any question(s) that you may not be comfortable with and should you change your mind later and would wish to withdraw from the study at any point you will not be penalized for that. Kindly note that your participation in this study is entirely voluntary and there will be no remuneration or direct benefits to be awarded. However, it is our hope that the knowledge gained from your participation in this research will benefit the livestock value chain by informing us on how to better design interventions that enhance the livelihoods of value chain actors. There are no major risks, to you as a participant in this study, that are anticipated except for loss of your time during the interview. If you experience any form of discomfort during the interview kindly alert the researcher who will advise you on the action to take. The interview will take approximately 1 hour and during this time the researcher will be writing down responses to the questions discussed on a tablet. This data shall later be entered and stored in electronic databases where it can be extracted for analysis.

Any personal identifying information discussed in this interview shall be held in confidence, this means that this information shall not be shared with or given to anyone except the researchers in this project. However, the non-personal data and the generalized findings in form of publications from this research shall be put in publicly accessible databases and shall be available to other researchers and interested persons who would want to understand the cattle value chain and livestock production systems. I want to emphasize here that the open access data cannot be traced back to you as an individual by users. Do you have any questions?

For further queries or concerns you would like to raise, kindly contact any of the contacts provided below.

PART B:

Consent

I have read (or someone has read to me) the foregoing information. I have had the opportunity to ask questions and all my questions have been answered to my satisfaction. I confirm that I have agreed to answer the questions that I will be asked. I also confirm that I have retained a copy of this consent.

Participant Name

Participant Signature (print)

Date

PART C:

Contacts

Name of main researcher: Mr. Marsy Asindu

Institution: University of Kiel

Telephone: +256 775193913

Email address: M.Asindu@cgiar.org

Section 1. Background information	
1.1. Questionnaire ID (New IDs will be used for replaced Households)	
1.2. Date of Survey (DD/MM/YYYY)	
1.3 Name of the District	1= Isingiro 2= Sembabule 3= Butebo 4= Napak 5 = Lyantonde 6 = Rwampara
1.4 Name of sub-county	
1.5 Name of parish	
1.6 Name of village	
1.7 Enumerator Name	
1.8. Name of the household head	
1.9 Gender of the household head	1= Male 2= Female
1.10 Household head's marital status	1=Married 2=Widow/Widower 3=Single parent 4=Other
1.11 Is the respondent also the household head? (if yes, skip)	
1.13. Respondent's name	
1.14 Telephone number of respondent	
1.15 Gender of respondent	1=Male, 2=Female
1.16. Marital status of respondent	1=Married 2=Widow/Widower 3=Single parent 4=Other
1.17 Religion of respondent	1= Christian 2= Moslem 3= Traditionalist 4= Other specify [_____]
1.18 When did you start rearing cattle (year)	

Section 2: Household details/Roster

2.1a. How many people do you have in your household?

2.1b. In the table below, please provide details of your household members (start with household head's details followed by the respondent then the rest of the members). We define a "household" to include all members of a common decision-making unit (usually within one residence) that are sharing income and other resources and rely on same kitchen.

	Members of your household [FIRST NAMES]	Year of birth	Gender 1=Male 2=Female	Relationship to household head	Highest education level attained	Primary source of income
1						
2						
3						
Relationship to household head		Highest education level attained		Primary source of income		
1 = Head 2 = Spouse 3 = Child 4 = Sibling 5 = Parent 6 = Grandchild 7 = Other relative 8 = Non-relative (including employees who live in house) 9 = Other (specify)		0 = No formal education 1 = Nursery 2 = Pre-school age 3 = Primary education (P1-P4) 4=Primary education (P5-P7) 5=Secondary school (S1-S2) 6=Secondary school (S3-S4) 7=High school (S5-S6) 8=Vocational training (specify no of years)		9=Tertiary training specify yrs _____ 10=University degree (undergraduate) 11=University degree (postgraduate) 12=Adult literacy 13=Others (specify) _____		
0 = None 1 = Crop farming 2 = Remittance 3 = cattle keeping 4 = poultry/keeping (inc. sales) 5 = Salaried employment 6 = Self-employed-off farm 7 = Casual laborer 8 = Boda boda 9 = Student/pupil 10 = Charcoal burning 11 = Pre-school age 12= Other _____						

Section 3: Land ownership and utilization

3.1a. How many parcels of land do you own?

3.1b. In the following table, please provide full details regarding all parcels of land that was utilized by your household within the last 12 months (Repeat the table for each parcel of land the farmer has)

1. Parcel No: []		Parcel size []		Parcel size units [] (Use unit codes below)	
2. Where is this parcel located Parcel size		3. Under what tenure system is this parcel of land		4. Plot number	
				5. Plot size	
				6. What is the household's use of the plot currently	
				7. Who in the household owns this plot	
	Code for parcel location: 1. Within this village 2. Outside this village, but within the Parish 3. Outside the parish but within same Sub- County 4. Elsewhere in within this District 5. Outside this District	Code for parcel and plot size units: 1. Square miles 2. hectares 3. acres 4. Feets 5. square meters 6. Others specify	Code for land tenure system: 1. Freehold 2. Leasehold 3. Mailo 4. Customary 5. Public land 6. Don't know 9. Rented in	Code for plot use: 1. Crop cultivation 2. Grazing land 3. Forage production 4. Land under fallow 5. Settlement/housing 6. Woodlot 7. Others specify	Plot ownership code: 1. Household head only 2. Spouse only 3. Jointly owned 4. Others specify

3.1c Did you grow any crops or already had crops on some of your plots in the last 12 months? 1= Yes, 0= No

3.1d If yes, please fill in the table below with the different crops grown in the first and second season and there uses in the last 12 months (Note: for perennial crops, please provide details for the last 12 months)

Season 1: [Please record details for crops grown and harvested in season one]												
Parcel No	Plot No	What crops were grown on this plot in the first season (Codes in the appendix)	Did you harvest the crops (1= Yes, 0= No)	Quantity harvested from first season crops	Unit measure of harvest from first season crops (Codes in Appendix)	How much of the first season crop harvested did you sell?	Unit measure for quantity of first season crop sold	What was the total value of sales for crops harvested in the first season	How much of the first season crop did you consume at home (This includes what was consumed while crop was still in the field)	Unit measure for quantity of first season harvest consumed at home	How much of the first season crop harvested did you feed to animals?	Unit measure for quantity of first season harvest did you feed to animals?
1												
2												
3												
4												
5												
Season 2: [Please record details for crops grown and harvested in season two]												
Parcel No	Plot No	What crops were grown on this plot in the second season (Codes in the appendix)	Did you harvest the crops (1= Yes, 0= No)	Quantity harvested from second season crops	Unit measure of harvest from second season crops (Codes in Appendix)	How much of the second season crop harvested did you sell?	Unit measure for quantity of second season crop sold	What was the total value of sales for crops harvested in the second season	How much of the second season crop did you consume at home (This includes what was consumed while crop was still in the field)	Unit measure for quantity of second season harvest consumed at home	How much of the second season crop harvested did you feed to animals?	Unit measure for quantity of second season harvest did you feed to animals?
1												
2												
3												
4												
5												
Perennial crops production and utilization records (Details to be captured on 12 months basis)												

Parcel No	Plot No	What crops were grown on this plot (Codes in the appendix)	Did you harvest the crops in the last 12 months (1= Yes, 0= No)	Quantity harvested in the last 12 months	Unit measure of harvest (Codes in Appendix)	How much of the crop harvested did you sell?	Unit measure for quantity sold	What was the total value of sales for crops harvested	How much of the crop did you consume at home	Unit measure for quantity of harvest consumed at home	How much of the harvested crop did you feed to animals?	Unit measure for quantity fed to animals?
1												
2												
3												
4												
5												

Section 4: Food security, Nutrition

4a). Household Food Insecurity Access Scale

I am going to ask you questions about your household's food supply over the past four weeks. Food supply includes staples, sauces, and any other foods in your diet and the diets of all members of your household.

Household Food Insecurity Access Scale [HFIAS]

No	Question	Response
1 a)	In the past four weeks, did you <u>worry</u> that your household would not have enough food?	<input type="checkbox"/> 1=Yes <input type="checkbox"/> 0=No
1 b)	If yes, how often did this happen?	[____]
2 a)	In the past four weeks, were you or any household member not able to eat the kinds of foods you preferred because of a lack of resources?	<input type="checkbox"/> 1=Yes <input type="checkbox"/> 0=No
2 b)	If yes, how often did this happen?	[____]
3 a)	In the past four weeks, did you or any household member have to eat a limited variety of foods due to a lack of resources?	<input type="checkbox"/> 1=Yes <input type="checkbox"/> 0=No

3 b)	If yes, how often did this happen?	[____]
4 a)	In the past four weeks, did you or any household member have to eat some foods that you really did not want to eat because of a lack of resources to obtain other types of food?	<input type="checkbox"/> 1=Yes <input type="checkbox"/> 0=No
4 b)	If yes, how often did this happen?	[____]
5 a)	In the past four weeks, did you or any household member have to eat a smaller meal than you felt you needed because there was not enough food?	<input type="checkbox"/> 1=Yes <input type="checkbox"/> 0=No
5 b)	If yes, how often did this happen?	[____]
6 a)	In the past four weeks, did you or any household member have to eat fewer meals in a day because there was not enough food?	<input type="checkbox"/> 1=Yes <input type="checkbox"/> 0=No
6 b)	If yes, how often did this happen?	[____]
7 a)	In the past four weeks, was there ever no food to eat of any kind in your household because of lack of resources to get food?	<input type="checkbox"/> 1=Yes <input type="checkbox"/> 0=No
7 b)	If yes, how often did this happen?	[____]
8 a)	In the past four weeks, did you or any household member go to sleep at night hungry because there was not enough food?	<input type="checkbox"/> 1=Yes <input type="checkbox"/> 0=No
8 b)	If yes, how often did this happen?	[____]
9 a)	In the past four weeks, did you or any household member go a whole day and night without eating anything because there was not enough food?	<input type="checkbox"/> 1=Yes <input type="checkbox"/> 0=No
9 b)	If yes, how often did this happen?	[____]
Code for how often this happens: 1 = Rarely (once or twice in the past four weeks). 2 = Sometimes (3 to 10 times in the past four weeks) 3 = Often (more than 10 times in the past four weeks)		

4 b). Household Dietary Diversity [HDDS]

Was it a 'special' day yesterday (e.g., wedding, funeral, etc.)? (0 = No, 1 = Yes). If yes specify: _____

In this table, please describe the foods that you and your household consumed in the last 7 days and those you had in the past 24 hours.

Food Groups	Food Items	Consumed in the past 7 days by household members (1=Yes, 0=No)	On how many days was it eaten in past week (0-7 days)	Consumed in the past 24 hours by household members (1=Yes, 0=No)	Consumed in the past 7 days by children <5 years? (1=Yes, 0=No)	On how many days was it eaten in past week (0-7 days)	Consumed in the past 24 hours by children < 5 years? (1=Yes, 0=No)	Source of food item (1=Own production; 2=Purchase 3= Borrowed = 4 Received as gift; 5=Food aid. 6= Others (multiple choice option)
CEREAL STAPLES OR FOOD FROM CEREALS	<i>Millet, sorghum, maize, rice, wheat, bread, noodles, biscuits</i>							
VIT A RICH VEGETABLES & TUBERS	<i>pumpkin, carrot, orange fleshed sweet potato</i>							
TUBERS, ROOTS AND BANANAS	<i>Potatoes, yams & sweet potato, cassava, cooking bananas or foods made from these</i>							
DARK GREEN LEAFY VEGETABLES	<i>okra, spinach, sukuma wiki, cassava leaves, pumpkin leaves, (Otigo).Jute mallow</i>							
OTHER VEGETABLES	<i>Tomato, onion, eggplant, cabbage, capsicum, mushroom, Ntulla</i>							
VIT A RICH FRUITS	<i>orange fruits: ripe mango, grapes, Watermelon, Jack fruit, papaya</i>							

OTHER FRUITS	<i>Apple, dessert bananas, plantain, pineapple, avocado</i>							
ORGAN MEAT/Blood (IRON RICH)	<i>Liver, kidney, heart, other organ meat (incl. intestine), Blood</i>							
FLESH MEAT	<i>Beef, pork, lamb, goat, rabbit, wild game, chicken, other poultry</i>							
EGGS	<i>Eggs</i>							
FISH & SEAFOOD	<i>Fresh or dried fish, Mukene</i>							
MILK & MILK PROD.	<i>Fresh milk, cheese, yoghurt, Fermented milk, other products. Include milk in tea if $\geq 1/3^{\text{rd}}$ of cup</i>							
LEGUMES, NUTS & SEEDS	<i>Beans, peas, pigeon peas, green grams, nuts(Ground, Bambara, simsim</i>							
OILS AND FATS	<i>ANY oil, ANY butter, sun flower oil</i>							
SWEETS	<i>Sweets, sugar, honey</i>							
SPICES, BEVERAGES, CONDIMENTS	<i>Any other foods, coffee, tea</i>							

4 c). Household related shocks and Food security

In the table below, kindly identify and tick all shocks that this household has experienced in the last 12 months

Shock	Did you experience these shock 1= Yes, 0= No (If No for a given shock, skip the follow-up questions)	Extent of damage to animals 0. None 1. Slight 2. Moderate 3. severe	Extent of damage to crops 0. None 1. Slight 2. Moderate 3. severe	To what extent has this affected food security 1. Not at all 2. Slight 3. Moderate 4. Severe
Floods				
Drought				
Hailstorms				
Pests				
Diseases				
Insecurity (raids/land disputes)				
Covid19				
Others specify				

Section 5: Household Poverty indicators

5a). Farm expenses

Please indicate the different farming components and expenses you incurred in the last production season.

No	Activity name	Did you and household members participate in this component? [1 = Yes, 0 = No]	How much did you spend on this component (Cost in UGX). If payment was made in kind, capture the cash equivalent
1	In organic fertilizers		
2	Organic fertilizer		
3	Land preparation		
4	Grazing and milking		
5	Dipping and spraying of animals		

6	Guarding of the farm		
7	Farm input and output transportation		
8	Storage of milk and farm produce		
9	Crop spraying		
10	Weeding		
11	Planting		
12	Mulching		
13	Herbicides		
14	Pesticides		
15	Farm equipment hire		
16	Seeds		
17	Vet treatment		
18	Acaricides		
19	Hired labor		
20	Others specify		

5b) Household expenditure

In this table, please do indicate the amount of money you or your household has spent on different food and nonfood items in the last four weeks.

No	Food Expenses	Amount spent on food item (UGX)	Nonfood expenditure	Amount spent on nonfood item (UGX)
1	Matooke		Leisure and recreation	
2	Maize flour		Health	
3	Rice		School fees and scholastic materials	
4	Sorghum/millet		Building/rental	
5	Bread/wheat		Airtime and internet on phone	
6	Cassava		Local transportation	
7	Irish Potatoes		Social and cultural functions	
8	Sweet potatoes & Other tubers		Firewood/ electricity	
9	Beans & peas		Fuel	
10	Groundnuts & Pulses		Others specify	
11	Fish			
12	Red meat (sheep/goat/beef)			
13	White meat (poultry)			
14	Vegetable oil, fats			
15	Eggs			

16	Milk and dairy products			
17	Vegetables (including leaves)			
18	Fruits			
19	Sweets, sugar			
20	Condiments (spices, tea, coffee, salt)			
21	Others specify			

5c). Household assets

In the table below, please kindly fill in all the information related to assets owned by your household.

Asset No	Asset type	Does your household own this asset at present (1 =Yes, 0 = N0)	How many does your household own at present	Average age of the household asset		
				Less than 3 years	3 – 7 years	More than 7 years
	Domestic assets					
1	Cooker/Gas stove					
2	Refrigerator					
3	Radio					
4	Television					
5	DVD player					
6	Mobile phone					
7	Telephone (Table phone)					
8	Sofa set					
9	Sewing machine					
10	Mosquito net					
11	Computer (laptop/desktop/tablets)					
	Transport					
12	Car/Truck/Tractor					
13	Motorcycle					
14	Bicycle					
15	Cart (Animal drawn)					

	Farm assets					
16	Hoes					
17	Spades/shovel					
18	Ploughs					
19	Sprayer pump					
20	Water pump					
21	Own built dam					
22	Lawn mower					
23	Other assets (jewellery/watches)					

5d). Household income

Household income other than livestock and crop income in the last 12 months

No	Income source	Did any member of the household received income from this source in the last 12 months (1= Yes, 0= No)	How often did the household member receive income from this source? (1= Daily, 2= Weekly, 3= Fortnightly, 4= monthly, 5= quarterly, 6= biannually, 7= Annually, 8= Irregularly (give over all annual amount received), 9= Others specify	What was the amount received per frequency (Cash or in kind). If the payment was in kind, please indicate the cash equivalent.		Who in the household received the income and decided on how it was used? (1=HHhead (male), 2=HHhead (female), 3 =HHhead spouse (female), 4=Other HH male, 5=Other HH female, 6=Household joint)
				Cash (UGX)	In kind (Cash equivalent (UGX)	
1	Rent from buildings					
2	Rent from land					
4	Business (Including petty business e.g VEG sales)					
5	Hired farm labor					
6	Employment salary					
7	Remittance from relatives					
8	Interest on savings					
9	Pension					
10	Gratuity					
11	Others specify					

5e1). What is the ownership status of the house your household is currently residing in? [_____] 1. Borrowed 2. Rented 3. Owned

5e2). How many rooms does the house contain? [_____] 1. 1 to 2 rooms 2. 3 to 4 rooms 3. More than 4 rooms

5e3). What is the floor material of the house you live in made of? [_____] 1. Earth 2. Cement 3. Tile

5e4). What is the wall material for the house you live in made of? [_____] 1. Earth/mud 2. Wood/Bamboo/ 3. Iron sheets 4. Cement/Bricks

5e5). What is the roofing material for the house your household members reside in? [_____] 1. Grass 2. Iron sheets /Asbestos 3. Tiles

Section 6: Livestock Inventory, watering and feeding systems.

6.1 Please provide information about the different livestock types owned and kept by the **household**.

Livestock Species		Total number kept within the household	Total number owned	Number owned/male HH member	Number owned/female HH member	Number owned jointly	Number not owned but kept for others	No. owned but kept by others
Goats	Local							
	Cross*/exotic							
Sheep	Local							
	Cross/exotic							
Cattle	Local							
	Cross/exotic							
Pigs	Local							
	Cross/exotic							
Poultry	Local							
	Cross/exotic							
Rabbits	Local							
	Cross/exotic							
	Local							

Donkeys	Cross/ exotic							
Others specify	Local							
	Cross/ exotic							

6.2 Indicate the different categories of cattle that are kept

Type	No. kept	Breed type
1. Bulls (> 3 years)		
2. Oxen (Castrated adult males > 3 years)		
3. Cows (calved at least once)		
4. Steers (Castrated immature males <3 years)		
5. Immature males (Male \geq 1yr, but not ready for serving)		
5. Heifers (females \geq 1yr, but have not calved)		
6. Male calves (From 15days & <1yr)		
7. Female Calves (From 15 days & <1yr)		
8. Female calves (< = 14 days)		
9. Male calves (< =14 days)		
A) Breed type		
1 = Local		
2 =Cross/exotic		

6.3 Which feeding system is currently practiced [_____] 1. Tethering 2. Extensive system 3. Semi intensive system 4. Intensive system

6.4 Does the feeding system change in the course of the year [_____] 1. Yes 2. No

6.5 Please indicate the different feeding systems and type of fodder given to the animals across the year in the table below

Feeding system	Months in which feeding system is used in the last year (2021)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Extensive system												
Semi intensive												
Intensive system												
Tethering												
Type of fodder	Months in which this fodder type was given to animals in the last year (2021)											
Napier grass												
Planted grasses e.g. Rhodes grass												
Maize fodder												
Fodder shrubs (Calliandra, Sesbania, Lucaenia)												
Other fodder legumes (Desmodium, lucern, vetch)												
Brachiaria												
Others specify												

6.6 Do your animals mix with other animals from the village during grazing [] 1. Yes 2. No

6.7a What is the main source of water for your animals? [] 1. Borehole / well 2. Dam 3. River/Lake / Spring / Stream 4. Constructed small pan /ponds / valley tanks 5. Rainwater harvesting 6. Piped onto holding 9. Other (Specify)

6.7b Does the water source for your animals vary by season? [] 1. Yes 2. No

6.7c. Please indicate in the table below the months in which your animals relied on each of the different water sources (Last year)

Water source	Months in which your animals depended on the stated water source (2021)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Borehole/well												
Dam												
River/lake/spring/stream												
Constructed small pan/ponds/valley tanks												
Harvested rainwater												
Piped into holding												
Others specify												

6.8 Do your animals ever water with other animals from the village [] 1. Yes 2. No

6.9 If yes to question 5.7, how often does this occur? [] 1= Daily 2= Often 3= Rarely

6b. Herd movement

6b.1 Do you manage your cattle in herds? [] 1. Yes 2. No, (If No, Skip to 6.4)

6b.2 If yes how many animals make up your herd []

6b.3 How many herds are managed by the household []

6b.4 Do you at any time within the year move your animals out of the subcounty and beyond in search of pasture? [] 1. Yes 2. No

(If yes proceed to the next set of questions if no skip to the next section)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
6b.5a. During which months does your herd move away from your village ?												
6b.5b. Do other herds move into your village? [if no, then skip 6.5c]	1= yes 2= No											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
6b.5c. During which months do other herds move into this village?												

6b.6a When moving your herd do you follow a fixed route each year? [] 1. Yes 2. No

6b.6b. Which are the routes you follow while moving your herd? _____

Section 7: Livestock diseases and management

7.1 Have any diseases affected your cattle in the last 12 months? [] 1. Yes 2. No If yes go to 7.2 if no go to 7.3

7.2 If yes please fill in the table below.

Disease	Cattle type affected	Main clinical signs	Number that fell sick	Number that died	No. that recovered	No of days to Recovery	Did you treat 1. Yes 0. No	Who treated?	Cost of treatment (UGX)	Months when disease occurred
A). Code for diseases		B). Code for clinical signs				C). Code for cattle type affected			D). Code for who treated	
1. CBPP 2. East Coast Fever 3. FMD 4. Brucella 5. Worm infestations 6. Skin disease 7. Anthrax 8. RVF 9. others specify		1. Watery discharge in eyes, nose, and mouth 2. Difficulty in breathing 3. High fever 4. Reddened eyes mouth 5. Smelling exudates from mouth 6. Diarrhoea 7. Significant death rate 8. Rapid abortions among pregnant cows 9. Others specify				1. Bulls (> 3 years) 2. Oxen (Castrated adult males > 3 years) 3. Cows (calved at least once) 4. Steers (Castrated immature males <3 years) 5. Immature males (Male \geq 1yr, but not ready for serving) 6. Heifers (females \geq 1yr, but have not calved) 7. Male calves (<1yr) 8. Female Calves (<1yr)			1. Vet 2. Paravet 3. Self 4. Other specify [____]	

7.3a Did you carry any disease prevention on your farm in the last 12 months? 1= Yes 0= No

7.3b If Yes, how did you prevent diseases from entering your farm in the last 12 months?

Prevention method	For which diseases	Practiced in which months	Cattle type applied to.	Number of animals treated/handled	Cost of prevention if applicable (UGX)
Isolation of sick animals					
Isolation of new animals					
Isolation of left-over stock from the market					
Restriction of flock movement					
Vector control					
Disinfection of utensils					
Use of antibiotics					
Use of dewormers					
Not selling during disease outbreaks					
Burying dead animals					
Vaccination					
Use local herbs					
Code for cattle type: 1. Bulls (> 3 years) 2. Oxen (Castrated adult males > 3 years) 3. Cows (calved at least once) 4. Steers (Castrated immature males <3 years) 5. Immature males (Male ≥ 1yr, but not ready for serving) 6. Heifers (females ≥ 1yr, but have not calved) 7. Male calves (<1yr) 8. Female Calves (<1yr)			Code for diseases: 1. CBPP 2. East Coast Fever 3. FMD 4. Brucella 5. Worm infestations 6. Skin disease 7. Anthrax 8. RVF 9. Others specify		

Section 8: Farm labor use and decision making.

8.1 Please describe the different people that carry out activities related to cattle in your household. Also describe whether they are household or non-household members and if they are paid either in cash or kind.

Labour resource type	Number of women	Number of men	No. of hours worked per day/person	How often do you pay the labourers for work done? 1= daily 2= weekly 3= Fortnightly 4= monthly 5= Quarterly 6= Biannually 7 = Yearly 8= others specify	How much are the labourers paid on each of the occasion you make payment (UGX)	Describe in-kind payments
Casual labourer (short term)						
Fixed term (Long term) labourer						
Family labour						
Other _____						

8.2 Please describe the different activities related to general cattle production and the person responsible for carrying them out.

S/N	Type of activity	Done 1= Yes 2= No	Main person responsible		Who in the household makes decisions on each of the activities mentioned
			Family labor	Hired labor	
1	Watering cattle				
2	Caring for sick animals				
3	Constructing the pen for the calves				
4	Grazing				
5	Milking				
6	Collection of feeds				
7	Handling and treatment of cattle manure				
8	Animal shed cleaning				
9	Marketing of live animals				
10	Marketing of meat				

11	Marketing of milk				
	A) Family labor	B) Hired Labor			
	1. Family adult male 2. Family adult female 3. Family male child 4. Family female child	1. Hired adult male 2. Hired adult female 3. Hired male child 4. Hired female child			

8.3 Please describe the different activities related to health and diseases management in the herd.

S/N	Type of activity	Done 1= Yes 2= No	Main person responsible		Who in the household makes decisions on each of the activities mentioned
			Family labor	Hired labor	
1	Vector control				
2	Animal inspection for disease symptoms and isolation				
3	Vaccination				
4	Deworming				
5	Nursing sick animals				
6	Culling				
7	Herd decongestion				
8	Purchasing vet drugs				
9	Disinfection of the pens and area				
10	Moving animals to treatment or vaccination sites				
11	Burning, burying and disposal of dead animals				
	A) Family labor	B) Hired Labor		C) Decision maker in the household	

	1. Family adult male 2. Family adult female 3. Family male child 4. Family female child	1. Hired adult male 2. Hired adult female 3. Hired male child 4. Hired female child	1. Household head 2. spouse 3. Another adult male household member 4. Another adult female household member 5. Child 6. non-Household member
--	--	--	---

Section 9: Herd entry and exits

9.1 Have you acquired cattle in the last 12 months [] 1. Yes 2. No

9.3 For all that have been selected please fill in the details below for the last 12 months.

Animal type	Total number	No. Births	No. Purchased	Unit price if purchased	From where	Numbers received through payment in kind	Numbers received as gifts
1. Bulls (> 3 years)							
2. Oxen (Castrated adult males > 3 years)							
3. Cows (calved at least once)							
4. Steers (Castrated immature males <3 years)							
5. Immature males (Male ≥ 1yr, but not ready for serving)							
6. Heifers (females ≥ 1yr, but have not calved)							
7. Male calves (<1yr)							
8. Female Calves (<1yr)							
From where							
1. Traders 2. Neighbours/fellow farmer 3. Market 4. Middlemen 5. Others specify							

9.4 Have any animals exited your farm in the last 12 months [] 1. Yes 2. No

9.5 If yes how have they exited [] 1. Death 2. abortion 3. Theft 4. Gifts 5 Payment in Kind 6. Sales 7 others specify () (this should be multiple)

9.6 For all that have been selected please fill in the details below for the last 12 months.

Animal type	Total number	No. Deaths	Abortions	Theft	Numbers given out as payment in kind	Numbers given out as gifts	Numbers consumed at home	Numbers sold off	Unit price if sold off.
1. Bulls (> 3 years)									
2. Oxen (Castrated adult males > 3 years)									
3. Cows (calved at least once)									
4. Steers (Castrated immature males <3 years)									
5. Immature males (Male \geq 1yr, but not ready for serving)									
6. Heifers (females \geq 1yr, but have not calved)									
7. Male calves (<1yr)									
8. Female Calves (<1yr)									

9.7) What factors do you consider in deciding when to cull a cow? [] 1. milk production, 2. number of calving, 3. Injury, 4. poor mothering ability, 5. Lameness
6. Diseases 7. Others specify

9.7b) If the reason is based on number of calvings, how many times does a cow calve before its culled out? []

Section 10: Milk production and reproduction

10.1a) Have you been milking any cows in the last 12 months? 1=Yes, 0 = No

10.1b) If yes, please enter the following details on milk production for 3 cows milked during the last 12 months (Two best and one poor performer).

10.1c) Number of lactating cows: _____

	cow 1	cow 2	cow 3
Breed of cow (1 = local; 2 = cross bred; 3 = pure exotic)			
Average milk production per day			
Milk production per day (<i>morning and evening milk</i>) at calving			
Milk production per day (<i>morning and evening milk</i>) at peak (if known)			
Milk production yesterday (<i>morning and evening milk</i>)			
Milk production per day (<i>morning and evening milk</i>) at late lactation			
Lactation length (number of months cow is milked between 2 calvings)			
Calving interval (time between one calving (cow) to the next in months)			
When did the cow calve down (give birth)? (<i>MM/YY</i>)			
Breeding method used for the last calving [1=Own bull 2=Other bull 3= AI]			
Number of services (repeats) before conception for this service			
Price paid for the last breeding service (UGX)			
Milk utilization: For milk produced yesterday or the last day milking was done, please indicate how	Quantity (liters)		
Amount fed to calves (if any)			
Amount used/consumed by household fresh			
Maximum amount per day mostly used/consumed by household			
Amount given to relatives, workers etc.			
Amount of fresh milk sold per day (morning and evening) milk)			
Amount used for other purposes (specify _____)			
Price (UGX/litre) of amount used for other purposes if sold			

Section 11: Marketing

11.1 Did you sell any of your cattle or products from your farm in the last month [_____] 1. Yes 2. No

11.2 In the table below, please indicate the sales of animal products in the last 1 year. Note: marketing for milk will be captured separately

Product	Did you sell this product in the last 1 year? (1= yes, 0= No)	Qty	Unit	Unit price (UGX)	Where sold	To whom
1. Live animal 2. Meat 3. Hides and skin 4. Manure 5. Others specify			1. Kg 2. Animal 3. Skins 4. Trips 5. Tonnes 6. Others specify		1. Farm gate 2. Village Livestock market 3. District livestock market 4. Within village 5. Outside village 6. abattoir	1. individual households 2. Traders
1. Live animals						
2. Meat						
3. Hides and skin						
4. Manure						
5. others specify						

11.3 In the next table we would like you to indicate the peak periods for each of the products that you sold in the last 12 months.

Product	Sold 1. Yes 2. No	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1. Live animals													
2. Meat													
3. Hides and skin													
4. Manure													
5. others specify													

Milk sales: For milk produced yesterday or the last day milking was done, please provide details of milk sales.

	Morning milk			Evening milk		
	Buyer 1	Buyer 2	Buyer 3	Buyer 1	Buyer 2	Buyer 3
Type of buyer (code)						
Gender of buyer 1 = 1=Female; 0 = Male						
Quantity sold to buyer (liters)						
Price received (UGX/liter), if in kind, provide cash equivalent						
Distance to buying point (Kms)						
Who transports milk to buyer						

Transport cost if any						
Buyer 1. = Individual consumers 2. = Private milk-traders 3. = milk collection point 4. = Cooperatives = Other (specify)_____			Who transports 1. = Farmer 2. = Hired transport, organised by farmer 3. = Hired transport, organised by Coop/ FG/trader 4. = other, (specify)_____			

11.4a). Have you ever failed to sell your animals in the last market day? [_____] 1. Yes 2. No

11.4b) If yes, how many animals do you fail to sell on that given market day? [_____]

11.4c). What was the underlying reason for failing to sell these animals on that market day? 1. Health condition 2. Body condition not fine, 3. many animals in the market, 4. Others specify

11.4d). What did you do with these animals? [_____] 1. Isolated the animal 2. Gave it away 3. Slaughtered it for home consumption 4. Mixed it with my other animals. 5. Left it in the market 6. Put it to rest

11.5 How do you handle the animals you have bought from the market for re-stocking? [____] 1. Isolate for some time 2. Mix immediately with other animals 3. Others specify

Section 12: Draft power and costs

12.1a) Do you use some of your cattle for draft power? [_____] 1. Yes 2. No

12.1b) If yes, for how many hours do they work in a typical day? Hours

12.1c) Do you also use the cattle to offer draft power for other people? 1= Yes, 0= No

12.1d) If Yes, what is the payment agreement based on, Land size,

12.1e) In the last season, how much did you earn from traction?

12.1f) How many days do they work in a typical month? Days

12.1g) How many of your cattle do you use for draft power?

12.2 At what age do you start using the cattle to offer draft power? Years

12.3 Do you have specific cattle that offers draft power? 1= Yes 0= No (skip 11.3 if NO)

12.4 For how many years do you utilize a particular cattle before it is replaced? years?

Section 13: Access to information, facilities, credit, and extension

13.1 Access to Livestock Production information

S/N	Type of information	Received information (1 = Yes, 0= No)	Source of information received
1	Weather		
2	New livestock breed		
	Animal welfare, herd health, general husbandry practices, disease outbreaks, livestock pasture		
3	New livestock production and disease management practices		
4	Vaccination program		
5	Market prices of livestock		
6	Where to sell animals		
7	Credit facilities		
Codes for sources of information: 1= Radio 2= Farmer to farmer 3= Television 4= NAADS/Operation Wealth Creation 5= Telephone 6 = Agricultural Shows 7 = NGOs 8= Newspaper 9= Kraal leaders 10= local council authorities 11 = Demonstration Farms 12= Extension workers/CAHW 13= Other, specify			

13.2 Access to facilities

S/N	Facility	Access in last one year (Jan 2021 – Dec 2021) (1= Yes, 0= No)	Distance in KMs from your homestead
1	Vet shop		
2	Cattle vaccination center		
3	Feeder road		
4	Quarantine site		
5	Tarmac road		
6	Livestock market		
7	Livestock production demonstration center		
8	Main urban center		

13.3. Access to credit

Did any member of your household receive an agricultural-related loan service between January 2021 and December 2021? ... 1= Yes, 0= No

If yes, what were the different sources from which the loan was obtained? 1= commercial bank 2= Sacco 3= Local money lenders 4= Farmer associations 5= family and friends, 6= VSLA 7= others specify

Did the household have to provide collateral for this credit/loan? 1= Yes 0= No

What was the interest rate that was charged? UGX

13.4. Access to extension services

Did any member of this household attend a farmers' training related to livestock production between January 2021 and December 2021? 1= Yes, 0= No

Between January 2021 and December 2021, did any member of this household receive any advisory service related to livestock production and management? 1= Yes, 0= No.

If Yes, In the table below, please fill in the topics covered during the advisory service and the source of the advisory service.

Topic covered	Was this topic covered? 1= Yes, 0= No	Source of advice (1. NGOs, 2. OWC, 3. CAHW, 4. Local government, 5. Radio, 6. Television, 7. Newspapers, 8. cooperatives, 9. input suppliers, 10. Model farmers, 11. Others specify)
Animal breeding		
Vector control		
Animal disease management		
Animal and human nutrition		
Pasture production and management		
Vaccination		
Health herd management		
Livestock marketing		
Others specify		

Section 14: Group membership

No	Type of group	Does any member of the household belong to this group? 1= Yes, 0= No	How many members of the household belong to this group	How many men in the household belong to this group?	How many women in the household belong to this group?
1	1= social/ welfare & community development groups				
2	2 = savings and credit groups				
3	3 = agricultural producer groups				
4	4 = livestock producer groups				
5	5 = agricultural marketing groups				
5	6 = livestock marketing groups				
7	7 = others specify				

Thank you for your time.

End time (HH:MM) [_____]

GPS Coordinates [_____]

KAP survey and Choice Experiment tool for use with livestock farmers

Introduction and consent

PART A: Project Information

I am _____ (name of enumerator) and I work with the International Livestock Research Institute (ILRI) as a researcher. ILRI is an international research organization that focusses on livestock research and development. We are carrying out a study to determine the level of knowledge, attitudes, and practices for RVF control within the pastoral and agro-pastoral systems of Uganda and also, we would like to elicit cattle farmers' opinions and willingness to pay for potential Rift Valley fever vaccines that are being used for control of RVF in other countries. Information from this study will inform our project's interventions and activities that are aimed to strengthen the capacity of government of Uganda and other stakeholders in the livestock sector to better manage Rift Valley Fever disease. The project is funded by BMZ under the program titled BUILDUganda. I would like to invite you to participate in the study in form of an interview. If you consider participating, you will not be compelled to answer any question(s) that you may not be comfortable with and should you change your mind later and would wish to withdraw from the study at any point you will not be penalized for that. Kindly note that your participation in this study is entirely voluntary and there will be no remuneration or direct benefits to be awarded. However, it is our hope that the knowledge gained from your participation in this research will benefit the livestock value chain by informing us on how to better design interventions that enhance the livelihoods of value chain actors. There are no major risks, to you as a participant in this study, that are anticipated except for loss of your time during the interview. If you experience any form of discomfort during the interview kindly alert the researcher who will advise you on the action to take. The interview shall take approximately 1 hour and during this time the researcher will be writing down responses to the questions discussed on a tablet. This data shall later be entered and stored in electronic databases where it can be extracted for analysis.

Any personal identifying information discussed in this interview shall be held in confidence, this means that this information shall not be shared with or given to anyone except the researchers in this project. However, the non-personal data and the generalized findings in form of publications from this research shall be put in publicly accessible databases and shall be available to other researchers and interested persons who would want to understand Knowledge, attitudes, and practices with potential to expose communities to risk of RVF infections. I want to emphasize here that the open access data cannot be traced back to you as an individual by users. Do you have any questions?

For further queries or concerns you would like to raise, kindly contact any of the contacts provided below

PART B:

Consent

I have read (or someone has read to me) the foregoing information. I have had the opportunity to ask questions and all my questions have been answered to my satisfaction. I confirm that I have agreed to answer to answer the questions that I will be asked. I also confirm that I have retained a copy of this consent.

Participant Name

Participant Signature (print)

Date

PART C:

Contacts

Name of main researcher: Mr. Marsy Asindu

Institution: International Livestock Research Institute

Telephone: +256 775193913

Email address: M.Asindu@cgiar.org

Section1: Household Information

Table 1.1: Household Information

1.1.1.	Date of interview (dd/mm/yyyy)	
1.1.2.	Name of interviewer?	
1.1.3.	Livestock production system	1= Pastoral 2= Agro-pastoral
1.1.4.	District	1= Isingiro 2= Sembabule 3= Soroti 4= Napak 5= Lyantonde 6= Rwampara
1.1.5.	Sub-County	
1.1.6.	Parish	
1.1.7.	Village	
1.1.8.	Household ID	
1.1.9.	GPS Location	Last item on questionnaire
1.1.10.	Telephone number	
1.1.11.	Household head's full name	
1.1.12.	Sex of household head	1=Female; 0=Male
1.1.13.	Household head's marital status	1=married, monogamous; 2=married, polygamous; 3=cohabiting; 4=single; 5=widowed; 6=divorced; 7=separated
1.1.14.	Is the respondent also the household head? (If yes, skip)	1=yes, 0=no
1.1.15.	Respondent's full name (Person who takes care of the animals)	
1.1.16.	Respondent's marital status	1=married, monogamous; 2=married, polygamous; 3=cohabiting; 4=single; 5=widowed; 6=divorced; 7=separated
1.1.17.	Respondents' main profession	1=fulltime wage employed, 2=part time wage employed, 3= self-employed, 4= others specify
1.1.18.	Religion of the respondent	

1.1.23b. Were you living in this village between 2016 and 2020? 1=Yes 2=No 3=NA

1.1.23a. How many people do you have in your household?

1.1.23e. Please provide details of your household members (start with household head's details followed by the respondent then the rest of the members). We define a "household" to include all members of a common decision-making unit (usually within one residence) that are sharing income and other resources and rely on same kitchen.

	Members of your household [FIRST NAMES]	Year of birth	Gender 1=Male 2=Female	Relationship to household head	Highest education level attained	Primary source of income
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
Relationship to household head	Highest education level attained		Primary source of income			
1 = Head 2 = Spouse 3 = Child 4 = Sibling 5 = Parent 6 = Grandchild 7 = Other relative	0 = No formal education 1 = Nursery 2 = Pre-school age 3 = Primary education (P1-P4) 4=Primary education (P5-P7)	9=Tertiary training specify yrs _____ 10=University degree (undergraduate)	0 = None 1 = Crop farming 2 = Remittance 3 = cattle keeping 4 = poultry/keeping (inc. sales) 5 = Salaried employment 6 = Self-employed-off farm			

8 = Non-relative (including employees who live in house) 9 = Other (specify)	5=Secondary school (S1-S2) 6=Secondary school (S3-S4) 7=High school (S5-S6) 8=Vocational training (specify no of years) _____	11=University degree (postgraduate) 12=Adult literacy 13=Others (specify) _____	7 = Casual laborer 8 = Boda boda 9 = Student/pupil 10 = Charcoal burning 11 = Pre-school age 12= Other _____
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1.1.24	Have you ever heard of the disease "Rift Valley fever"?	1. Yes 2. No 3. Not sure (If No skip to 1.1.27)
1.1.25	Which season are the cases of Rift Valley fever likely to be high?	1. March to June 2. Oct-December 3. Prolonged heavy rainfall season with excess flooding 4. Do not know
1.1.26	What are the clinical signs of Rift Valley fever seen in animals?	1. Sudden onset of abortion 2. High mortality of new-born: 3. Weakness /Unsteady gait 4. Thick nasal discharge could be bloody 5. Profuse fetid diarrhea 6. High fever 7. Bloody nose 8. Tearing 9. Other (Specify.....) 10. Do not know

1.1.27. Have you ever encountered any cattle disease on your farm in the last 12 months? 1. Yes 2. No.

1.1.28 Which of the following disease prevention method do you always use on your farm?

Prevention method	Did you use this method [Yes/No]	For which diseases	Practiced in which months	Category of animal applied to	Cost of prevention if applicable (UGX)
Isolation of sick animals					
Isolation of new animals					
Isolation of left-over stock from the market					
Restriction of flock movement					
Vector control (Spraying mosquitoes & ticks)					
Disinfection of watering and feeding utensils					

Use of antibiotics					
Use of dewormers					
Not selling during disease outbreaks					
Delivering animals with protective gear (gloves)					
Burying abortus and mummified fetuses					
Boiling milk before consumption					
Burying dead animals					
Vaccination					
Traditional ways [Use herbs]					

1.1.29. If the response is yes or no to 1.1.28 above, please respond to the follow-up questions in the table below

Prevention method	If yes, I will continue using this practice for RVF control	If no, I Intend to use this practice for RVF control
Isolation of sick animals		
Isolation of new animals		
Isolation of left-over stock from the market		
Restriction of flock movement		
Vector control (Spraying mosquitoes & ticks)		
Disinfection of watering and feeding utensils		
Use of antibiotics		
Use of dewormers		
Not selling during disease outbreaks		
Delivering animals with protective gear (gloves)		
Burying abortus and mummified fetuses		
Boiling milk before consumption		
Burying dead animals		
Vaccination		
Traditional ways [Use herbs]		
Code: 1 = Strongly disagree 2= Disagree 3= not sure 4= Agree 5= Strongly agree		

Section 2

Knowledge, Attitudes, and Practices towards Rift Valley Fever

Please indicate by ticking your strength of agreement or disagreement for each of the following statements from 1- 5

No	Statement	Strongly disagree (1)	Disagree (2)	Uncertain (3)	Agree (4)	Strongly agree (5)
RVF Knowledge related statements						
1.	RVF disease affects both humans and animals					
2.	RVF can be spread to animals and humans through mosquito vectors					
3.	One can contract RVF if he gets into contact with an infected person					
4.	Consumption of uncooked or half cooked meat can result into RVF					
5.	Consumption of raw milk increases risk of contracting RVF					
6.	Animal slaughter under veterinary supervision prevents RVF					
7.	RVF in humans can only be diagnosed through medical tests					
8.	Humans of all age group are susceptible to RVF infection					
9.	Herders are the most at risk of RVF infection					
10.	Butchers handling animals and products without protective gear easily contract RVF disease					
11.	Animal blood sample is the most appropriate for testing RVF					
12.	Almost all pregnant animals abort due to RVF infection					
13.	Handling of aborted animal without protection spreads RVF					
14.	Animal's contract RVF through direct contact with infected animal					
15.	Animals licking, sniffing, and eating aborted fetus contract RVF					
16.	I suspect RVF if there are many sick animals and abortion on farms					
17.	All calves less than 14 days of age die because of RVF					
18.	Humans get RVF infection through contact with infected animal tissues and secretion					
19.	Vaccination of sick animals prevents RVF					
20.	Isolation of all sick animals prevents RVF spread					
21.	Isolation of aborted animals is essential to RVF prevention					

22.	RVF commonly occurs in years with heavy and above average rains					
RVF ATTITUDINAL RELATED QUESTIONS AND STATEMENTS						
1.	Vaccination against RVF will only happen if vaccines are less costly					
2.	Animals will abort if they are vaccinated against RVF					
3.	It is the role of the government to vaccinate animals against RVF					
4.	My district and village in particular are susceptible to RVF infection					
5.	Even if animals are quarantined, they will still get the RVF					
6.	Our local herbs are effective against RVF					
7.	Many animals will die in case they are vaccinated against RVF					
8.	Patients suffering from RVF should be isolated from the community					
9.	If I get RVF infection, I will be stigmatized in the community					
10.	Meat will be recalled, and slaughters banned due to RVF outbreaks					
11.	Early detection of RVF is essential to its prevention					
12.	Many animals will pick RVF infection if taken to vaccination points					
13.	RVF will greatly impact milk production					
14.	Herders around will not allow my animals in the communal ground if they suspect my animal has RVF					
15.	The vets around do not have adequate capacity to manage RVF					
16.	I know how to protect myself from acquiring the RVF disease					
17.	All slaughterhouses will close due to RVF outbreak in this area					
18.	People this area are likely not to eat meat and drink milk due to RVF					
19.	Many people will lose their lives if RVF infections occur					
20.	People will have to throw away or bury all dead animals to avoid RVF					
21	I have enough resources to enable me carry out RVF control on my farm					

RVF Prevention and Control Related Practices (Please indicate if you currently use and intend to use the following practices for RVF disease control)

	Disease management practice	Yes/No	If yes, I will continue using the practice to prevent RVF spread	If no, I intend to use the practice for controlling RVF
1	I Isolate aborted animals to prevent disease spread			
2	I quarantine my animals to avoid disease spread			
3	I vaccinate animals to avoid disease spread			
4	I avoid consuming raw milk to prevent disease spread			
5	I do not consume half cooked or raw meat to control disease spread			
6	Burn and bury all dead animals to prevent disease spread			
7	I slaughter animals away from the homestead to reduce disease spread			
8	Use protective gear like gloves when helping animals during delivery			
9	I use mosquito nets to prevent mosquito bites and disease spread			
10	I regularly spray mosquitoes and other disease-causing vectors			
11	I consume meat that has been inspected			
12	I do not consume meat from dead animals			
13	I wear protective gloves when handling meat			
14	I regularly monitor my animals for disease symptoms			
15	I use herbs for treating animals			
16	I usually cull sick animals on my farm to prevent disease spread			
17	I avoid mixing my animals with those from other areas while in the grazing ground			
18	I do not immediately mix animals from the market with those at home			
19	I avoid herding animals in communal grazing grounds to avoid disease spread.			
20	I don't sleep with animals in the same house to avoid disease spread			
Code: 1= Strongly disagree 2= Disagree 3= not sure 4= Agree 5= Strongly agree				

Break news for livestock farmers in Uganda!!!!

There is a new disease of cattle, sheep and goats that also affects humans. This disease is called Rift Valley fever (RVF). In 2016 the disease was identified in Kabale district and caused a lot of abortions in cattle. Majorly young cattle below the age of 14 days and pregnant cows were heavily impacted with several deaths and abortions being registered among these categories of livestock. The disease has quickly spread to many other districts in Uganda where cattle keeping is being carried out. It is mainly spread by mosquitoes and humans can become infected from mosquito bites, although majority of the human cases are thought to result from handling the blood, tissues, secretions, or excretions of infected animals, notably after abortion. Consuming infected animal products like fresh meat, milk and urine is also a source of infection. The RVF disease occurs every 5 to 15 years following periods of above normal and persistent rainfall. Several options exist to control the disease in livestock. For instance, during times of RVF outbreak, market closures, quarantine, animal movement and trade bans are always applied to minimize spread of the disease. Vector control and bio safety precautions such as using protective gloves when handling animal products are deployed to prevent the disease from reaching farms. However, these measures can only slow down the spread of the disease, but do not offer long term protection against the disease. The good news is that there has been progress made to produce vaccines that offer a longer-term protection of the animals against this RVF disease. However, before these vaccines can be used on your animals to offer protection against the RVF, scientists would like to know your opinion about the attributes of the potential vaccines so that they can plan and bring vaccines that align with your interests.

Section 4 perceptions and attitudes on RVF vaccines and willingness to pay.

Farmer perceptions and attitudes in relation to RVF vaccines and vaccination programs

No	Perception and attitudinal Statement	Response
1	My pregnant animals will abort if they are vaccinated against RVF	[]
2	I trust the veterinary doctors around my village to administer the right RVF vaccines to my animals	[]
3	I will vaccinate my animals only if the costs are not very high	[]
4	Government should be the one to procure vaccines and vaccinate our animals	[]
5	My animals are likely to die of RVF even after they get vaccinated against the disease	[]
6	Rare and more dangerous type of RVF will emerge if we vaccinate our animals	[]
7	I fear that there will not be enough vaccines available for all animals in this district	[]
8	My animals will contract other diseases from the collective vaccination area	[]
9	My animals' milk yield will drop if they are vaccinated against RVF	[]
10	I fear, I will have to lose revenue from milk if my animals are vaccinated	
11	The tails of our animals will fall in case we decide to vaccinate them	[]
12	I will only vaccinate my animals if I see the disease has become serious in my village	[]
13	I will only accept my animals to be vaccinated if they are first diagnosed for RVF	[]
14	My culture is against vaccination of animals	[]
15	If market prices of animals are good, I will vaccinate my animals	[]

16	I will vaccinate my animals only if my neighbors and other cattle farmers in this area accept to vaccinate theirs	<input type="text"/>
Code: 1= Strongly disagree 2= Disagree 3= not sure 4= Agree 5= Strongly agree		

Introduction to potential RVF vaccine shopping scenario

In the questions that will appear next, you will be presented with different vaccine scenarios that are being used to protect animals against RVF. Each of these scenarios describe the characteristics of the RVF vaccine that you are likely to encounter in the real market. We would like you to consider the vaccine options as described through its attributes and select the vaccine option that you prefer and are willing and able to buy for each choice scenario. In cases where you do not prefer the vaccine options for a choice scenario, you can choose the none or no-buy option.

Attribute	Attribute description	Attribute level
Dose regimen and effectiveness	Dosage regimen required for the animal to be fully protected against RVF.	<ul style="list-style-type: none"> ❖ Single vaccination required for lifelong protection ❖ Initial vaccination + booster 3 - 4 weeks after the first vaccination + annual boosters required to attain full protection ❖ Initial vaccination + annual boosters required for full protection
Distance and vaccination points.	Vaccination points and cost associated with distance travelled	<ul style="list-style-type: none"> ❖ Vaccination done at designated communal vaccination point, No extra cost. ❖ Vaccination done at farmers home within 5 km of the designated communal vaccination point + 5000 UGX extra cost per vaccination event. ❖ Vaccination done at farmers home, > 5 km away from the designated communal vaccination point + 10,000 UGX extra cost per vaccination.
Adverse effects	Advance events likely to occur following vaccination of the animals against RVF	<ul style="list-style-type: none"> ❖ 28% chances of abortion if in-calve animals are vaccinated. ❖ No reaction ❖ Febrile reaction occurs on the second to fourth day following vaccination after which clears
Vaccine withdrawal period	Time taken before animal products (Milk & Meat) can be used for human consumption following vaccination.	<ul style="list-style-type: none"> ❖ 1 week before animal product can be consumed following vaccination ❖ 2 weeks before animal products can be consumed following vaccination ❖ 3 weeks before animal products can be consumed following vaccination
Cost of vaccination	Cost of vaccination per head of cattle per vaccination event. (This includes cost per 100 ml vial, insurance, freight, Verification, and value added tax, transport to district of vaccination and mark-up)	<ul style="list-style-type: none"> ❖ UGX 5700 ❖ UGX 8550 ❖ UGX 11400
Exemption of vaccine use	Circumstances under which vaccine cannot be used on animals	<ul style="list-style-type: none"> ❖ Calves below 6 months of age from immune cows can't be vaccinated ❖ No exemption ❖ Can't be used during outbreak (epidemic period)

To which block does the choice card presented to the respondent belong? [1 = Block 1 2= Block 2 3 = Block 3]

Which option has the respondent picked from choice card 1 presented? [Option A, Option B, Option C]

Which option has the respondent picked from choice card 2 presented? [Option A, Option B, Option C]

Which option has the respondent picked from choice card 3 presented? [Option A, Option B, Option C]

Which option has the respondent picked from choice card 4 presented? [Option A, Option B, Option C]

Which option has the respondent picked from choice card 5 presented? [Option A, Option B, Option C]

Which option has the respondent picked from choice card 6 presented? [Option A, Option B, Option C]

Which option has the respondent picked from choice card 7 presented? [Option A, Option B, Option C]

Which option has the respondent picked from choice card 8 presented? [Option A, Option B, Option C]

How much level of attention do you feel you offered to each of the attributes that appears in the table below?

Attribute	Never	rarely	Sometimes	Often	always
Dose regimen and effectiveness	[]	[]	[]	[]	[]
Distance and vaccination points.	[]	[]	[]	[]	[]
Adverse effects	[]	[]	[]	[]	[]
Vaccine withdrawal	[]	[]	[]	[]	[]
Cost of vaccination	[]	[]	[]	[]	[]
Exemption of vaccine use	[]	[]	[]	[]	[]

Rank the following statements on a scale of 1 – 5 concerning your level of involvement and understanding of the choice tasks that were presented to you during the hypothetical vaccine marketing (with 1 Strongly disagree to 5 Strongly agree).

Statement	1	2	3	4	5
All the six attributes of the RVF vaccines presented to me during the hypothetical marketing session were important in my choice decisions	[]	[]	[]	[]	[]
I fully understood and was able to comprehend all the choice tasks presented to me.	[]	[]	[]	[]	[]
I was able to make my choices of vaccine like it would be if I were to go sourcing from the actual vet practitioners or market	[]	[]	[]	[]	[]

On a scale of 1 - 6 (1 = Most important and 6 = Least important), kindly rank the vaccine attributes provided in the table below based on their importance and influence on your choice of different vaccine types you were presented with.

Attribute	1	2	3	4	5	6
Dose regimen and effectiveness	[]	[]	[]	[]	[]	[]
Distance and vaccination points.	[]	[]	[]	[]	[]	[]
Adverse effects	[]	[]	[]	[]	[]	[]
Vaccine withdrawal	[]	[]	[]	[]	[]	[]
Cost of vaccination	[]	[]	[]	[]	[]	[]
Exemption of vaccine use	[]	[]	[]	[]	[]	[]

Section 5

Socio-economic characteristics

Livestock details and movement (Only for farmers)		
1a.	Which species of animals do you keep in this household?	1= Cattle 2= Goats 3= sheep 4= others specify
1b.	How many of each animal species do you own?	
1c.	What are your three most important reasons (in order) for keeping animals	1= Milk 2= store of wealth 3= Meat 4= Sell of live animals 5= Hides/skin 6= others specify
1d.	For cattle only, how many of your cattle are currently lactating	
1e.	How many liters of milk on average does each lactating cow produce per day	
1f.	How long does it take for animals to stop lactating on your farm (months)	
1g.	How many newborn calves on average do you obtain each year?	
1h.	How long do your cows take from birth before they start reproducing?	
1i.	How many abortions did you have this year?	
1j.	How many cattle died of disease or other death causes?	
1k.	How long do bulls/male animals take on your farm before they are sold?	
1l.	How long do the cows take on the farm before they are sold off?	
1m.	What is the average selling price for the following on your farm?	1. Mature cow 2. Bull
2a.	Do you at any time move your flock out of this area in search of pasture?	1= yes 0= No
2b.	If yes, in which months of the year do you move out your flock?	
2c.	Which months of the year do you keep your flock within home?	
3a.	Does your flock meet others at the watering point?	1= yes 0= No

3b.	If yes, in which months of the years does this occur?	
4a.	Do you often take your flock into a communal grazing ground?	1= yes 0= No
4b.	If yes, in which months of the year does this occur?	
5a.	Do you often meet other flock while going out to graze?	1= yes 0= No
5b.	If yes, in which months of the year does this occur?	
Livelihoods and income generating activities		
No	Income source	Approximate amount in the last 1 year
1.	Crop farming	
2.	Cattle enterprise	
3.	Poultry enterprise	
4.	Salaried employment	
5.	Self-employment-off farm	
6.	Casual labor	
7.	Boda boda	
8.	Remittances	
9.	Property rent	
10.	Other(specify)	

Risk Exposure, Knowledge, Attitudes and Practices of livestock chain actors (Slaughterhouse attendants, Butcher, cattle traders, and transporters) towards Rift Valley Fever disease in the pastoral and agro-pastoral production systems of Uganda

Introduction and consent

PART A: Project Information

I am _____ (name of enumerator) and I work with the International Livestock Research Institute (ILRI) as a researcher. ILRI is an international research organization that focusses on livestock research and development. We are carrying out a study to determine the level of risk exposure, knowledge, attitudes, and practices for RVF control within the pastoral and agro-pastoral systems of Uganda with a focus on the beef cattle value chain. Information from this study will inform our project's interventions and activities that are aimed to strengthen the capacity of government of Uganda and other stakeholders in the livestock sector to better manage Rift Valley Fever disease. The project is funded by BMZ under the program titled BUILDUganda. I would like to invite you to participate in the study in form of an interview. If you consider participating, you will not be compelled to answer any question(s) that you may not be comfortable with and should you change your mind later and would wish to withdraw from the study at any point you will not be penalized for that. Kindly note that your participation in this study is entirely voluntary and there will be no remuneration or direct benefits to be awarded. However, it is our hope that the knowledge gained from your participation in this research will benefit the livestock value chain by informing us on how to better design interventions that enhance the livelihoods of value chain actors. There are no major risks, to you as a participant in this study, that are anticipated except for loss of your time during the interview. If you experience any form of discomfort during the interview kindly alert the researcher who will advise you on the action to take. The interview shall take approximately 1 hour and during this time the researcher will be writing down responses to the questions discussed on a tablet. This data shall later be entered and stored in electronic databases where it can be extracted for analysis.

Any personal identifying information discussed in this interview shall be held in confidence, this means that this information shall not be shared with or given to anyone except the researchers in this project. However, the non-personal data and the generalized findings in form of publications from this research shall be put in publicly accessible databases and shall be available to other researchers and interested persons who would want to understand Knowledge, attitudes, and practices with potential to expose communities to risk of RVF infections. I want to emphasize here that the open access data cannot be traced back to you as an individual by users. Do you have any questions?

For further queries or concerns you would like to raise, kindly contact any of the contacts provided below

PART B:

Consent

I have read (or someone has read to me) the foregoing information. I have had the opportunity to ask questions and all my questions have been answered to my satisfaction. I confirm that I have agreed to answer to answer the questions that I will be asked. I also confirm that I have retained a copy of this consent.

Participant Name

Participant Signature (print)

Date

PART C:

Contacts

Name of main researcher: Mr. Marsy Asindu

Institution: International Livestock Research Institute

Telephone: +256 775193913

Email address: M.Asindu@cgiar.org

Section1: Household Information

Table 1.1: Household Information

1.1.1	Date of interview (dd/mm/yyyy)	
1.1.2	Name of interviewer?	
1.1.3	Participant category	1= slaughterhouse attendant, 2= Butcher man 3= Cattle trader, 4= Cattle transporter, 5= others specify
1.1.4	Livestock production system	1= Pastoral 2= Agro-pastoral
1.1.5	District	1= Isingiro 2= Sembabule 3= Butebo 4= Napak 5= Lyantonde 6=Rwampara
1.1.6	Sub-County	
1.1.7	Parish	
1.1.8	Village	
1.1.9	Respondent ID	
1.1.10	GPS Location	
1.1.11	Telephone number	
1.1.12	Respondent's full name	
1.1.13	Respondent's relation to household head	1=husband; 2=wife; 3=mother; 4=father; 5=grandfather; 6=grandmother; 7=male child; 8=female child; 9=other specify
1.1.14	Respondent's marital status	1=married, monogamous; 2=married, polygamous; 3=cohabiting; 4=single; 5=widowed; 6=divorced; 7=separated
1.1.15	Respondent's years of completed education	
1.1.16	Respondents' main profession	1=fulltime wage employed, 2=part time wage employed, 3= self-employed, 4= others specify
1.1.17	Religion of the respondent	1= Moslem, 2= SDA 3=Pentecostal 4= Others specify

1.1.18a. How many people do you have in your household?

1.1.18b. Please provide details of your household members (start with household head's details followed by the respondent then the rest of the members). We define a "household" to include all members of a common decision-making unit (usually within one residence) that are sharing income and other resources and rely on same kitchen.

	Members of your household [FIRST NAMES]	Year of birth	Gender 1=Male 2=Female	Relationship to household head	Highest education level attained	Primary source of income
1						
2						
3						
4						
5						
	Relationship to household head	Highest education level attained		Primary source of income		
	1 = Head 2 = Spouse 3 = Child 4 = Sibling 5 = Parent 6 = Grandchild 7 = Other relative 8 = Non-relative (including employees who live in house) 9 = Other (specify)	0 = No formal education 1 = Nursery 2 = Pre-school age 3 = Primary education (P1-P4) 4=Primary education (P5-P7) 5=Secondary school (S1-S2) 6=Secondary school (S3-S4) 7=High school (S5-S6) 8=Vocational training (specify no of years)	9=Tertiary training specify yrs _____ 10=University degree (undergraduate) 11=University degree (postgraduate) 12=Adult literacy 13=Others (specify) _____	0 = None 1 = Crop farming 2 = Remittance 3 = cattle keeping 4 = poultry/keeping (inc. sales) 5 = Salaried employment 6 = Self-employed-off farm 7 = Casual laborer 8 = Boda boda 9 = Student/pupil 10 = Charcoal burning 11 = Pre-school age 12= Other _____		

1.1.19. In what forms do you always handle animals? 1= Live animals 2= slaughtered already 3= Both live and slaughtered

Note: Those handling both live and slaughtered animals and only live can respond to questions 1.1.19a) to 1.1.20)

1.1.19a). How many animals do you handle in a typical week?

1.1.19b). How many of these animals end up slaughtered within the week?

1.1.19c). Who slaughters these animals? 1= I slaughter on my own 2= slaughtered at the abattoir, 3= Others specify.....

1.1.19d). What is the average market price of each animal you handle?

1.1.19e). How much do you make on average from selling each live animal?

1.1.19f). How much do you make on average from each animal when slaughtered?

1.1.20 How far away do you get the animals you handle? 1= Within this district 2= Neighboring districts, 3= other districts from different regions 4= neighboring country 5= from my own farm 6= others specify.....

SECTION 2: RVF RISK EXPOSURE

1	Do you keep animals within the house you sleep?	1=Yes 2=No
2	If yes in 1, which animals?	1=Sheep 2=Goat 3=Cattle 4=Others, Specify
3	Have you ever participated in slaughtering of an animal?	1=Yes 2=No
4	If yes 3; how often do you participate in slaughtering an animal?	1= daily (daily job) 2= At least 3 times a week 3= At least once a week 4 At least once a month
5	If yes in 3; which animal did you slaughter?	1=Sheep 2=Goat 3=Cattle 4=Others, Specify
6	Have you ever participated in slaughtering a sick animal?	1=Yes 2=No
7	If ever participated in slaughtering of animal; what role did you play during slaughtering?	1= Restraining the animal 2= Bleeding out (separating the neck from main body) 3= Skinning the animal 4= Removing the offal/viscera of the animal

		5= Splitting the carcass 6= Clean the carcass, offal and/ or visceral 7= Hanging the carcass 8= Butchering the carcass 9= Other, specify _____
8	If yes in 3; was antemortem inspection made by the Veterinary Officer before the animal was slaughtered?	1=Yes 2=No 3=Do not know/don't remember
9	If yes in 3; was postmortem inspection made by the Veterinary Officer before the meat was sold out/consumed?	1=Yes 2=No 3=Do not know/don't remember
10	Do you have access to hand washing facilities at your workplace?	1=Yes 2=No
11	Do you use personal Protective gear as you go about your work?	1=Yes 2=No
12	If yes in 11, what PPEs do you use?	1= Lab coat 2= Goggles 3= Gloves 4= Coveralls 5= face masks 6= gumboots
13	Have you ever seen animals dying of unknown cause during handling?	1=Yes 2=No
14	If yes, what do you normally do with the dead animals?	1= Burry 2= report to a veterinarian 3= slaughter 4= Proceed with selling carcass/meat 4= Others specify
15	Do you always request for veterinary clearance and movement permits for all animals you handle?	1=Yes 2=No
16	Have you ever heard of RVF disease?	1=Yes 2=No

Section 3

Knowledge, Attitudes, and Practices towards Rift Valley Fever

Please indicate by ticking your strength of agreement or disagreement for each of the following statements from 1- 5

No	Statement	Strongly disagree (1)	Disagree (2)	Uncertain (3)	Agree (4)	Strongly agree (5)
RVF Knowledge related statements						
1.	RVF disease is spread by mosquito vectors					
2.	Consumption of uncooked or half cooked meat can result into RVF					
3.	Consumption of raw milk increases risk of contracting RVF					
4.	Animal slaughter under veterinary supervision prevents RVF					
5.	RVF in humans can only be diagnosed through medical tests					
6.	Humans of all age group are susceptible to RVF infection					
7.	Herders are the most at risk of RVF infection					
8.	People handling animals and related products without protective gear easily contract RVF disease					
9.	Almost all pregnant animals abort due to RVF infection					
10.	Handling of aborted animal without protection spreads RVF					
11.	Animals contract RVF through direct contact with infected animal					
12.	Animals licking, sniffing, and eating aborted fetus contract RVF					
13.	I suspect RVF if there are many sick animals and abortion on farms					
14.	Only trained veterinary specialist can diagnose RVF cases					
15.	All calves less than 14 days of age die because of RVF					
16.	Humans get RVF infection through contact with infected animal tissues and secretion					
17.	Vaccination of animals prevents RVF					
18.	Isolation of all sick animals prevents RVF spread					
19.	Isolation of aborted animals is essential to RVF prevention					
20.	RVF commonly occurs in years with heavy and above average rains					
22.	RVF can spread from one country to another					

23	RVF can spread from my district to other regions of the country					
24	RVF can lead to trade ban between regions within the country					
25	RVF can lead to trade ban outside the country					
26	Humans can get RVF incase infected mosquitoes bite them					
RVF ATTITUDINAL RELATED QUESTIONS AND STATEMENTS						
1.						
2.	Animals will abort if they are vaccinated against RVF					
3.	It is the role of the government to vaccinate animals against RVF					
4.	Many animals will be lost if RVF breaks out					
5.	Suppliers will increase the price of animals due to RVF					
6.	I and my colleagues will not get animals from RVF infected areas					
7.	My family and friends will discourage me from dealing in livestock business if they learn about RVF					
8.	Inspection of animals for slaughter will be intensified due to RVF					
9.	If I get RVF infection, I will be stigmatized in the community					
10.	Meat will be recalled, and slaughters banned due to RVF outbreaks					
11.	Early detection of RVF is essential to its prevention					
12.	RVF will greatly impact milk production					
13.	International trade restrictions will be implemented due to RVF					
14.	The vets around do not have adequate capacity to manage RVF					
15.	I know how to protect myself from acquiring the RVF disease					
16.	I have the capacity to put in place all the necessary requirements for RVF mitigation.					
17.	All slaughterhouses will close due to RVF outbreak in this area					
18.	People are likely not to eat meat and drink milk due to RVF					
19.	Many people will lose their lives if RVF infections occur					
20.	People will have to throw away or burry all dead animals					
21.	I am able to continue using some of the current disease prevention measures I implement to control RVF					

Disease Prevention and intentional practices for Control of RVF (Please indicate if you currently use the following practice for control of zoonoses and indicate your level of intention to use or continue using them for RVF disease control)

	Disease management practice	Yes/No	If yes, I will continue using the practice to prevent RVF spread	If no, I intend to use the practice for controlling RVF
	I will implement disease management practice one for RVF control			
1	I do purchase animals from places without disease outbreaks			
2	I restrict animal movement when I hear of disease outbreak			
3	I vaccinate all animals bought for later sale or slaughter			
4	Avoid consumption of raw milk to prevent RVF infection			
5	Avoid consumption of meat in raw or half cooked form			
6	I bury or burn all dead animals/carcass from dead animal			
7	I slaughter animals away from the homestead			
8	I always disinfect transportation facilities for carcass or live animal			
9	I use mosquito nets to prevent infection through mosquito bites			
10	I regularly spray or destroy mosquito breeding sites			
11	I only deal in meat that has been inspected by the vet			
12	I do not consume meat from dead animals increases			
13	I do wear protective gear when handling meat.			
14	I thoroughly inspect animals from the market for signs of diseases before I purchase			
15	I use traditional herbs to prevent disease spread.			
16	I only purchase animals after it has been cleared to be fit and disease free by the veterinary officers			
17	I do not slaughter sick animals for sale			
18	I do not immediately mix animals from the farm with those already at home			
Code: 1= Strongly disagree 2= Disagree 3= not sure 4= Agree 5= Strongly agree				

Section 4

Socio-economic characteristics

Livelihoods and other income generating activities		
No	Income source	Approximate amount in the last 1 year
1.	Crop farming	
2.	Livestock farming	
3.	Poultry enterprise	
4.	Salaried employment	
5.	Self-employment-off farm	
6.	Casual labor	
7.	Boda boda	
8.	Remittances	
9.	Property rent	
10.	Other(specify)	

Key Informant Checklist for use with RVF specialists

Introduction

I am Marsy Asindu, a research fellow affiliated with the International Livestock Research Institute (ILRI). ILRI is an international research organization that focusses on livestock research and development. We are carrying out a study to determine the social and economic impact of Rift Valley Fever control options on farm productivity, farmer welfare, food and nutrition security in pastoral and Agro-pastoral livestock production systems of Uganda. Information from this study will inform our project's interventions and activities that are aimed to strengthen the capacity of government of Uganda and other stakeholders in the livestock sector to better manage Rift Valley Fever disease. The project is funded by BMZ under the program titled BUILDUganda. As a preliminary phase to the study, we intend to rank different on-farm RVF risk exposure mitigation practices (Biosecurity Practices) based on level of importance and ability to avert RVF infections and rapid spread on farms. I would therefore like to invite you to participate in the study in the form of an interview. Kindly note that your participation in this study is entirely voluntary and there will be no remuneration or direct benefits to be awarded. However, it is our hope that the knowledge gained from your participation in this research will benefit the livestock value chain by informing us on how to better design interventions that enhance protection against the widespread impacts of RVF disease infections on livestock farms.

Qn. 1. On a scale of 1 – 3 (1= Less Important, 2= Medium Importance, 3 = High Importance), Kindly rank each of the different on-farm RVF risk exposure mitigation practices presented in Table 1 below. (Note: management practices with the highest capability to minimize RVF risk exposure carries a score of 3 and those with the least impact carry a score of 1).

Table 1: Rank the following on-farm RVF risk exposure mitigation Practices on a scale of 1 – 3.

Item No	Risk exposure management practice	Economic score (1 – 3)
	Restraint and movement restriction	
1	Isolation of sick animals	
2	Isolation of newly acquired animals	
3	Isolation of leftover stock from the market	
4	Herd movement restriction	
5	Quarantine	
6	No selling animals during outbreaks	
	Vector control	
7	Spray mosquitoes	
	Regular farm husbandry	
8	Disinfection of feeding and watering utensils	
9	No immediate mixing of market stock with home animals	
10	Non mixing livestock from communal grazing sites	
11	Helping animal delivery with protective gear	
12	Burn and burry carcass from dead animals	
13	Isolate recently aborted animals	
14	Slaughter animals away from homestead	
	Food safety	
15	Consume only pasteurized milk	
16	Consume only thoroughly cooked meat	
17	Does not consume meat from dead animals	
18	Handle meat with protective equipment	

Thank you very much for your time.

An investigation of factors that hinder and/or facilitate uptake of various Rift Valley Fever control options in pastoral and agro-pastoral communities of Uganda.

FGD guide for engagement with cattle farmers

Community name: _____

District: _____

Date: (DD/MM/YYYY) ____ / ____ / ____

Name of Facilitators: _____, _____

Group name/description: _____

Number of participants: _____

Rift Valley Fever disease awareness, control, and prevention dynamics

The activities under this section will be done with sex disaggregated focus group discussions in Sembabule, Isingiro, Napak and Butebo in two sub counties per district.

Objectives

The objective is to understand beef cattle production, link to livelihoods sources for men and women in the targeted communities, common animal diseases, preventive and curative control measures specific to RVF and constraint and solutions to uptake of the suggested RVF control and prevention measure.

Methodology

Consent will be sought before the livestock farmers are interviewed. The farmers will be separated in women and men's groups, each group constituting 6-8 participants. Each group will be asked the same questions and then they will be brought back in a plenary to discuss and agree on some of the key issues.

SN	Guiding Question (Facilitator)	Process (Facilitator)	Output
A	Livestock production and Community Livelihoods		
1a	(i) What kind of cattle breeds do you rear in this community? (ii) What is the proportion of each breed? (iii) How does this proportion differ among men and women farmers?	In separate groups, List the breeds in the area and indicate proportions using 100 counters. Moderator produces a list of the available cattle breeds in the area on a flip chart and asks Participants to rank the breeds from the most resistant to the least resistant noting down reasons for their ranking.	Recorder draws a chart with the different cattle breeds reared their respective proportions allocated. List of cattle breeds kept in the area ranked based on level of resistance and tolerance to disease and the reasons behind the ranking.

1b.	<p>(iv) How do men/women acquire these breeds?</p> <p>(i) Among the breeds mentioned, which breeds are the most affected by disease and which are least affected? (rank them in order of disease resistance.</p>		
1c.	(i) Based on community perceptions, how would you categorize farmers into small, medium, and/or large scale)	Moderator initiates a discussion and notes down the key characteristics the community uses for categorizing of cattle farmers and probes for proportion of men and women under each category and elicit reasons behind the proportions.	A table with cattle farmers categorized into small, medium, and large together with proportions of men and women under each category.
1d. 1e.	<p>(i) What benefits do men and women in this community derive from cattle rearing?</p> <p>(i) In case of disease outbreak, which benefit streams are mostly affected? How are they affected?</p>	<p>In separate groups for men and women participants give a list of the main benefit stream realised from cattle in their community. These benefits should be listed and ranked separate for men and women in the community. Ranking should be in descending order from most important to the least and reasons provided for each ranking. For locations where draught power is mentioned moderator should probe for proportion of community members using cattle for draught power, average work hours per day, charge per work hour? and frequency of use in a typical month or year.</p> <p>For each benefit, participants indicate how they are affected by disease outbreak.</p>	<p>A table drawn on a flip chart showing benefits derived from cattle rearing separate for male and females. And a clear illustration of how each benefit stream is affected by disease outbreaks.</p> <p>Well drawn representation of proportion of community members/households relying on animal draught power and usage patterns.</p>
1f.	(i) Where are the cattle grazing and watering points located within this community? (identify available/unused resources, locations, frequency of use, who uses, and constraints faced).	In separate groups men and women, participants draw a map of their community on the flip chart beginning with a central feature, moderator allows each participant to mention what should be on the map and writes it on a different coloured card e.g. (watering points, grazing areas, crop fields, forested areas, game reserves and valley dams). Probes include	Resource use maps for men and women drawn and comparisons made.

1g.	<p>(i) What is type of grazing system is common in this community?</p> <p>(ii) How does this vary for men and women cattle farmers?</p>	<p>frequently used watering points/grazing areas, the reasons for this and what happens when droughts happen. In a plenary the two groups identify similarities and differences in the maps.</p> <p>Moderator notes down the major cattle production systems in the area, probes for those affected by seasonal changes (droughts, floods etc.) and who is affected most.</p>	<p>Cattle production systems in the area identified and documented together with impact of seasonal changes.</p>
B	Knowledge of livestock diseases with focus on zoonosis in the community		
2a.	<p>(i) What are some of the common cattle diseases in this area?</p> <p>(ii) Which time of the year do they occur and how do you recognize these diseases within your area?</p>	<p>Moderator draws a table on the flip chart, lists down all the diseases mentioned by the participants (by their local names). For each disease, signs and symptoms are provided by the participants and the Vet personnel present with the team is asked to provide the actual veterinary/scientific name of the disease. The participants then proceed to indicate on the chart months of the year in which each disease commonly occurs and offer reasons for outbreaks during those selected months.</p>	<p>Flip chart containing table clearly highlighting common cattle diseases in the area, period of occurrence, way of disease recognition and list of vaccinated diseases in the area.</p>
2b.	<p>(i) Among the diseases you have listed, which are spread from animals to humans?</p> <p>(ii) How do animals and humans get such diseases in this area?</p> <p>(iii) Who is most at risk in the household? Why?</p>	<p>In this next step, the moderator asks the participants if they are aware that some of the diseases, they mentioned earlier are zoonosis. They are then requested to identify them from the list of diseases that they have already generated. For each potential zoonotic disease, they have identified from the list, they are requested to provide causes and risk behaviors responsible for its spread.</p> <p>Vet personnel within the team chips in to explain to the participants what zoonosis are and takes them through the list of potential zoonotic diseases that they have already provided. The participants then refine and add to the list based on the explanation provided by the vet personnel.</p> <p>If RVF is not mentioned among the zoonotic diseases in the refined and final list, the moderator probes by asking if the participants have ever heard of RVF in their community? If</p>	<p>Table with list of zoonotic diseases, there causes and means of spread from one subject to another.</p>

		yes, probe for proportion of people in the community who are aware of the disease? Ask participants to identify signs and symptoms of the disease and how is it transmitted? Lastly find out from participants when the disease commonly occurs in the area? If no one is aware, the vet personnel describe the disease to the participants including cause, spread mechanism, signs and symptoms and effects.	
2c.	<p>(i) Where and from whom did you first hear about RVF?</p> <p>(ii) In your opinion, how do animals and humans get the RVF?</p> <p>(iii) Who in the community do you think is/will be more exposed to the RVF disease?</p>	Moderator lists all answers on a flip chart and explores beliefs, practices, norms, and cultural sentiments in the area that can lead to transmission of the disease to animals and humans. Probe for who in the community is more exposed to RVF and why.	List of sources of RVF information and full notes on RVF disease transmission in animals and humans.
C	Animal health and disease management procedures		
3a.	<p>(i) How do people in this community protect themselves and their animals from zoonotic diseases like RVF?</p> <p>(ii) What do women do?</p> <p>(iii) what do men do?</p>	Moderator generates a table with two columns (One for men and the other for women) notes down all responses from the participants against the column for each gender.	Sex aggregated List of possible zoonosis/RVF disease prevention activities in the community
3b.	(i) What are the most common vectors that transmit diseases to humans and animals in this community? (Probe for mosquitoes, ticks, tsetse fly etc.)	Moderator takes notes on implementation of vector control practices, reasons for the vector control, challenges involved and suggestions for better implementation of the activities.	Table with RVF disease prevention activities/procedures with pros and cons for each activity mentioned and suggestions for better implementation.
3c.	(i) How do people in this community manage these vectors?		

	<p>(ii) What activities are done by men or women in managing the vectors identified?</p> <p>(iii) What challenges are involved in vector control within this area?</p> <p>(iv) what needs to be done for smooth implementation of vector control activities in the area.</p> <p>(v) If not done in the area, ask for reasons why it is not done?</p>		
3d.	(i) Are there any disease surveillance programmes going on in this community?	Probe which disease is being monitored, who does it and why? How is it done? Then follow up on constraint and way forward for better implementation of surveillance programmes in the near future.	List of diseases being monitored, challenges associated with surveillance and way forward for better surveillance
3e.	<p>(ii) Do you experience quarantine at times in this community? If yes, probe reason behind the quarantine,</p> <p>(ii) who implemented it quarantine?</p> <p>(iii) What are some of the challenges that were associated with the quarantine</p> <p>(iv) How best should quarantines be implemented in the future.</p>	Moderator explains to the community what quarantine is and then consults from them if they would accept implementation of quarantine as a disease control procedure in their community. Moderator follows up on potential challenges and way forward for better implementation of quarantine in the future.	Detailed documentation on community acceptance of quarantine as a zoonotic disease control option.
3f.	(i) In case trade ban was to be introduced as a way of preventing spread of diseases from animals to humans in this area, how would your community react to this action.	Moderator describes what trade ban in livestock and related product means (people in a particular area are stopped from selling live animals and its related products in markets due to disease outbreak) and then asks communities about their opinion towards use of trade ban as a disease prevention measure. Further probe is done to identify possible	

	<p>(ii) Who will be most affected in this community?</p> <p>(iii) What challenges do you envision from implementation of such a trade ban?</p> <p>(iv) What solution would you recommend for better implementation of the trade ban?</p>	shortfalls of implementing a trade ban and solutions for better implementation.	
3g.	<p>(i) In case RVF has been confirmed in humans and animals in your area, what kind of action would you expect from the central government or MAAIF/MOH?</p> <p>(ii) What actions would you expect from the sub-county and your local council authorities?</p> <p>(iii) What actions would you undertake as an individual or do you expect at individual farm level?</p>	Moderator creates a table with three rows and three columns. In the three rows, he/she notes down the three expected levels of action i.e., central government level, local government, and individual/farm level. In the first column in front of each row, they note down all expected activities at the different levels. In the second column, they indicate challenges they anticipate with each of the proposed activity at each level and offer ways for better implementation.	List of RVF management activities, challenges, and solutions for better implementation at three operational levels of central government, local government, and farm level.
3h.	(i) What do you think people in your community should do to prevent possible outbreak and spread of RVF disease?	Moderator lists down all the suggested preventive measures on a flip chart then proceeds to ask the participants to allocate responsibilities for action to people within their community and offer reasons for their respective task allocation. Point out potential constraints that is likely to be associated with each preventive option listed and suggest a solution for better implementation of the activity.	Full list of RVF disease prevention measures with detailed action plan of who to execute each task in the community and reasons for the task allocation. Constraints associated with each RVF prevention measure and suggestions for better implementation
3i.	(i) Have cattle in this community been vaccinated in the past? If yes, what diseases have been	Moderator notes down separately believes and perception of men and women on use of vaccines for disease prevention in the area.	Detailed note on men and women perception towards use of vaccines for disease prevention.

	<p>vaccinated against? What experiences did you encounter during those vaccination programmes?</p> <p>(ii) What myths and thoughts do people in this community hold about vaccine use for prevention of animal diseases?</p> <p>(iii) How are livestock vaccination programmes organized and coordinated in this place?</p> <p>(iv) What challenges do you face? what can be done to address these challenges and ensure effective vaccination?</p> <p>(v) Suppose there is going to be a vaccine available for RVF, what attributes would you want to see in that vaccine before you accept it for use in your herd.</p>	<p>Facilitated discussion with separate groups of men and women. Moderator asks participants to list down diseases for which vaccination has been conducted within the area in the recent past, they then proceed to identify the source of the vaccines and indicate how they accessed it. The moderator then probes for average cost of vaccination for each head of cattle, estimated proportion of animals vaccinated in the area using 100 counters, and proportion of vaccinated animals that fall sick even after vaccination). Participants list all the challenges associated with vaccination and rank from the most to least important in the area, for each challenge mentioned, ask participants to propose a solution.</p> <p>Moderator guides participants to mention all the qualities and desired specifications that they would expect of any vaccine to be used against RVF on their farm. (probe for price of the vaccine, willingness to pay for the vaccine, cost sharing arrangements, likely effects on animals, accessibility etc)</p>	<p>Record of all listed common vaccinated diseases in the area, available vaccines in the area and the disease vaccinated against.</p> <p>Proportion of vaccinated animals in the area and proportion of vaccinated animals that fall sick after vaccination.</p> <p>Challenges associated with vaccination in the community and solutions to challenges related to cattle vaccination in the area.</p> <p>List of attributes expected of a good vaccine against RVF.</p>
D	Communication strategy for RVF disease management		
	<p>(i) What are some of the main sources of information available for your community on prevention and treatment of zoonosis such as RVF?</p> <p>(ii) What type of information does</p>	<p>Moderator lists down available sources of RVF prevention and treatment to the community and the type of information obtained from each source. Request the participants to identify among the different sources which are more available to men or women and offer reasons behind their answers. Probe for challenges associated with each source and guides participants to suggest plausible solutions to constraints mentioned.</p>	<p>Record of Information sources available to men and women for control and prevention of zoonosis (RVF), Challenges associated with each source and solutions to address each challenge</p>

	<p>your community get about RVF disease from these sources?</p> <p>(iii) Who mostly receives this information?</p> <p>(iv) Who is likely to miss out or struggles to access this information? why?</p> <p>(v) What could be done to improve information access?</p>		
	<p>(vi) What do you think is the best way of sharing information on RVF disease and management in your community? (Identify separately for women and men)</p>	<p>Moderator notes down suggestions from the participants and goes on to explore on the most appropriate language to be used for information dissemination in the area, identify channels for information sharing, channels trusted/not trusted and reasons behind? How regularly the information should be shared?</p>	<p>Well documented bullets for best ways of information sharing on RVF disease.</p>
E	Concluding remarks		
	<p>(i) If you had a question or wanted to inquire something about RVF disease, where would people in this community go? how best do you handle this?</p> <p>(ii) What challenge do you foresee with each approach mentioned and how can this be averted?</p>	<p>Moderator notes down discussions from the participants. Picks out possible constraints to each approach selected and solutions to mitigate the mentioned constraints. (Special attention be paid to where women can go and where men opt to go).</p>	
	Closure	<p>Moderator runs a quick recap of the entire process and asks the participants If there is anything else, they would like to discuss that was not accommodated in the discussions?</p>	<p>Remarks and any additional insights from the FGD participants</p>

Appendix B: Curriculum vitae

Marsy Asindu
Steenbeker Weg 4
24106 Kiel, Germany
Mobile: +491630057786/+256775193913
Email: asimessy@gmail.com

Personal information

Name: Marsy Asindu
Date of Birth: 30th October 1988
Sex: Male
Place of birth: Arua, Uganda
Nationality: Ugandan (Resident of East Africa)

Educational background

2021 – 2024: PhD candidate (Agricultural and Food Economics)
University of Kiel, Germany

2018 – 2020: Post graduate Diploma in Monitoring and Evaluation
Uganda Management Institute (UMI), Kampala – Uganda

2014 – 2019: Master of Agribusiness Management (MABM)
Makerere University, Kampala – Uganda

2008 – 2011: Bachelor of Vocational Studies in Agriculture with Education (B. Voc. Agric)
Kyambogo University, Kampala – Uganda

Work experience

Jan 2020 to date: Graduate Research Fellow, International livestock Research Institute (ILRI)
Key functions:

- Conduct ex-ante impact assessment on food security and nutrition and poverty implications of zoonotic diseases across the livestock value chain.
- Design protocols for systems modelling and assessing the impact of multiple RVF disease management policy options across the livestock value chain in Uganda.
- Contribute to development of data collection tools and the development of manuscripts for publication in scientific journals.
- Scaling out successful innovations for adoption and use by livestock farmers to enhance productivity and livelihoods.

Feb 2018 to Jan 2020: M&E consultant, Alliance of Bioversity International and CIAT
Key functions:

- Participate in development of projects with potential to sustainably transform food systems and improve people's lives under climate crisis.

- Conduct ex-ante and ex-post impact assessment studies.
- Design and implement social experiments.
- Conduct FGDs and KII with key stakeholders
- Develop of project Monitoring Learning and Evaluation (MLE) systems.
- Contribute to development of data collection tools and digitization in CAPI using ODK, and survey CTO.
- Develop protocols for scaling scientific innovations within the crop value chain.
- Participate in drafting blog and infographic materials.

April 2017 to Feb 2018: Project Assistant Food security and Livelihoods, Norwegian Refugee Council (NRC)

Key functions:

- Pilot mini-irrigation and permaculture schemes to ensure Refugee communities undertake agricultural activities in an environmentally friendly manner.
- Mobilize and sensitize communities on climate smart agricultural food production, cash transfer programing, Micro small-scale business establishment, Protection and Nutrition etc.
- Participate in the selection and Recruitment of project beneficiaries.
- Regularly collect M&E data and document impact stories.
- Ensure Weekly, monthly, quarterly, and Annual documentation of project reports.
- Represent NRC in coordination meetings with other Key stakeholders including OPM, UNHCR, and WFP

May 2015 to Dec 2016: Research Fellow, International Potato Center (CIP)

Key functions:

- Develop business models for marketing of climate smart livestock feeds and foster youth employment within the sweetpotato value chain.
- Collect baseline and end line survey data for project monitoring and evaluation.
- Conduct market research for Eco-friendly livestock fodder (supplemented sweet-potato silage) among livestock farming communities.
- Conduct FGDs and Key Informant interviews with actors and key stakeholders along the sweetpotato and smallholder pig value chain.
- Contribute to writing of biannual project reports on improving the utilization of Root-Tuber crops in Uganda.
- Quantifying post-harvest losses across the sweetpotato value chain and designing post-harvest lost handling mechanisms

Jan 2012 to June 2014: Agricultural Advisory Service Provider (Livestock), NAADs/NUSAFII

Key functions:

- Organize herd-health training programs for livestock farmers.
- Participate in livestock disease surveillance programs.
- Set out programs for vector control (tsetse flies)
- Schedule and participate in cattle vaccination and spraying activities.
- Routine monitoring and evaluation of project performances and documenting success stories.

- Selection and verification of potential beneficiaries (market-oriented farmers).
- Formation of higher-level livestock farmer producer associations.
- Identification and appraisal of livestock related livelihood projects.

Publications

- Asindu M, Ouma E, Elepu G and Naziri D (2020). Farmer Demand and Willingness-To-Pay for Sweet Potato Silage-Based Diet as Pig Feed in Uganda. Sustainability 12(16), 6452; <https://doi.org/10.3390/su12166452>
- Asindu M, Elepu G, Ouma E, Kyalo G, Lule P and Naziri D 2017: Sweet potato wastes in major pig producing districts in Uganda: an opportunity for investment in silage technologies. Livestock Research for Rural Development. 29(11), 1- 6. Accessible via <http://www.lrrd.org/lrrd29/11/asim29216.html>

Competencies/special skills:

- Business plan and project proposal development
- Excellent with MS office (Word, Excel, Access (database) publisher, MS Project, and PowerPoint)
- Good data analytics using (SPSS, STATA, GIS, R, NVIVO, Python, STELLA, iTHINK and GAMS)

Languages spoken.

English	Very good
Swahili	Very good
French	Basic
Deutsch	Basic (A1)

Membership association

- Member of the European Association of Agricultural Economists
- Member of the African Association of Agricultural Economists
- Member of the Agricultural and Applied Economics Association
- The International Consortium on Applied Bioeconomy Research

Referees

Prof. Dr. Awudu Abdulai
 Chair of Food Economics and Food Policy
 Christian Albrechts Universitat zu Kiel (CAU)
 Tel: +49431-8804426
 Email address: aabdula@food-econ.uni-kiel.de

Dr. Emily Ouma (PhD)
 Senior Scientist (Agricultural Economist)
 International Livestock Research Institute (ILRI)
 Tel: 0781573978
 Email address: E.Ouma@cgiar.org