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Participatory survey of risk factors and pathways for Rift Valley fever in pastoral and agropastoral communities of Uganda

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ABSTRACT

To assess pastoralists' and agropastoralists' knowledge on Rift Valley fever (RVF), participatory epidemiological studies were conducted with 215 livestock keepers and 27 key informants in Napak, Butebo, Isingiro and Lyantonde districts, Uganda, between January and February 2022. Livestock keepers in all four districts had knowledge of RVF and even had local names or descriptions for it. Pastoralists and agropastoralists possessed valuable knowledge of RVF clinical descriptions and epidemiological risk factors such as the presence of infected mosquitoes, living in flood-prone areas, and excessive rainfall. RVF was ranked among the top ten most important cattle diseases. Pastoralists called RVF *Lonyang*, symbolizing a disease associated with jaundice, high fever, abortions in pregnant cows, and sudden death in calves. Key informants identified infected domestic animals, the presence of infected mosquitoes, livestock movement and trade, and infected wild animals as risk pathways for the introduction of RVF into an area. Drinking raw blood and milk was perceived as the most likely pathway for human exposure to RVF virus; while the highest consequence was high treatment costs. The results indicate that pastoralists provided key epidemiological information that could be essential for designing an effective national RVF surveillance and early warning system.

1. Introduction

Rift Valley fever (RVF) is a mosquito-borne viral zoonosis caused by Rift Valley fever virus (RVFV) that primarily affects domestic ruminants and humans (Adams et al., 2017; Bird et al., 2009; Chevalier et al., 2010). Bites of mosquitoes of the *Aedes* and *Culex* genera transmit the disease among animals and between animals and humans (Pepin et al., 2010a). Transmission of RVFV between ruminants may occur (Nicholas et al., 2014), but no human-to-human transmission has been reported (Chevalier, 2013). RVFV is associated with sporadic outbreaks of disease characterized by a sudden onset of abortion and neonatal mortality in sheep, goats, cattle, and camels (Paweska, 2015). In humans, RVFV transmission follows direct mosquito transmission or mainly by percutaneous or aerosol routes during the handling of aborted foetal materials or the slaughtering of infected livestock or possibly from the ingestion of raw milk (Archer et al., 2013; Bird et al., 2009; Kenawy et al., 2018; Nyakarahuka et al., 2018). In humans, RVF varies from a mild influenza-like syndrome (> 80 per cent) to severe symptoms such as renal failure, encephalitis, vision problems, haemorrhages, and death (Madani et al., 2003; Njenga et al., 2009).

Since its first identification in 1930 in Kenya (Daubney et al., 1931), RVF outbreaks have been reported throughout the African continent with subsequent epidemic deaths in humans and losses of livestock (Gerdes, 2004; Little, 2009; Nanyingi et al., 2015). Between 2000 and 2001, the first confirmed cases of RVF outside of Africa occurred in Saudi Arabia, exemplifying the potential for RVFV spread to other

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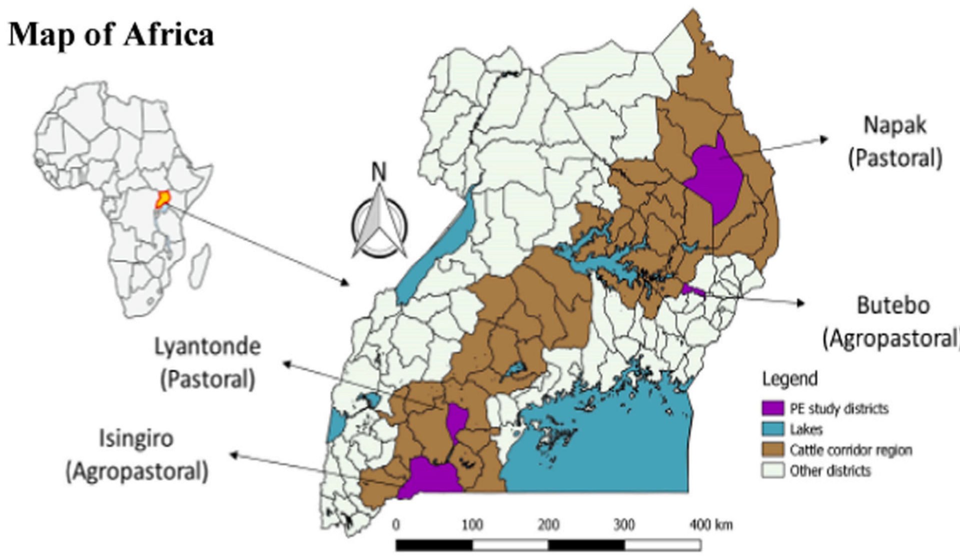

Fig. 1. Study area. Map of Uganda showing location of Butebo, Lyantonde, Isingiro and Napak districts. The map was constructed for this publication in QGIS version 2.18.15.

regions of the world (Madani et al., 2003). Uganda reported an outbreak of RVF in 2016 in Kabale district (Shoemaker et al., 2019), during which only 36% farmers were reported to possess knowledge on RVF symptoms (De St. Maurice et al., 2018). This was the first outbreak in Uganda since 1968 when human cases were recorded in the central region (Shoemaker et al., 2019). Between August 2017 and August 2018, Uganda experienced multiple outbreaks of RVF, mostly in the southwestern and central regions (Mbonye and Sekamatte, 2018). In Uganda, RVF control measures have mainly revolved around limited surveillance and preparing situational reports with diminutive inclusion of local community knowledge on predisposing risk factors and disease identification. Some pastoral and agropastoral communities in Uganda live in remote sparsely populated marginal parts of the country that are underserved with veterinary services despite their reliance on livestock as a source of livelihood (Abebe, 2016; Nantima, 2015). In such areas, implementing conventional veterinary research, disease surveillance, and epidemiological information sharing is a challenge since pastoralists and agropastoralists often live in transboundary ecosystems and regularly cross national borders to access grazing areas (Alhaji et al., 2018; Byaruhanga et al., 2015).

The definition of participatory epidemiology (PE) has lately been modified as “the systematic use of approaches and methods that facilitate the empowerment of people to identify and solve their health needs” (Allepuz et al., 2017). Earlier, PE has been defined as “the systematic use of participatory approaches and methods to improve the understanding of diseases and options for animal disease control” (Catley et al., 2012). Pastoralists possess a well-built knowledge of livestock health, diseases and treatment to support their livestock dependent lifestyle (Bach et al., 2017). We hypothesize that understanding local community knowledge on RVF risk factors in Uganda could improve the design of the national RVF surveillance system. Epidemiologists are increasingly using PE methods to improve the understanding of RVF occurrence, for example in Kenya (Owange et al., 2014) and Nigeria (Alhaji et al., 2018). The approach utilizes groups of people within which different members suggest ideas that are collectively discussed and refined until the group reaches a consensus (Catley et al., 2002a). The validity of the findings is improved by triangulation of information collected using different methods and sources such as literature and biological sampling (Catley et al., 2012). Previous studies recommended the use of PE techniques for critical disease surveillance, reporting and control strategies of livestock diseases (Alhaji et al., 2018; Jost et al., 2010; Owange et al., 2014), and in human health research to enrich epidemiologic methods and facilitate implementing the right actions (Bach et al., 2017). This study aimed to assess community knowledge on RVF identification and risk factors for its occurrence in pastoral and agropastoral areas in Uganda by learning from local ethnoveterinary knowledge.

2. Materials and methods

2.1. Study area

The FGDs took place in 16 parishes in four districts, namely, Isingiro (Masha and Kashumba subcounties), Lyantonde (Lyantonde and Kasagama subcounties), Butebo (Butebo and Kanginima subcounties) and Napak (Iriri and Matany subcounties) located in the cattle corridor stretching from southwestern to north-eastern part of Uganda representing different agro-ecological zones (Fig. 1). The cattle corridor has most of Uganda’s cattle, goats and sheep population (about 60% of the domestic ruminant population) (Miller et al., 2015). The area receives bimodal rainfall with the first rainy season extending from February to May and the second season extending from September to November (NEPAD-CAADP, 2012). However, recently the corridor experiences both prolonged droughts and floods due to shifting rainfall patterns (Nimusiima et al., 2013). The study area was chosen because of having reported past RVF outbreaks, widespread anti-RVF IgG seropositivity in livestock (Tumusiime et al., 2023), a large livestock population (Uganda Bureau of Statistics, 2014), and availability of *dambos*, seasonally flooded wetlands, that favour mosquito breeding. Whereas Isingiro and Lyantonde were selected due to the historic occurrence of outbreaks of RVF between 2017 and 2019, Butebo and Napak had not reported outbreaks despite serological studies indicating anti-RVF IgG seropositivity in livestock. All four districts are prone to flooding in times of heavy persistent rainfall.

2.2. Study design and social stratification of target population

The studies consisted of focus group discussions (FGD) with livestock keepers, for which parishes were the unit of analysis; and key informant interviews with veterinary and public health practitioners. Two parishes were randomly selected per subcounty and the FGD participants were purposively selected. The FGD participants in Napak and Lyantonde rely primarily on rearing of livestock supplemented with limited crop cultivation (pastoralists), while those in Isingiro and Butebo depend on both livestock and crop cultivation for their livelihoods (agropastoralists).

2.3. Data collection

Discussions with the participants were conducted in local languages (Lugwere in Butebo; Ngakarimojong in Napak; Runyankore in both Lyantonde and Isingiro). The study team comprised a team leader who interviewed and moderated most of the discussions, the Principal Investigator, a note-taker, and a local mobilizer. Quality assurance was enhanced by training of the study team on PE techniques, informal interviewing skills, in-class rehearsal and pre-test of selected PE techniques (Catley et al., 2002b). All participants consented to participate in the study and were active during the study. A pre-test for the interview checklist and the selected PE tools was conducted in one non-study location in Butebo district, which was not incorporated in the final study. One or two FGDs per day were conducted normally in the afternoon, with discussions averaging two hours. During the FGDs, selected participatory tools (semi-structured interviews, proportional piling, matrix scoring, disease calendar and Key Informant interviews), previously described (Catley et al., 2002; Mariner and Roeder, 2003; Catley et al., 2012), were used to collect data between January 2022 and February 2022.

2.4. Semi-structured interviews

Semi-structured interviews (SSI) guided by a checklist of open-ended questions were used to collect qualitative data on the livestock owners, important species of livestock kept, descriptions of clinical and epidemiological manifestations of major cattle diseases encountered and experience of diseases that are transmissible from livestock to people.

2.5. Proportional piling

This PE tool was used to rank the relative importance of each disease in a community; and the perceived risk factors that influence RVF occurrence. Participants described syndromes and/or local names. First, participants were asked to list all cattle diseases that they had observed in the past year. Probing was done if participants mentioned syndromes rather than a disease name. After participants exhausted the list of diseases, ten circles were drawn on a flipchart placed on the ground, using a permanent marker, with each circle representing a disease. A total of 100 stones was provided to the participants who were asked to pile them in the circles based on the proportional relative burden they perceived of each disease in terms of monetary loss, milk loss, draught power loss and mortality. Ranking of perceived risk factors for RVF occurrence in cattle was done once RVF was mentioned during the semi-structured interviews. Participants were asked to list ten most important perceived predisposing risk factors. Following consensus among participants, the study team drew ten circles on flipcharts with each representing a mentioned risk factor. Participants were given 100 stones and asked to pile them in proportion to the perceived impact of each factor on RVF occurrence in cattle. The study team then counted the stones in each circle to give a proportion that signified impact of the factors on RVF occurrence.

2.6. Matrix scoring for clinical presentation of cattle diseases

This tool was used to assess participants' knowledge on the clinical manifestations of RVF and other livestock diseases. In each district, the seven diseases top-ranked by proportional piling were scored against the clinical signs mentioned. The diseases were written along the top x-axis of the matrix and the indicators were written along the y-axis. The participants were given 10 stones to divide among the diseases, the stones representing the strength of association with the indicator (clinical sign) being scored. The study team then counted and recorded the number of stones assigned to each box. Scoring was conducted for all indicators against each disease. To assess participants' knowledge of RVF, five other diseases that were consistently mentioned among the top seven by FGDs were considered during the exercise.

2.7. Disease calendar

A seasonal calendar was created to determine linkages between major cattle diseases including RVF and seasons. The PE facilitator drew a horizontal line on a flip chart to represent one full year of 12 months. Participants were asked to mention the wet months and dry months of the year. The 12 months were then divided into 4 seasons as determined by participants, i.e., December-February (first dry season), March-May (first rainy season), June-August (second dry season), September-November (second rainy season). The variables were written along the Y-axis and included East Coast fever (ECF), Anaplasmosis, Lumpy Skin Disease (LSD), Foot-and-Mouth Disease (FMD), brucellosis and RVF. For each variable in turn, participants were asked to indicate the relative distribution between seasons using 10 stones as counters. Participants were asked to distribute stones depending on their perceived seasonality of abundance of a given variable until consensus was achieved. The PE facilitator used probing questions to understand the perceptions of participants based on variations in the distribution of disease incidence among seasons.

2.8. Key informant interviews for risk pathways analysis

The KII were conducted with purposively selected officials who included Veterinary Officers, Assistant Veterinary Officers, community-based animal health workers in Napak, and public health practitioners. Some of these had been involved in the management of past outbreaks. Three pathways for risk assessment (entry, exposure and consequence) were used by the key informants, which are comparable to entry, transmission, and spread of RVFV into herds and humans in the four districts. To rank the entry risk pathways of RVF into an area, four ranks were used (1: most important, 2: important, 3: less important, and 4: not important). Ranking pathways of human exposure to RVFV was done at three levels (1: high, 2: medium, and 3: low); while RVF outbreak consequences were ranked at four levels (1: high, 2: medium, 3: low and, 4: negligible). An arbitrary weight of 1–4, where 4 was given to the most important rank while 1 to the least important was used for weighting entry risk pathways and RVF virus outbreak consequences. The weights used were linear, increasing with one point at a time. The weighting of pathways of human exposure used arbitrary weights of 1–3, where 3 was assigned to the most important rank while 1 to the least. The scores of the ranked perceived risk pathways were then weighted and summaries generated.

2.9. Triangulation

Data attained from each participatory exercise in each community were cross-checked and further discussed among the FGD participants to reach consensus. The outcomes of the sixteen pastoral and agropastoral communities were also triangulated at the end of all the PE exercises by the appraisal team, analysed and median outcomes of perceived relative burden and seasonal trends of RVF and some important cattle diseases obtained. Local names of cattle diseases and their descriptions provided by the pastoralists were validated at the District Veterinary Offices and Subcounty Veterinary Offices for expert opinion. Data for the epidemiological predisposing factors from the sixteen communities was triangulated to obtain their median outcomes, which were further cross-checked with the District Veterinary Offices and Subcounty Veterinary Offices.

2.10. Data management and analysis

Semi-quantitative data generated from proportional piling, scoring and ranking exercises were recorded in notebooks by the note-takers, entered, stored and analysed in a Microsoft (MS) Excel® 7 database

Table 1
Description of cattle diseases.

S/no	Disease condition or clinical sign	Local name	Literal meaning	Major clinical signs
1	FMD	*Kalusu*^{L}; *Chigichigi*^{A}	'Salivation disease; Limping disease'	-Excessive salivation, wounds in the mouth and feet -Limping -Difficulty in eating
		Ejwa^{R}	'Gum bleeding, mouth wounds'	
		Ejaa^{N}	'Salivation, mouth wounds'	
2	ECF/Theileriosis	*Amashiyo*^{R}	'Swelling beneath ear'	-Enlargement of the parotid lymph nodes (initial stages) -Difficulty in mooing (later stages)
		Lokit^{N}	'Ear sickness'	
		Masiya^{L}	'Swelling of ear lymph nodes'	
3	Anaplasmosis	*Kashanku*^{R}	'Hard dry dung balls'	-Passing of hard dry dung -At slaughter, presence of hard dry digesta in the stomach, yellowish discoloured gums, eyes, and internal organs
		Lopid^{N}	Bile disease	
		Sansanyi^{L}	'Omasum with dry dung'	
4	Babesiosis	*Omuzito or Omusito*^{R}	'Projectile red urine likened to a straight stick used for roasting meat'.	-Passing of red urine.
		Lokulamu^{N}	'Urinary bladder disease'	
5	CBPP	Orukororo^{R}	'Cough'	-Painful, rapid breathing and cough -Fluid-filled lungs attached to the thoracic cavity (at slaughter) -Swollen joints in calves
		Loukoi^{N}	'Lung disease'	
		Chikoolo^{L}	'Cough'	
6	Trypanosomiasis	Kipumpuru^{R}	'Emaciation, weakness, poor haircoat'	-Emaciation -Weakness -Poor haircoat -Dosing in humans
		Okuyonda^{L}	'Emaciation'	
		Muwongota^{L}	'Dosing sickness in humans'	
		Ediit^{N}	'Tsetse fly disease'	
7	Heartwater	Lokou^{N}	'Head disease'	-Animals move in circles -Exaggerated blinking and lip movements
		Okwetoloola^{L}	'Circling movement'	
		Okwetoroora^{R}	'Circling movement'	
8	Black quarter	Kwata^{L} or Pwata^{L}	'Thigh disease'	-Crepitation swelling over heavy muscles especially the hip, shoulder or back -Lameness of affected limb -High mortality.
		Ekicumet^{N}	'Speared or pierced thigh'	
9	Brucellosis	Obutoroogye^{R}	'Abortion disease'	-Fever in humans -Abortions in cattle in the third trimester.
		Oburwaire bwenyama^{L}	'Meat disease'	
		Lokithecan^{N}	'Abortion disease'	
10	Photodermatitis	Ebiharata^{R}	'Skin patches'	-Ulcerations, blisters and necrosis on the animal skin -Animal moves away from sunlight.
		Locheke^{N}	'Skin ulcers'	
11	Mange	Emitina^{N}		-Itchy spots punctuated by hairless areas around the body parts of cattle
		Olukuku^{L}	'Itchy hairless patches on the body'	
12	Mastitis	Ibani^{L}	'Swollen udder'	-Cows have a swollen udder that is painful to touch
		Efumbi^{R}	'Inflamed painful udder'	
13	LSD	Lonaru^{N} or Loir^{N}	'Swellings on the skin'	-Inflammation of the skin with the cause coming from the inside
		Ekifuruuto^{R}	'Skin inflammation'	
		Kawali^{L} or Obweidiba^{L}	'Measles in humans, disease of the skin'	
14	Three-day sickness	Kagarura^{R}	'Limb stiffness'	-Stiff limbs
15	Rift Valley fever	Lonyang^{N}	'Yellowish discoloured meat'	-Jaundice -High fever -Diarrhoea -Sudden abortions in pregnant cows regardless of stage -Sudden death in calves

Note: Superscript letters *L, R, and N*, represent local names in Lugwere (Butebo), Runyankore (Isingiro and Lyantonde), and Ngakarimojong (Napak) respectively. Superscript *A* represents Ateso language for the word *Chigichigi*, which was also common among Lugwere speakers to refer to FMD. Participants in Lyantonde knew both Runyankore and Luganda but preferred to use the former. FMD: Foot and Mouth Disease; ECF: East Coast Fever; CBPP: Contagious Bovine Pleuropneumonia; LSD: Lumpy Skin Disease.

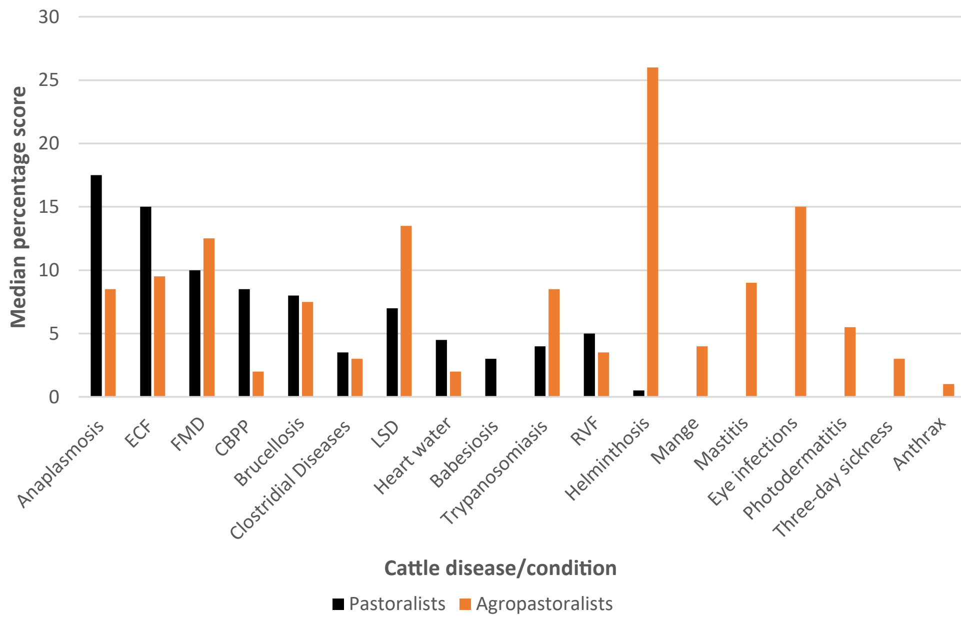

Fig. 2. Median proportional piles of relative burden of RVF and some cattle diseases in pastoral and agropastoral communities of Uganda.

(Microsoft Corp., Redmond, WA, USA). Descriptive statistics were used to describe the relative burden of RVF and other cattle diseases and the disease seasonal calendar. The Kendall's coefficient of concordance (W), a non-parametric statistic, was used to assess agreement between informant groups. This test measures the association between sets of ranks assigned to objects by judges (or in this article, clusters of judges) and computes a W value between 0 and 1. The higher the value, the higher the level of agreement between the judges suggesting the use of a similar standard in ranking. The test was used for determining inter-judge reliability (Siegel and Slegel, 2012). Kendall W Pgm.php software program (www.StatsToDo.com) was used to assess agreement among the informant groups at a 95% confidence level. The software program automatically transforms ordinal scores from each observer into cardinal ranks (Egendre, 2005). The data were presented in a matrix, in which rows represented subjects and columns represented judges or rankers (focus groups or KIs). Kendall's coefficient of concordance W was interpreted as “Slight agreement” ($0.00 <= w < 0.20$); “Fair agreement” ($0.20 <= w < 0.40$); “Moderate agreement” ($0.40 <= w < 0.60$); “Substantial agreement” ($0.60 <= w < 0.80$) or “Almost perfect agreement” ($w >= 0.80$) (Landis and Koch, 1977). A value of $P < 0.05$ indicates the statistical significance of the agreement.

3. Results

A total of 215 livestock keepers participated in the FGDs and 27 key informants were consulted.

4. Demographics of the focus groups

While nearly all FGD participants in Napak were unable to read and write, about 50% of the informants were literate in the rest of the study areas. Cattle, goats, and sheep were the most important livestock species, respectively, kept by participants.

5. Description of cattle diseases

Semi-structured interviews revealed that the informants demonstrated good knowledge of clinical signs, post-mortem findings, and early warning events of cattle diseases. Such traditional knowledge is orally passed on from generation to generation. Cattle keepers can only describe clinical signs but not make an etiologic diagnosis and as such, participants named cattle diseases using verbatim connotations in the local language which correspond to specific disease(s) (Table 1).

Pastoralists of Napak district reported to have seen RVF when River Awoja burst its banks and flooded in 2007 in the neighbouring districts and in 2008 due to communal conflicts between pastoral groups involving livestock raiding and competition for water and pastures. To safeguard pastoralists and their livestock, the government of Uganda facilitated the convergence of different herds in select guarded locations, potentially exposing the animals to RVF. In Butebo, Lyantonde and Isingiro, participants likened RVF to an Ebola-like disease, referring to haemorrhaging symptoms such as vomiting, blood, bloody stool and gum bleeding in humans, and abortion in livestock.

Clinical presentations of mixed infections were described by the replication of concurrent clinical signs and/or post-mortem features of the particular diseases. Overall, the information collected from the informant groups and individuals regarding the discernment and knowledge of livestock diseases did not conflict in the four districts.

6. Zoonotic disease knowledge

Pastoralists and agropastoralists mentioned five zoonotic diseases in common: brucellosis, trypanosomiasis, anthrax, RVF, and bovine tuberculosis. Pastoralists mentioned three additional zoonoses: Crimean Congo Haemorrhagic Fever (CCHF), cysticercosis, and rabies, which agropastoralists groups did not.

7. Ranking of livestock diseases

7.1. Proportional piling for disease relative burden

Pastoralists and agropastoralists demonstrated a wealth of knowledge of RVF and other diseases affecting their cattle. While there was slight variation in the list of cattle diseases mentioned by participants in the 16 communities, RVF was mentioned in 12 of the communities studied. The median top five proportional piles of pastoralists' perceived burden of cattle diseases in terms of production and productivity were Anaplasmosis, ECF, FMD, Contagious Bovine Pleuropneumonia (CBPP), and brucellosis. The top five ranked diseases in agropastoral communities were helminthosis, eye infection, LSD, FMD, and ECF (Fig. 2 and S1 Table). RVF was ranked the seventh most important cattle disease by pastoralists with a relative burden of 5.0% while agropastoralists ranked

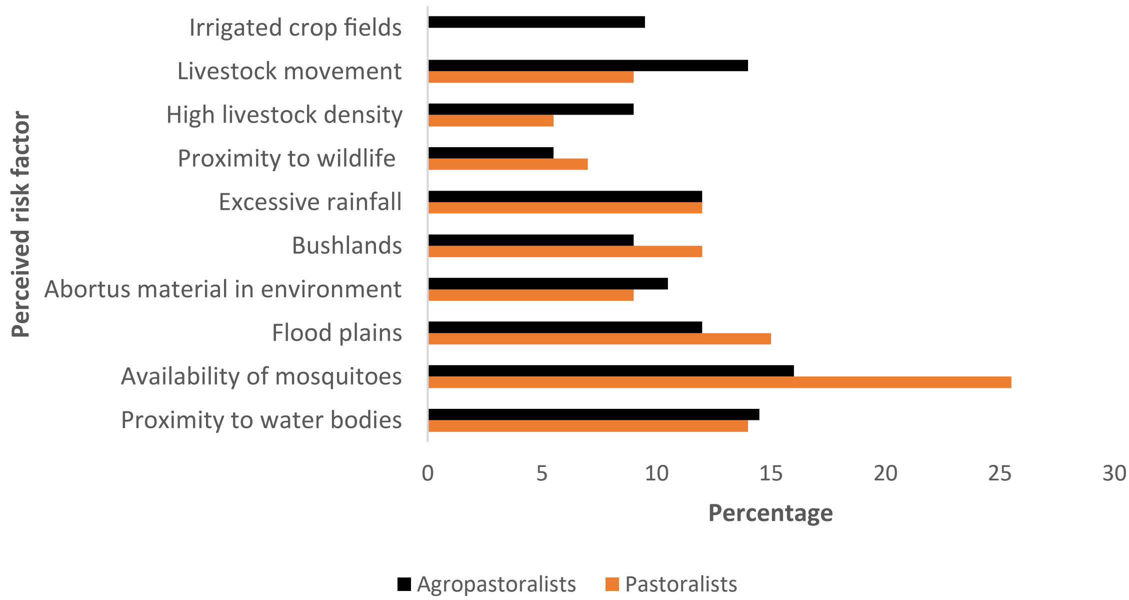

Fig. 3. Median proportional piles of perceived risk factors influencing Rift Valley fever occurrence in pastoral and agropastoral communities of Uganda.

Table 2
Summarised overall matrix scores of perceived clinical signs associated with Rift Valley fever and the five common important cattle diseases according to pastoralists' and agropastoralists' criteria in four selected districts, Uganda.

Clinical sign	Disease ECF (W = 0.2934 ***)	Anap. (W = 0.321 ***)	LSD (W = 0.291 ***)	FMD (W = 0.345 ***)	Bruce. (W = 0.663 ***)	RVF (W = 0.604 ***)
Coughing	2 (0, 10)	0 (0, 3)	0 (0, 2)	0 (0, 5)	0 (0, 0)	0 (0, 1)
Fever	1 (0, 3)	1 (0, 3)	1 (0, 3)	1 (0, 4)	1 (0, 1)	1 (0, 3)
Lethargy	0 (0, 3)	0 (0, 5)	0 (0, 2)	0 (0, 4)	0 (0, 1)	0 (0, 2)
Anorexia	2 (0, 3)	2 (0, 4)	1 (0, 2)	2 (0, 5)	0 (0, 2)	1 (0, 3)
Constipation	0 (0, 4)	5 (0, 10)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)
Abortion	0 (0, 3)	0 (0, 4)	1 (0, 5)	1 (0, 4)	2 (1, 10)	2 (1, 4)
Feet lesions	0 (0, 0)	0 (0, 0)	0 (0, 5)	2.5 (0, 10)	0 (0, 0)	0 (0, 0
Mouth lesions	0 (0, 2)	0 (0, 0)	0 (0, 4)	9 (0, 10)	0 (0, 0)	0 (0, 0
Circling	0 (0, 10)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0
Lameness	0 (0, 0)	0 (0, 0)	0 (0, 1)	0 (0, 10)	0 (0, 0)	0 (0, 0
Sudden death	0 (0, 3)	0 (0, 6)	0 (0, 0)	0 (0, 0)	0 (0, 1)	1 (0, 10)
Nasal discharge	0 (0, 2)	0 (0, 2)	0 (0, 3)	0 (0, 8)	0 (0, 0)	0 (0, 0)
Swollen lymph nodes	0 (0, 10)	0 (0, 6)	0 (0, 8)	0 (0, 2)	0 (0, 0)	0 (0, 0)
Lacrimation	2 (0, 7)	0 (0, 10)	0 (0, 3)	0 (0, 7)	0 (0, 1)	0 (0, 2)
Diarrhoea	2.5 (0, 10)	0 (0, 4)	0 (0, 5)	0 (0, 0)	0 (0, 0)	0 (0, 10)
Standing hair	1 (0, 7)	0 (0, 5)	2.5 (0, 4)	0.5 (0, 6)	0 (0, 1)	0 (0, 2)
Dyspnoea	0 (0, 3)	0 (0, 4)	0 (0, 4)	0 (0, 4)	0 (0, 1)	0 (0, 1)
Salivation	0 (0, 4)	0 (0, 0)	0 (0, 1)	0 (0, 10)	0 (0, 0)	0 (0, 0)
Emaciation	0 (0, 3)	0 (0, 2)	0 (0, 3)	1 (0, 4)	0 (0, 1)	0 (0, 3)
Skin lesions	0 (0, 0)	0 (0, 0)	3.5 (0, 10)	0 (0, 5)	0 (0, 0)	0 (0, 0)

Median scores (number of stones that were piled) are shown in each cell. Minimum and maximum values are shown in parentheses. More counters represent a stronger positive association.
W = Kendall's Coefficient of Concordance (***$p < 0.0001$). W values vary from 0 to 1; the higher the value, the higher the level of agreement between the focus groups.
Anap: Anaplasmosis; Bruce: Brucellosis

it tenth with a relative burden of 3.5%. FGDs' agreement on the relative burdens of these diseases was moderately strong ($W = 0.411$) and statistically significant ($p < 0.001$).

7.2. Proportional piling for risk factors influencing RVF occurrence

The median top three proportional piles of pastoralists' perceived risk factors identified by pastoralists to influence the occurrence of RVF in their communities were: presence of infected mosquitoes (25.5%), living in flood prone areas (15.0%), and proximity to water bodies (14.0%). Agropastoralists perceived the presence of infected mosquitoes (16.0%), proximity to water bodies (14.5%), and livestock movement (14.0%) as the top three risk factors. Other factors mentioned by the FGD participants included the presence of bushlands, ponds, and dams, high livestock density, irrigated crop fields, and proximity to wildlife (Fig. 3 and S2 Table). There was a moderate agreement among all focus groups on the perceived risk factors influencing RVF occurrence ($W = 0.588$) and was statistically significant ($p = 0.012$).

7.3. Perceived clinical signs of RVF and some cattle diseases

Using matrix scoring, we determined the median scores of clinical signs associated with RVF and five other important cattle diseases (ECF, anaplasmosis, LSD, FMD and brucellosis) consistently mentioned in all FGDs (Table 2), to assess participants' knowledge of RVF. RVF was mentioned in twelve out of the sixteen communities. Participants

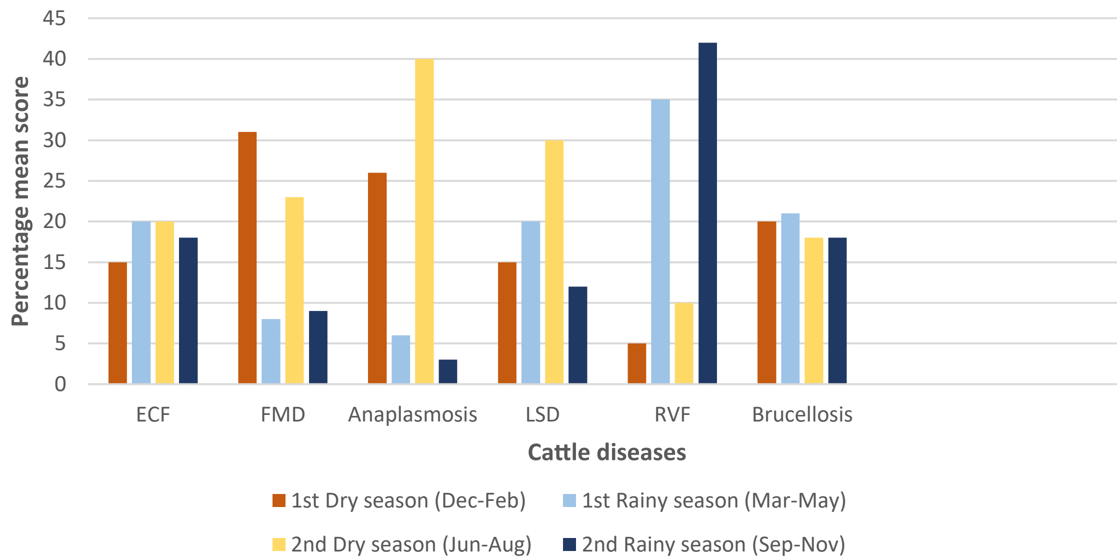

Fig. 4. Pastoralists' and agropastoralists' perception of seasonal variation in the occurrence of RVF and other important cattle diseases in Isingiro, Lyantonde, and Butebo districts, Uganda.

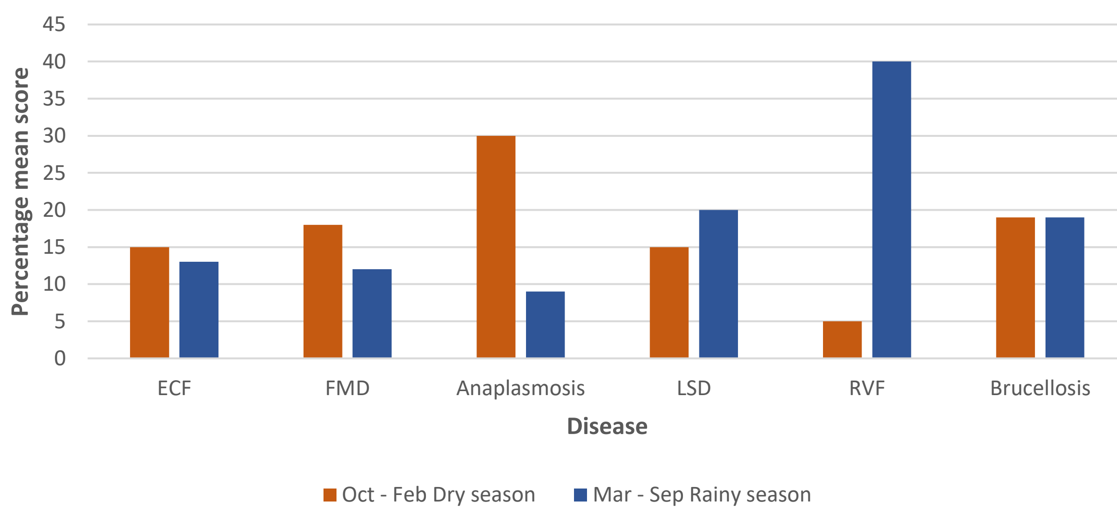

Fig. 5. Pastoralists' perception of seasonal variation in the occurrence of RVF and other important cattle diseases in Napak district, Uganda.

exhibited good knowledge of recognizing clinical signs of cattle diseases including RVF, in their herds.

8. Seasonal patterns of RVF and consistent cattle diseases

While four distinct seasons were identified in Butebo, Lyantonde and Isingiro districts, two distinct seasons were described in Napak district as *Nakamu* (October to February-dry season) and *Nakiporo* (March to September-rainy season). FGD participants' perception in Butebo, Lyantonde and Isingiro was that RVF was more likely to occur during the second rainy season which spans September to November (42%), while it was least likely in the first dry season (5%) (Fig. 4). Participants' agreement on seasonal patterns of RVF and some important cattle diseases in the three districts was almost perfect ($W = 0.922$; $W = 0.848$; $W = 0.930$) for the first dry season (December to February), second rainy season (September to November) and second dry season (June to August) respectively, and statistically significant ($p < 0.01$). There was substantial agreement ($W = 0.744$) on seasonal variations for the second dry season and was statistically significant ($0.05 > p > 0.01$). The FGD participants in Napak perceived RVF to occur in the rainy season (March to September and least in the dry season (October to February) (Fig. 5).

9. Review of surveillance data, direct observation and key informant interviews

The data collected from cattle keepers was confirmed by the appraisal team's observations such as the presence of mosquito breeding sites, bushy vegetation and livestock. Review of surveillance data and published surveillance reports indicated past occurrence of RVF outbreaks in the cattle corridor districts of Uganda. Key Informants confirmed information about the most important cattle diseases and the local disease names that were provided by the livestock keepers.

10. Perceived RVF virus risk pathways

Three risk pathways for RVF introduction, exposure, and consequence were assessed by 27 key informants.

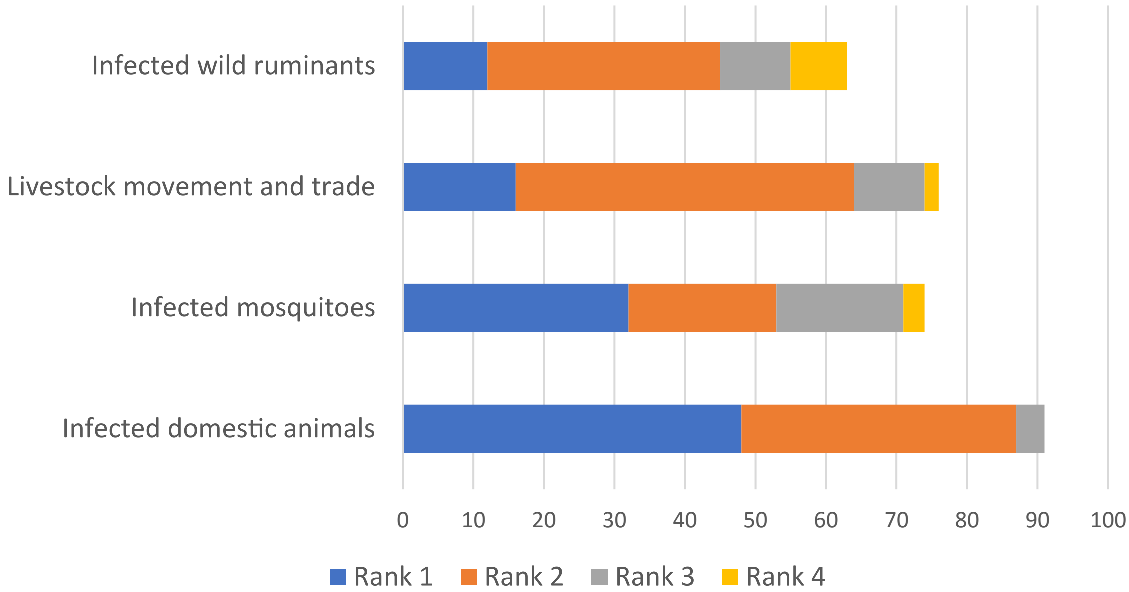

Fig. 6. Weighted scores of perceived risk pathways that enable the introduction of RVF into an area. Rank is the perceived degree of importance of Rift Valley fever risk pathway for introduction into an area (1: most important, 2: important, 3: less important, 4: negligible).

Table 3
Summary weighted scores of perceived risk pathways that enable the introduction of RVF into an area.

Risk pathway	N †	Rank ‡	Weight (Wt)	Score (N † x Wt)
Infected domestic animals (W = 0.899 **)	12	1	4	48
	13	2	3	39
	2	3	2	4
	0	4	1	0
Total	27			91
Infected mosquitoes (W = 0.328^)	8	1	4	32
	7	2	3	21
	9	3	2	18
	3	4	1	3
Total	27			74
Livestock movement and trade (W = 0.777 **)	4	1	4	16
	16	2	3	48
	5	3	2	10
	2	4	1	2
Total	27			76
Infected wild ruminants (W = 0.367^)	3	1	4	12
	11	2	3	33
	5	3	2	10
	8	4	1	8
Total	27			63

Number of key informants interviewed was 27.
† Denotes number of key informants suggesting the ‡ (qualitative measure).
‡ Rank is the perceived degree of importance of Rift Valley fever risk pathway for introduction into an area (1: most important, 2: important, 3: less important, 4: negligible).
Wt Denotes arbitrary weight of 1–4, where 4 was given to the most important rank while 1 to the least important.
W = Kendall's Coefficient of Concordance (**$p < 0.01$; *$p < 0.05$ >0.01; ^ $p > 0.05$). W values vary from 0 to 1; the higher the value, the higher the level of agreement between the focus groups.

10.1. Risk pathways that enable RVF introduction into an area

The perceived risk pathways that enable the introduction of RVF into an area were ranked, converted into weighted scores by multiplying the weight by the number of key informants suggesting a rank. The weighted summary scores show that infected domestic animals are considered the most important (91), followed by livestock movement and trade (76), while infected wild animals as the least important (63). [Fig. 6 and Table 3].

Table 4
Practices that promote human exposure to RVF virus.

Risk pathway of exposure	N †	Rank ‡	Weight (Wt)	Score (N † x Wt)
Drinking raw animal blood and milk (W = 0.817 *)	23	1	3	69
	1	2	2	2
	3	3	1	3
Total	27			74
Handling of infected animal tissues and fluids at parturition (W = 0.929 **)	21	1	3	63
	4	2	2	8
	2	3	1	2
Total	27			73
Handling of infected livestock meat and fluids at slaughter (W = 0.929 **)	21	1	3	63
	4	2	2	8
	2	3	1	2
Total	27			73
contact with infected domestic animals in the herd (W = 0.857 ***)	13	1	3	39
	12	2	2	24
	2	3	1	2
Total	27			65

Number of key informants interviewed was 27.
† Denotes number of key informants suggesting the ‡ (qualitative measure).
‡ Rank is the perceived degree of importance of Rift Valley fever human exposure risk pathway (1: high, 2: medium, 3: low).
Wt denotes arbitrary weight of 1–3, where 3 was given to the most important rank while 1 to the least important.
W = Kendall's Coefficient of Concordance (*$p < 0.01$; **$p < 0.005$; **$p < 0.001$). W values vary from 0 to 1; the higher the value, the higher the level of agreement between the focus groups.

11. Practices that promote human exposure to RVF virus

The findings of the practices that promote human exposure to RVF virus were via drinking raw animal blood and milk, handling of infected animal tissues and fluids at parturition, handling of infected meat and fluids at slaughter, and contact with infected domestic animals in the herd (Table 4 and Fig. 7). Drinking raw blood and milk was perceived as the highest exposure pathway. Key Informants' agreement on practices that promote human exposure to RVF virus was almost perfect (W>0.8)

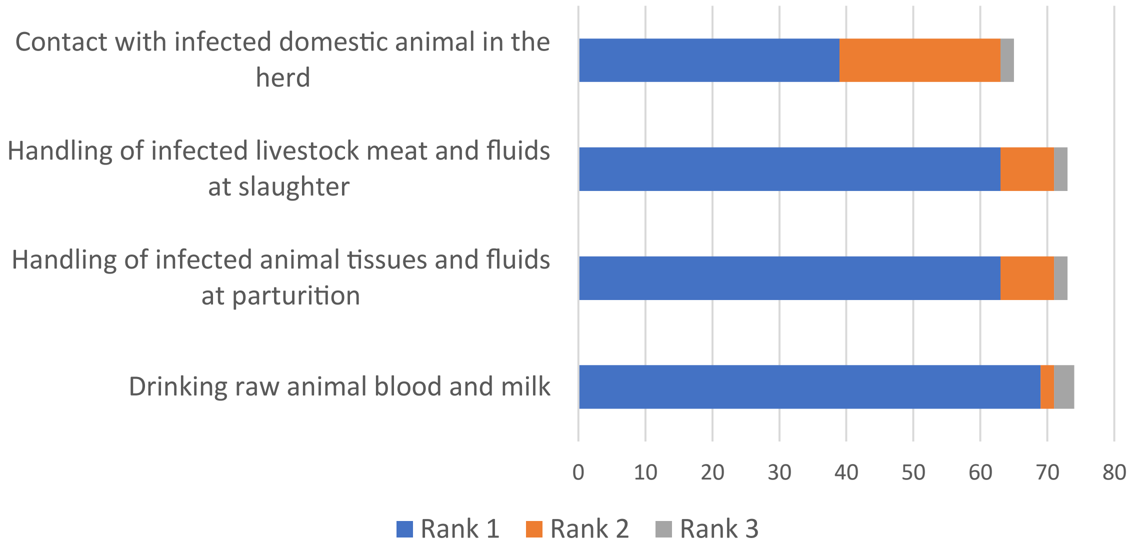

Fig. 7. Weighted scores of perceived risk pathways that promote human exposure to RVF virus. Rank is the perceived degree of importance of Rift Valley fever human exposure risk pathway (rank 1: high, rank 2: medium, rank 3: low).

in all the pathways.

12. Rift Valley fever outbreak consequences

High treatment costs, abortions, reduced production, and morbidity were the top four high consequences in the case of RVF outbreak (Table 5 and Fig. 8).

13. Discussion

To our knowledge, this was the first study to investigate RVF in Uganda using PE methods. We used PE methods to describe and rank cattle diseases, identify seasonal variations in disease occurrence, and perceived risk pathways of RVF in pastoral and agropastoral communities of Uganda.

The findings of this study highlight pastoralists' and agropastoralists' local knowledge on RVF and showed that they can certainly distinguish clinical signs of cattle diseases, including RVF. The possession of such knowledge by pastoral and agropastoral communities should be used for establishing an early warning system for timely control of RVF outbreaks. This study highlights the significant role that livestock keepers can play in veterinary surveillance (Jost et al., 2007, 2010; Mariner and Roeder, 2003). The government authorities could establish and operationalize an early warning system that integrates cattle keepers' knowledge by building the capacity of the cattle keepers on timely reporting any epidemiological risk factors and noticeable clinical signs in herds. A strategy should be in place for the authorities to validate community reports to implement interventions timely, for instance, community sensitization on an imminent outbreak of RVF, prevention and risk mitigation strategies. Most pastoral and agropastoral communities live in remote areas typified by varying degrees of herd mobility. This, coupled with the reluctance of livestock keepers to provide accurate numbers of their herd sizes to outsiders, could result in doubtful disease estimates determined using conventional research methods due to invalid denominators (Catley et al., 2002a). PE methods have significant advantages in pastoral settings (Byaruhanga et al., 2015), for instance by lowering the risk of informants, who may give deliberately inaccurate or misleading information as the subject under discussion is often a community priority (Catley et al., 2012).

It is observed that the focus groups that participated in this study had varying levels of traditional knowledge regarding cattle diseases including RVF. Compared to agropastoralists (Butebo and Isingiro districts), the pastoralists of Napak and Lyantonde districts provided more comprehensive and accurate clinical descriptions of diseases affecting their livestock, including RVF and had adept knowledge of the risk factors associated with the disease. Pastoralists in Napak called RVF *Lonyang*, symbolizing a disease associated with jaundice, high fever, abortions in pregnant cows, and sudden death in calves. This is an indication that PE approaches can be useful for early detection of RVF incidence based on pastoralists' descriptions coupled with active syndromic surveillance (Jost et al., 2007; Mariner and Roeder, 2003). Pastoralists of Poron parish in Napak district believed to have seen RVF when River Awoja burst its banks and flooded in 2007 in the neighbouring district with subsequent abortions in livestock, unusual deaths in young stock, and a yellowish discoloration of carcasses, which they termed "yellow meat''. Pastoralists of Nakichumet parish in Napak were suspected to have experienced RVF in 2008 in Lopeei, formerly Matany subcounty (Morulinga) due to communal conflict which prompted authorities to converge the different herds in select guarded locations, resulting in possible exposure of animals to RVF. The findings on RVF, clinical signs and risk factors associated with RVF are consistent with those done in Kenya (Jost et al., 2010; Otieno et al., 2021; Owange et al., 2014), where it was revealed the cattle keepers had correct knowledge on the symptoms of RVF and the associated risk factors mainly immense rains and mosquito swarms well in advance of the detection of RVF by veterinary service and public health surveillance systems. It has been suggested to perform confirmation of diagnoses with biomedical testing if ethnodiagnoses are ambiguous before developing and implementing recommendations for disease control based on participatory research findings (Queenan et al., 2017).

While pastoralists in the study area predominantly depended on livestock for their livelihoods (Lyantonde and Napak), the agropastoralists (Isingiro and Butebo) depended on both livestock and crop production. While RVF was not the most important disease in the study area, participants described it to have potential negative consequences on livelihoods. The sporadic nature of small outbreaks in Isingiro and Lyantonde districts and the fact that Butebo and Napak districts had never reported an outbreak of RVF at the time of the study could be responsible for a less effect on traditional knowledge systems. At the same time, it also indicates that RVF might have been around in Butebo and Napak districts, which also concurs with categorization of the two locations as medium risk on Uganda's RVF risk map (Tumusiime et al., 2023), but no outbreaks, suggesting such communities might know better how to contain RVF. Previous reports indicate that differences in

Table 5
Qualitative ranking of Rift Valley fever outbreak consequences in humans and animals as perceived by the key informants in Isingiro, Lyantonde, Butebo, and Napak districts, Uganda.

Risk pathway of consequence	N †	Rank ‡	Weight (Wt)	Score (N † x Wt)
Morbidity (W = 0.676 *)	8	1	4	32
	10	2	3	30
	9	3	2	18
	0	4	1	0
Totals	27			80
Mortality (W = 0.697 *)	6	1	4	24
	9	2	3	27
	11	3	2	22
	1	4	1	1
Totals	27			74
Abortions (W = 0.804 **)	12	1	4	48
	12	2	3	36
	3	3	2	6
	0	4	1	0
Totals	27			90
Reduced production (W = 0.838 **)	11	1	4	44
	11	2	3	33
	4	3	2	8
	1	4	1	1
Totals	27			86
High treatment costs (W = 0.939 **)	19	1	4	76
	5	3	3	15
	3	2	2	6
	0	4	1	0
Totals	27			97
Quarantine (W = 0.733 *)	3	1	4	12
	9	2	3	27
	8	3	2	16
	7	4	1	7
Totals	27			62
Trade restrictions (W = 0.640 *)	4	1	4	16
	10	2	3	30
	3	3	2	6
	10	4	1	10
Totals	**27**			**62**
Demand for vaccination (W = 0.336^)	10	1	4	40
	6	2	3	18
	6	3	2	12
	5	4	1	5
Totals	27			75

Number of key informants interviewed was 27.
† Denotes number of key informants suggesting the ‡ (qualitative measure).
‡ Rank is the perceived degree of importance of Rift Valley fever outbreak consequences (1: high, 2: medium, 3: low, 4: negligible).
Wt denotes arbitrary weight of 1–4, where 4 was given to the most important rank while 1 to the least important
W = Kendall's Coefficient of Concordance (**$p < 0.01$; *$p < 0.05$ >0.01; ^ $p > 0.05$). W values vary from 0 to 1; the higher the value, the higher the level of agreement between the focus groups.

local ecology of the RVF virus, livestock breed susceptibility, or the virulence of the RVF virus could lead to low morbidity and mortality among livestock.

The differences in the stated clinical manifestations of RVF could partly be attributed to the fact that whereas study sites in Isingiro and Lyantonde districts had experienced and reported outbreaks, Butebo and Napak districts in Eastern and Northeastern Uganda had never reported outbreaks. All four communities that did not mention RVF were from agropastoralists groups. Of the four, three communities that did not mention RVF were in Butebo district, while one was in Kabare parish in Isingiro District. Of the four communities that participated in the study in Butebo district, only Nalidi parish mentioned RVF. This could be due to the fact that no outbreaks have occurred in the district. Findings point to the possible occurrence of RVF in areas notwithstanding the absence of clinical outbreaks. The finding in Kabare parish was unexpected, given that Isingiro had reported RVF outbreaks in the past (Mbonye and Sekamatte, 2018). The absence of reported outbreaks in some districts could have had a great bearing on the recall memory of participants. It has been documented that variations in the local ecology of RVFV, differences in breed susceptibility, or the virulence of the RVFV involved in the outbreak could potentially influence pastoralists' ranking of RVF as an important disease (Jost et al., 2010). Regions with less widespread RVF outbreaks could experience less impact on traditional knowledge systems (Jost et al., 2010).

RVF was ranked among the top ten most important cattle diseases by agropastoralists and pastoralists alike. Despite its lower ranking among other diseases, RVF was ranked as a disease of potential high consequence on community livelihood resulting from trade bans, treatment costs of livestock and humans, mortality, among others. This denotes that RVF is perceived as a potential threat to livestock health, production, productivity, and public health. This finding should be a significant motivation for authorities to mount preventive and control measures against RVF at the community level.

Using the proportional piling technique, pastoralists and agropastoralists identified the presence of mosquitoes, living in flood-prone areas, and excessive rainfall, presence of bushlands, livestock movement, high livestock density, and presence of water bodies, among others as the most important risk factors for RVF occurrence. Similar findings have been observed in Kenya in a study that demonstrated a strong connotation between RVF infection and large numbers of animals and mosquitoes in the 2006/2007 RVF outbreaks in Kenya (Anyangu et al., 2010). High cattle density should be predicted to significantly influence RVF occurrence in the Ugandan cattle corridor, in which 46% of Uganda's livestock is raised (NEPAD-CAADP, 2012), since cattle, sheep and goats are the principal animal host of RVFV (Pepin et al., 2010b). Several studies have linked RVF outbreaks to above-normal rainfall as this is a prerequisite for mosquito emergence (Anyamba et al., 2001; Bird et al., 2009; Anyamba et al., 2010; Linthicum et al., 2016). Presence of water bodies such as ponds and streams were stated as a predisposing factor for RVF occurrence, which is expected as streams common in low-lying areas are prone to constant flooding during periods of excessive rains (Hepworth and Goulden, 2008). Low lying areas in Uganda have been demonstrated to have higher odds of RVFV exposure due to their susceptibility to flooding and favourable climatic conditions for the emergence of mosquitoes (Tumusiime et al., 2023). Similarly, previous studies have linked RVF occurrence to proximity to perennial water bodies (Sindato et al., 2012; Chevalier, 2013). In this study, it was observed that many homesteads in Eastern Uganda use wetlands for rice growing, which precipitates frequent water logging, facilitating mosquito breeding and subsequent exposure to mosquito bites. Similar findings have been reported in Niger (Alhaji et al., 2018) and in Kenya (Mbotha and Nyakwea, 2020). Some pastoralists constructed ponds and valley tanks in addition to government dams to provide water for livestock. A previous study in Western Africa reported that artificial water bodies, such as dams and irrigated rice fields, were found to be associated with the high abundance of RVFV vectors (Chevalier et al., 2010). A previous study in Uganda has demonstrated that live animal movement poses a high risk of RVF entry due to cross-border movements of livestock for trade (Roger, 2019). The focus groups in Napak indicated that during drought in Kenya, Kenyan pastoralists move their livestock into Napak and neighbouring districts of Karamoja. In Isingiro, participants reported illegal animal movements between Uganda and Tanzania along the Uganda-Tanzania border. Ranked by pastoralists as a risk factor for predisposing to RVF occurrence in this study, proximity to wildlife has also been implicated in studies done in Kenya where wild ungulates were found to have been exposed to the disease (Beechler, 2013; Britch et al., 2013; Chenais and Fischer, 2021; Rosta et al., 2017).

In this study, three pathways for entry, exposure, and consequence were assessed by Key informants. Collectively, infected domestic ruminants were perceived to be the most important, followed by livestock movement and trade, infected mosquitoes, and infected wild animals as risk pathways for the entry of RVFV in the area. Similar observations

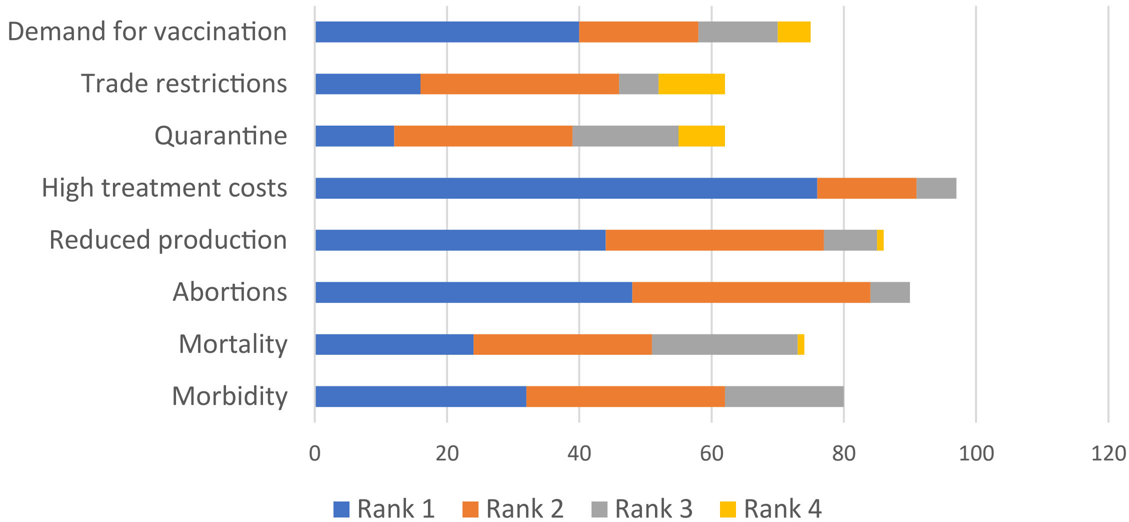

Fig. 8. Weighted scores of perceived risk pathways of Rift Valley fever outbreak consequences in humans and animals as perceived by the key informants. Rank is the perceived degree of importance of Rift Valley fever outbreak consequences (1: high, 2: medium, 3: low, 4: negligible).

have been made by scholars in Kenya and Nigeria (Alhaji et al., 2018; Otieno et al., 2021; Owange et al., 2014). The key informants mentioned drinking of raw animal blood and milk, handling of infected animal tissues and fluids at parturition, handling of infected meat and fluids at slaughter, and contact with infected domestic animals in the herd as exposure pathways for humans, signifying informants' knowledge of risky practices that promote human exposure to RVF. Pastoralists have a custom of helping their animals while giving birth, thereby increasing the chances of infection with RVFV in case the animal is infected. A similar study done in Kenya reported handling aborted foetuses to be the single most important risk factor directly linked with exposure and spread of RVFV (Anyangu et al., 2010). The practice of drinking raw animal blood and milk is common among pastoralists. In pastoral communities, milk is commonly consumed in raw form and significantly contributes to protein and micronutrient and energy requirements to trek herds for grazing over long distances. In Napak, consuming raw milk and blood has been a socio-cultural practice for generations and could be further qualified by the lack of plant source foods in the semi-arid environment. Previous reports in Ethiopia have shown reluctance of pastoralists to boil milk before consumption due to the misconception that boiling destroys the nutrients in the milk and "boiled milk is dead'' (Amenu et al., 2019), and in Senegal, "We never boil our milk, it will cause sore udders and mastitis in our cows" (Prakashbabu et al., 2020). Such practices could predispose humans to infections with RVF virus should the livestock be infected with RVF virus. This calls for the need for veterinary and public health authorities to seek dialogue with cattle keepers to identify the primary reasons for such practices and develop targeted health messages to invoke appropriate social behavioural change. Pastoralists usually inhabit marginal and hard-to-reach isolated settlements of underserved veterinary and public health services including public health education. This suggests that veterinary and public health messages should be developed and disseminated in the respective local languages for suitable targeting and seizing. The authorities should utilize local communication channels in the communities, for instance, religious leaders, kraal leaders, and local radio stations.

The Key informants ranked trade restrictions and quarantine restrictions as medium and low to medium consequences, respectively. This finding contradicts that from a study in Ijara County in Kenya in which 100% of the informants rated the two factors as high consequence (Owange et al., 2014). The low ranking of the two consequences in this study could be attributed to the fact that Uganda has not experienced overwhelming outbreaks like those that have occurred in neighbouring Kenya (Murithi et al., 2011; Woods et al., 2002), with massive deaths of livestock and an estimated 27,500 human cases with more than 600 deaths reported in 1997/1998 in Kenya alone. Furthermore, this could point to limited RVF surveillance in animal populations by veterinary authorities, especially human cases are confirmed by the public health authorities, with no apparent clinical disease in livestock (Birungi et al., 2021; Shoemaker et al., 2019). There was a varied level of knowledge among the informants. Assessment of the risk pathways in this study provides useful indications for RVF risk and impact in the study area. The potential uncertainties of the Key Informants' evaluation of the risk pathway analysis for RVF could be reduced by increasing the number of expert respondents.

The methods used in our study have shortcomings in case of mixed infections in cattle that result in the combined or simultaneous effects of different diseases, and which may present difficulties during scoring. In all FGDs, participants explained the possibility of mixed infections, due to simultaneous clinical manifestations of cattle diseases, for example abortions caused by brucellosis and RVF. In such scenarios, cases were allotted to the disease with a more pronounced clinical manifestation. This could result in underestimation of the burden of such diseases which, when present as a mixed infection, tend to be hidden by a more severe concurrent infection. In such cases, definitive diagnosis of the disease would be the solution, but is usually costly and would work against the advantages of the participatory approach used in this study.

To minimize geographical bias, this study covered areas that allowed for suitable dispersion within the study areas, while subject bias was limited by making no mention of RVF in the invitation to the meeting and introduction of objectives. Facilitators reduced bias of the dominant speaker by allowing as many participants as possible to deliberate on specific issues by encouraging otherwise silent participants to speak. Methodological bias was minimized by thorough training of the facilitators prior to the exercise.

In this study, pastoralists and agropastoralists perceived the occurrence of RVF and other cattle diseases to be associated with seasons. Perceived seasonal patterns of RVF were also observed. Participants cited the highest probability of RVF occurrence during the second rainy season which spans September to November. Periods of rainy season are a requisite for hatching of RVFV infected mosquito eggs with a resultant explosion in mosquito populations unlike during dry season. Nevertheless, circulation of RVFV in livestock has been reported to occur at any time of the year during the inter-epidemic period (Mbotha and Nyakwea, 2020).

14. Conclusion

The findings demonstrate that pastoralists and agropastoralists in the Ugandan cattle corridor had adept veterinary knowledge and traditional oral history on cattle diseases including RVF. The knowledge gap among the studied communities could be due to underserved areas in disease surveillance and public health education. These findings indicate a need for critical interventions to abate imminent RVF outbreaks with potential negative impacts on community livelihoods and public health. The identified risk factors for RVF occurrence should be an indicator for early warning to facilitate emergency preparedness for RVF. Knowledge of risk factors for introduction, exposure to humans, and consequences of RVF is crucial for the design of the national RVF surveillance system and control strategies by the Ugandan authorities in lessening the burden of this economically important zoonotic and Transboundary Animal Disease. PE approach is key in the surveillance of livestock diseases and zoonoses in remote communities.

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Declaration of Competing Interest

The authors declare that they have no conflicting interests that may have inappropriately influenced them in writing this original research article.

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Supporting Information.

S1 Table: Proportional piling: Ranking of relative burden of cattle diseases amongst groups of pastoralists and agropastoralists in Uganda, January 2022 to February 2022.

S2 Table: Summarised proportional piling of perceived risk factors for Rift Valley fever occurrence by pastoralists and agropastoralists groups, Uganda.

S1 Fig. Proportional piling exercise on cattle diseases at Butebo (TIF).

S2 Fig. Matrix scoring exercise on clinical manifestations at Nabwal, Napak (TIF).

S3 Fig. Proportional piling exercise on risk factors at Kashumba, Isingiro (TIF).

S4 Fig. Matrix scoring exercise on seasonal calendar at Poron, Napak (TIF).

S5 Fig. Proportional piling exercise on cattle diseases at Kabaare, Isingiro (TIF).

S1 Strobe Statement. Checklist of items for the participatory epidemiology (PE) survey. (DOCX).

S1 Checklist. Checklist for identifying and ranking Rift Valley fever among other cattle diseases/conditions in pastoral and agropastoral communities of Uganda. (DOCX).

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.prevetmed.2023.106071.

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