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Gender and exposure pathways to zoonotic infections in communities at the interface of wildlife conservation areas of Uganda: A qualitative study

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ABSTRACT

The changing climate and increasingly frequent environmental shocks are creating new pressures on land use and intensifying inter-species contact that might foster zoonotic disease transmission. In areas where there are complex interactions between wild/domestic animals and humans, preventing and managing zoonotic infections requires an integrated One Health approach based on interdisciplinary and multisectoral collaboration. We used a One Health approach to investigate how potential zoonotic disease exposures might be gendered based on sociocultural norms. In six conservation areas in Uganda, we focused on three zoonoses: Rift Valley Fever, Brucellosis and Crimean-Congo Haemorrhagic Fever. We conducted in-depth interviews and focus group discussions with 379 purposively selected participants. Interviews/discussions were audio recorded, transcribed, coded and analysed thematically. In all areas, women and girls were responsible for household-related work while men and boys cared for larger livestock outside of the home, with some regional variations in roles. Location-specific cultural norms differentially impacted women's and men's exposures, including male initiation rituals involving consuming raw meat and animal blood reported in one study area. The different activities performed by women and men lead to differential risks of infection, suggesting that gender-sensitive interventions are required to address the risks faced by people living in these settings.

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Introduction

In areas where there are complex interactions between the natural environment, wild and domestic animals, and humans, preventing and managing zoonotic infections requires a One Health approach. Users of this approach recognise that the health of humans, domestic and wild animals, and the environment are interdependent, and aim to optimise the health of each through interdisciplinary and multisectoral collaboration (Adisasmito et al., 2022). People living within and adjacent to conservation areas in Uganda have witnessed the emergence and re-emergence of

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zoonotic diseases which affect both their domestic animals and their own health. The changing climate and increasingly frequent environmental shocks are creating new pressures on land use and intensifying inter-species contact that might foster zoonotic disease transmission. Understanding the impact of differences in vulnerability to exposure and transmission of zoonoses, as well as inequalities in access to treatment and disease management, are critical to sustainable and equitable responses (Alders et al., 2020; Dzingirai et al., 2017; Garnier et al., 2022). A One Health approach, which takes into account socio-cultural factors, including gender differences, provides a lens through which to address these health challenges.

While previous publications have highlighted gender as an important factor in One Health, few One Health frameworks give attention to the sociocultural aspects of gender related to zoonotic disease exposure and management (Alders et al., 2020; Babo et al., 2022; Bikaako et al., 2022; Cataldo et al., 2023, 2024; Coyle et al., 2020; Oruganti et al., 2023). Gender norms, including power dynamics, household roles and responsibilities, and control over resources can impact pathways and frequencies of disease exposure and transmission, and access to healthcare and information for prevention and treatment (Babo et al., 2022; Coyle et al., 2020; Fusco et al., 2022; Gammino et al., 2020; Garnier et al., 2020; Oruganti et al., 2023). For both women and men, gender roles create varying odds of exposure to zoonotic infections, necessitating the need to examine these gendered risks to inform prevention and mitigation measures. For example, two studies from South Africa demonstrated how gender roles relate to different exposures (Coyle et al., 2020; Oruganti et al., 2023), showing that women were responsible for cooking raw meat, handling small livestock and poultry, and household hygiene tasks, which makes them susceptible to diseases transmitted from those household activities, while men were more involved in larger livestock care as well as exposure from going to the bushy areas near the homestead to dispose of waste where they come into contact with both the animals and animal products.

In addition to differential exposure to the sources of zoonotic disease, gender norms also create differential access to information, which can influence the response to animal epidemics. Studies from Uganda and Ghana show that men have greater access to information and more decision-making power than women, and thus engage in more prevention practices like vaccination and seeking veterinary services for their livestock and poultry (Bikaako et al., 2022; Ouma et al., 2023).

In this paper we used qualitative data from in-depth interviews and focus group discussions to examine the interaction between people, domestic animals and wildlife and the natural environment in six conservation areas in Uganda to investigate potential exposure pathways for zoonotic infections from a gendered perspective. The data for this paper are drawn from a multidisciplinary research project aimed at improving the understanding and control of zoonotic disease using enhanced surveillance systems and a One Health approach at the human-animal-wildlife interface in the cattle corridor of Uganda (Kizito et al., 2024 [in press]). Using a gender lens in One Health approaches, including incorporating household roles and tailoring strategies to household members most likely to perform certain tasks, can inform more targeted interventions to minimise exposures and improve management at the household and community level of interventions and at the policy level when it comes to distribution of resources and future research (Coyle et al., 2020; Oruganti et al., 2023).

Rift Valley fever, brucellosis and Crimean-Congo haemorrhagic fever modes of transmission

While several zoonoses exist in Uganda, we focused on Rift Valley Fever (RVF), Brucellosis and Crimean-Congo Haemorrhagic Fever (CCHF), which are among the country's priority neglected zoonotic diseases (Sekamatte et al., 2018). RVF virus is transmitted to humans from contact with infected livestock, wild animals and through mosquito bites. Outbreaks typically occur after periods of heavy rainfall and flooding leading to increased mosquito populations (Bird et al., 2009; Linthicum et al., 2016). Symptoms in humans include headache, fever, nausea, and general malaise, but

severe cases can progress to encephalitis, retinitis, and haemorrhagic syndrome. In livestock, RVF is characterised by acute onset of lack of appetite, nasal discharge, and diarrhoea (Bird et al., 2009; Javelle et al., 2020). Currently, there are no specific treatments for RVF beyond general supportive care for symptoms (Javelle et al., 2020).

Brucellosis is caused by bacteria of the genus Brucella, among livestock, infecting cattle, small ruminants, and swine, which are species of particular importance in human and livestock infections worldwide. Brucellosis has also been described in wildlife (Aruho et al., 2021; Kalema-Zikusoka et al., 2005). Zoonotic transmission mainly occurs through direct contact with infected animals, their tissues, or their products (Köse et al., 2014). Brucellosis is endemic in the country and associated with a significant disease burden. Brucellosis infection is characterised by undulating fever, and often follows a waxing and waning disease trajectory making it difficult to diagnose and treat, resulting in many hospital visits and reduced economic activity (World Health Organization, 2006).

CCHF is a tick-borne viral zoonotic disease affecting humans, livestock and wildlife caused by the CCHF virus (Bente et al., 2013). The virus is maintained and transmitted in a vertical and horizontal transmission cycle involving a variety of wild and domestic vertebrate species that act as refractory hosts, without showing signs of illness (Gargili et al., 2017). CCHF symptoms can include sudden onset of fever, weakness, headaches and muscle aches, vomiting, rash, gastrointestinal bleeding, and haemorrhage (Bente et al., 2013). CCHF is typically managed with general supportive care for symptoms, although the antiviral ribavirin has also been used to treat with some evidence of benefit (Bente et al., 2013).

All three diseases also have important economic consequences due to their impact on the livestock industry, lost productivity while sick, and the cost of avoidable health care to farmers. All have been associated with reduced milk production, spontaneous abortions and still birth in livestock (Bird et al., 2009; Nyakarahuka et al., 2023; World Health Organization, 2006).

Table 1. Key characteristics of selected conservation areas.

Conservation area	Human population[a]	Wildlife	Climate	Livelihoods
Lake Mburo-Nakivale (area of 370 sq km)	Male 587,000 Female 595,300	Large population of zebra, impala, waterbuck, buffalo, giraffe, bushbuck, topi (Jackson's hartebeest)	Semi-arid savannah. Bimodal rainfall	Mixed farming. Cattle keeping.
Queen Elizabeth Conservation Area (area of 700 square miles).	Male 643,000 Female 672,700	Large population of buffalo, Uganda kob, lions, leopards, warthogs, hyenas, hippos, bushbuck, topi, elephants, chimpanzees	Bimodal rainfall, mix of tropical forests with dry savannah thickets	Mixed farming, fishing
Bwindi and Mgahinga Conservation Area (area of 32,092 ha)	Male 284,900 Female 327,300	Population of mountain gorillas, elephants, chimpanzees, baboon and four species of monkeys	Bimodal rainfall Tropical rain forest in an Afromontane habitat	Mixed farming
Murchison Falls Conservation Area (area of 2,072 square miles)	Male 567,600 Female 537,300	Large population of buffalo, Uganda kob, lions, warthogs, hyenas, hippos, bushbuck, topi (Jackson's hartebeest), waterbuck, elephant, giraffe, baboons and several species of monkeys.	Semi-arid savannah. Bimodal rainfall	Mixed farming, fishing
Kidepo Valley Conservation Area (area of 1,442 sq Kms)	Male 96,900 Female 106,100	Large population of buffalo, waterbuck, bushbucks, Uganda kob, zebras, elephant, lions	Semi-arid savannah. Bimodal rainfall	Mixed farming
Pian Upe Wildlife Reserve (area of 2043 sq km)	Male 120,600 Female 123,700	Large population of eland, roan antelope, bushbuck, oribi, buffalo, Uganda kob and cheetah.	Semi-arid savannah. Bimodal rainfall	Mixed farming

[a]Population data from Uganda Bureau of Statistics (2022).

Study setting

We conducted the study in six conservation areas which were the focus for the overall study. We provide an overview of the characteristics of these areas in Table 1.

First, Lake Mburo-Nakivale Conservation Area located in southwestern Uganda has a high population of wildlife such as zebra, impala, waterbuck, buffalo, giraffe and bushbuck with significant numbers residing on the public lands surrounding the national park (Uganda Wildlife Authority, 2015). The Conservation area exhibits a semi-arid savannah climate. Rainfall is bimodal, the population in the park communities was 1,182,300 people in 2022 (Uganda Bureau of Statistics, 2022). Most people practice mixed farming. Unable to support their herds on allocated plots, pastoralists are eager to graze their cattle in the park. Whereas this is prohibited, wildlife outside the park compete with cattle for grazing on private land damaging people's crops. Second, Queen Elizabeth Conservation Area located in western Uganda is a protected area comprising Queen Elizabeth National Park, Kyambura Wildlife Reserve and Kigezi Wildlife Reserve. The area experiences two dry seasons. Vegetation is of central African rainforest and East African grassland biomes creating a range of diverse habitats of open grassland, with thickets, forests, wetlands, and 250 km of lakeshore (Uganda Wildlife Authority, 2012b). The human population occupies 11 fishing village enclaves. Third, is Bwindi and Mgahinga Conservation Area, located on the eastern edge of the Albertine Rift Valley in southwestern Uganda. It is a biodiversity hotspot of tree species referred to as the impenetrable forest. The area has a high population density of more than 300 people per square kilometre with 90% of the people dependent on subsistence agriculture. The Conservation area receives bimodal rainfall. The fourth site, Murchison Falls Conservation Area is Uganda's largest protected area. Located on the western side of Uganda the park lies at the northern end of the Albertine Rift Valley and receives two seasons of rainfall a year. The vegetation is forest, savannah, grassland and swamps. Human activities have had a great influence on the natural vegetation. Agriculture is the main source of livelihood for about 90% of the population. The Conservation area has in the recent past received an influx of Bahima pastoral people more commonly known as Basongora, from southwestern Uganda with large herds of cattle that have led to over grazing. Others carry out fishing on Lake Albert and Lake George. Oil and gas mining are a recent economic activity in the Albertine rift valley. Fifth, Kidepo Valley Conservation Area is located in the semi-arid valley between the Ugandan border with South Sudan in the northwest and the Kenyan border to the east. Kidepo Valley is characterised by a short-wet season and a long dry spell (Uganda Wildlife Authority, 2012a). The Conservation area exhibits desert type vegetation. People practice mixed farming. Land is customarily owned with potential of some conflicts especially in the wildlife dispersal corridors. Lastly, Pian Upe Wildlife Reserve located in the northeastern part of Uganda has a population of 244,300 people (Uganda Bureau of Statistics, 2022). Most of the people's livelihoods are based on livestock and agricultural produce. However, because of the dry spells and lack of adequate water for livestock, the people lead a semi-nomadic lifestyle (United Nations Development Programme, 2016).

Each of the regions has been affected by changes in the climate, but there has been a notable decrease in the amount of rainfall received in the western region compared to the eastern region. Temperatures too reflect the same pattern. These changes have affected people's livelihoods and farming practices. For instance, in the western region, prolonged dry seasons force cattle keepers to graze or water their animals in the wildlife protected areas hence bringing livestock into close contact with wildlife more frequently than in the past.

Site visits were carried out to all administrative districts[1] interfacing with these conservation areas to select districts where high interaction of humans, livestock and wildlife was observed. Within these districts and within 5 kilometres distance from the wildlife park boundary, sub counties/parishes, termed Satellite Research Sites for the purposes of this study, were selected as our research sites.

Methods and materials

Study participants were recruited from selected Satellite Research Sites in the six Conservation Areas. Data were collected using focus group discussions (FGD) and in-depth interviews (IDI). FGD participants were purposively sampled to include those residing in the sampled Satellite Research Sites and involved in a specific livestock related occupation. Key informants purposively included individuals who were technical and or political leaders in the study district, those participating in One Health activities at the district level, and available during the study period.

A total of 35 FGDs (an average of 6 FGDs per conservation area) were purposely selected from 22 Satellite Research Sites (up to 6 per conservation area). Participants included those engaged in crop and livestock farming, fishing, and small businesses (such as grocery shops and restaurants) as well as secondary school students.

Groups were divided by gender and occupation. Each group comprised of 6–10 participants. Topics and questions were formulated by an experienced interdisciplinary team of social scientists and aligned to the project's conceptual framework developed by a larger multidisciplinary team. An average of four key informants, people with particular knowledge of the area, were selected from each of the 15 districts in the six conservation areas for the in-depth interviews.

Data collection

Prior to data collection, meetings were held to brief the district leadership about the study and the purpose, solicit their support, identify district participants and also to gain community entry. At the community level, local council committees in the study sites were approached and engaged to support the study, identify local guides and potential participants. Selected local council committee members and Village Health Teams helped in mobilising community members to participate in the study. Appointments for individual interviews and discussions were made a day before the actual interviews to encourage the response.

A topic guide focusing on gendered power relations, social norms, ideologies, perceptions and beliefs and how these shape exposure to zoonotic pathogens was used for the interviews and discussions. An experienced moderator and note-taker (two female and two male Ugandan social scientists) guided the discussions. For district staff, interviews were conducted from the offices of selected staff while discussions were conducted in identified safe spaces in the community that provided privacy. Such spaces included classrooms, churches and places shaded by trees. The discussions were audio recorded.

Data management and analysis

Audio recorded data were transcribed, translated verbatim into English and captured in MS-Word. A team of three experienced social scientists (CA, MH and EP) read the transcripts and edited them for completeness. These were later uploaded into NVivo version 12 for coding. A draft code book was generated, discussed and agreed up on by a team of five social scientists (CA, SE, LF, MH, JS) to ensure the codes were aligned to the study objective. Three social scientists (SE, MH and MK) coded the same transcripts guided by the code book. Any new emerging themes in the data were flagged, discussed, and agreed upon before being coded. Analytic memos were utilised to guide data analysis. The memos were allocated to individual study team members to organise and conduct first and second level of data analysis. These memos were later discussed to inform further analysis and interpretation of results. The results are presented as quotes and narratives.

Ethics

Approvals were obtained from the Uganda Virus Research Institute Ethics Review Committee (GC/127/875). The study was registered with the Uganda National Council for Science and Technology

(UNCST – https://www.uncst.go.ug/). Each study participant was asked to provide written informed consent prior to participation in the study. Administrative clearance was sought from the study districts.

Results

Demographic characteristics of study participants

A total of 312 participants (169 (54%) female) took part in the FGDs and 67 key informant interviews were conducted (See Table 2). 57 (85%) of the key informants were male. Seventy (22.4%) of the participants were engaged in mixed groups. Of the 190 participants whose age was recorded, 87 (45.8%) were aged 18–29 years, 37 (19.5%) were aged 30–39 years, 28 (14.7%) were 40–49 years while 21 (11.1%) were aged 50 years and above. Only 17 (8.9%) participants were 17 years and below.

Table 3 provides an overview of the activities that might create risk of zoonotic disease exposure disaggregated by conservation area and gender.

During the analysis two broad themes were identified: the division of labour (based on women's/girls' roles and men's/boys' roles, and the associated gendered health risks) and sociocultural norms (for gendered social norms). We then divided the findings under these two broad themes, grouping topics according to the subheadings below, for example 'Women and risk of exposure and Men and risk of exposure'. We present our findings by theme first for women, and then for men.

Women and risk of exposure to zoonoses

Women in the study settings performed several different roles which potentially exposed them to zoonotic infections: food preparation, childcare and nurturing, gardening and house building-related activities. For instance, in Lake Mburo, the women were involved in food preparation, childcare and milk processing for small businesses. They made things like ghee, yoghurt and other milk products and, during these processes, were at risk of exposure to brucellosis. This was quite different from the roles performed by women in the Kidepo Valley and Pian-Upe conservation areas, which are also cattle-keeping areas. There, the women were not engaged in making milk products like ghee and yoghurt for sale, instead their zoonotic exposures come from other exposure pathways such as consuming raw milk and gathering construction materials (see below).

Participants noted that farming by women was done in all the conservation areas, however, the amount varied depending on the importance of agricultural products for livelihoods rather than solely for home consumption. For instance, in the Bwindi area, the women engaged more in farming than they did in milk processing for sale, whereas in the Lake Mburo area, the reverse was true.

Eating raw or partially cooked meat

In all the study sites women were engaged in cooking, childcare and cleaning the homestead. Participants described the risk of zoonotic infection for these women as coming from handling raw meat like beef. One woman, participating in a group discussion in Kidepo Valley, observed:

Table 2. Summary of participants in FGDs and IDIs by conservation area.

	Groups	Participants in groups			Interviewees		
Conservation area	No. of FGDs	Participants	Male	Female	Total	Male	Female
Kidepo Valley	6	48	24	24	3	3	–
Pian-Upe	5	52	20	32	9	8	1
Lake Mburo-Nakivale	5	33	13	20	34	28	6
Murchison Falls	8	60	32	28	8	6	2
Queen Elizabeth	5	57	28	29	8	8	-
Bwindi and Mgahinga	6	62	27	35	5	4	1
Total	35	312	144	168	67	57	10

Table 3. Activities and risk exposure by gender and site.

Activities that might create risk exposure	Lake Mburo		Kidepo Valley		Pian-Upe		Bwindi		Murchison Falls		Queen Elizabeth	
	F	M	F	M	F	M	F	M	F	M	F	M
Food preparation												
Handling raw meat												
Milk processing												
Childcare												
Fetching water												
Fetching firewood												
Crop Farming												
Collecting building materials												
Bush clearing												
Animal Farming												
Fishing												
Hunting												

> About the work women do at home like cooking and taking care of children, you find that a man might have gone hunting then brought meat home, so a woman might not be aware whether its good fresh meat or dead meat, so her work is to just cook and people eat. During the process of cooking, she might end up tasting the food to see if it's ready but only to realize she tasted before it was fully ready hence causing her problems which later might end up making her contract the disease called Brucellosis. (FGD, female crop farmer, Kidepo Valley)

Exposure could also come from a woman tasting meat products before giving them to her children; a practice which could put both the woman and the child at risk of infection if the meat were under-cooked. One of the men from the Murchison Falls area commented during an FGD that:

> Eating raw meat is as a result of bringing the child close to fire when maybe the meat is not ready and she cries for it, and they give her meat sometimes it can result in her getting that disease called brucellosis.

Thus, while women in these settings may not be involved in the killing of animals for meat, their roles in food preparation put them at risk of zoonotic exposure.

Consumption of milk products

Milk is an important part of the diet for most cattle keepers in Kidepo Valley, Pian Upe and Lake Mburo-Nakivale conservation areas and is also sold to supplement household income. Ghee, prepared by women, is also used to enhance the flavour of other food or as a sauce '*eshabwe*'. In some of the Bahima households in Lake Mburo-Nakivale Conservation Area we observed that people offered visitors cold, unprocessed, milk '*amakamo*'.

Participants from five of the six study sites described cultural beliefs related to women consuming raw milk. Participants in Kidepo Valley said that women are not allowed to have hot or boiled drinks if they are menstruating, sick or right after giving birth, so they are given raw milk at these times.

> It is also believed that when a woman just gives birth irrespective of the sex of the baby she is not supposed to drink anything hot but rather cold, so like milk if they are to give her she is supposed to take cold [milk] that is got direct from the cow so me I feel this kind of thing exposes them to diseases like brucellosis either in the short or long run. (FGD, female crop farmer, Kidepo Valley)

Participants from Murchison Falls and Queen Elizabeth noted that women in their areas traditionally are supposed to drink raw milk in order to gain weight. In addition, in Lake Mburo-Nakivale, among the cattle keepers, especially the Bahima, brides are still given raw milk ahead of a traditional marriage ceremony so that they gain weight ahead of the ceremony:

> Sometimes brides who are preparing for marriage are given raw milk because they believe that raw milk has some nutrients, so they give her this milk so much and this can result in these diseases like brucellosis. (FGD, male cattle keeper, Lake Mburo-Nakivale)

In Bwindi and Mgahinga, one participant described women and children as 'heavy drinkers' of raw milk, although this observation was not linked by the respondent to cultural practices or specific reasons for why this is the case.

Fetching firewood, water and building materials

Within wildlife conservation areas where many of the households we collected information from reside, families do not have access to electricity or piped water for domestic use. They rely mainly on firewood which they fetch from the bushes and water is gathered from streams, ponds and lakes. Participants described fetching firewood and water as the roles women and girls perform (even as in Lake Mburo boys also fetch firewood). From Murchison Falls, Queen Elizabeth, and Kidepo Valley participants note that women and girls are bitten by ticks and mosquitoes during these activities, causing them to fall sick.

> It is usually the girls who collect firewood for the household and they do this in the bushes where livestock and wildlife graze. So, during the process of fetching this firewood it exposes them to several risks of catching diseases through animal, tick and insect bites in the bush since this is the place where the ticks and mosquitoes stay. (FGD, female crop farmer, Kidepo Valley)

In the data from Bwindi and Pian-Upe, participants did not specifically mention whether women and girls experienced insect bites during these activities. In Lake Mburo-Nakivale, it was noted that both boys and girls fetch firewood and risk exposure to insect bites.

Other participants in Kidepo Valley and Pian-Upe observed that it is girls who are responsible for fetching water and firewood from swamps and bushes, and it is these places that are also grazing and drinking points for wild animals and habitats for ticks and mosquitoes that host the CCHF and RVF pathogens.

> In my community usually girls go to the swamps to fetch water and firewood, and they get exposed to tick and mosquito bites. This is because both wild and domestic animals graze and drink in such swamps hence exposing them to diseases like Congo-Crimean Haemorrhagic Fever and Rift Valley Fever. (FGD, female crop farmer, Kidepo Valley)

Women in the Kidepo Valley and Pian-Upe gathered building materials from the areas surrounding their homesteads. It was only in these regions that the construction of houses and gathering construction materials were performed by women. During data collection we observed several women and adolescent girls carrying poles and other building materials. Further inquiry revealed that men cut the building materials and then women go to fetch these products from the bush. During a discussion group a man said that:

> The roles and responsibilities women usually perform expose them to many diseases for example going to the bush to cut grass for building houses exposes me [and the women who collect the grass] because as I'm cutting grass I keep on having a physical touch with the grass. All these roles and activities expose them to diseases. (FGD, male crop farmer, Kidepo Valley)

Across regions, we found variation in the zoonotic vectors to which women were exposed based on differences in gender norms and roles. In the next section we focus on men's risk of exposure to infection.

Men and risk of exposure to zoonotic pathogens

In all regions, the gendered roles of men and boys also expose them to various zoonotic disease transmission pathways. Most of the male-specific exposures relate to labour performed outside the home, although in some regions, cultural rituals surrounding manhood can also result in exposure.

Clearing bush, cultivating land, and collecting building materials

Participants in all regions described how the roles of men in clearing bush, digging, cultivating land, or collecting building materials from the forest near their homesteads exposes them to ticks and mosquito bites. In Bwindi and Mgahinga, Queen Elizabeth, Murchison Falls, and Pian-Upe it was mentioned that boys also participate in these activities. In Kidepo Valley the participants described the transmission of CCHF from ticks that transfer from the oxen to men while ploughing the fields. In Murchison Falls, farmers described that when digging in the garden mosquitoes bite them. In Lake Mburo-Nakivale, Kidepo Valley, Pian-Upe, and Murchison Falls collecting wood or building materials for construction was linked to tick and mosquito bites. A man in Kidepo, reflecting on infection risk, noted that:

> The role of men is always to look for construction poles and also fetching building materials. This role and responsibility affects their ability to engage in the preventive […] health care interventions for the three diseases mostly the Crimean Congo fever and the Rift Valley fever because men tend to move long distances in the forest to look for poles and in the process a tick or mosquito can bite him. (FGD, male farmer, Kidepo Valley)

As noted above, in the Kidepo area, women were exposed to the same risk through collecting building materials.

Tending to and slaughtering livestock

In all regions, tending to livestock is primarily the responsibility of boys and men. Cattle keepers from Queen Elizabeth indicated that culture dictated men's roles in livestock care and that women were not allowed to participate in these activities. Male livestock-related activities that were mentioned include grazing cattle and goats, assisting cows in giving birth, milking, slaughtering livestock and handling the raw meat, and cleaning and treating livestock for diseases. These different aspects of caring for livestock result in different types of exposure. Grazing livestock in the field exposes men and boys to ticks and mosquitoes. In the context of drought, in all six of our study areas, although observed to be most common in Lake Mburo and Queen Elizabeth, livestock graze alongside wildlife such as several antelope species and zebras whether inside

conservation areas or just outside them, increasing the likelihood of disease transmission between wildlife and livestock and then, by extension, the boys and men who tend the livestock.

Cleaning cows and treating them for brucellosis was mentioned as a role specifically for boys in Kidepo Valley and Queen Elizabeth. In all regions the consumption of raw milk while grazing cattle is common, primarily among boys, and in Pian-Upe and Kidepo Valley, respondents mentioned that boys and men also consume raw meat while grazing livestock. Hunger and an inability to start a fire in the field to cook food were mentioned as reasons why men and boys would consume raw meat and milk when grazing livestock.

> […] or I have gone to graze, I cannot fail to take my animal to the field to eat grass because I fear being infected with a disease and we do not have clothes that we use for grazing so the mosquitoes will bite you or the tick that comes from this cow you have taken for grazing can also go on you and bite you because you have not covered yourself very well. (FGD, male crop farmer, Murchison Falls)

> As when grazing the animals, some children milk cows and drink that milk unboiled and sometimes they end up getting sick of Brucella that came from milk and the milk that came from the cow (FGD, female crop farmer, Bwindi and Mgahinga)

The particular case of butchers was mentioned in Kidepo Valley where, a participant said, it is a cultural norm for butchers to taste the meat product they are selling.

Hunting and fishing

In Bwindi and Mgahinga, Kidepo Valley, Pian Upe, and Lake Mburo-Nakivale, hunting is a male-specific activity that results in exposure to zoonotic pathogens, through mosquito and tick bites. Another route of transmission from hunting is that men slaughter and consume the raw wild animal meat while in the bush. In Bwindi-Mgahinga, one key informant described how when men go out to poach, they look for weak animals, which are often the sick ones, and become exposed to disease from infected animals. A government official, a key informant in Lake Mburo-Nakivale, discussed hunting for sport, where men in communities carry out illegal hunting and eat infected meat. The key informant attributed this illegal hunting in part to communities wanting the wild animals kept out of their homesteads.

> Poachers and herdsmen are also exposed to disease because they have contact with animals most of the time and even during their activity of poaching and grazing they do consume half cooked meat from the bush since they don't have enough time to cook food very well. (FGD, Male crop farmer, Kidepo Valley)

The respondents from Murchison Falls, Lake Mburo-Nakivale, and Queen Elizabeth cited fishing as a male role and stated that this activity exposes men to diseases due to mosquitoes on or near the water. In Lake Mburo-Nakivale and Murchison Falls, boys also engaged in fishing and are therefore also at risk. In Queen Elizabeth, focus group participants specifically mentioned RVF as a disease affecting fishermen, and some mentioned that men use mosquito nets while fishing to protect themselves.

> Me I think the group of men is the one that is quickly affected by these diseases for example like us the fishermen, mosquitoes find us at the shores. (FGD, male fisherman, Lake Mburo-Nakivale)

In Lake Mburo-Nakivale, respondents described this exposure to mosquitoes being particularly high during the rainy season, heightening the risk of infection for those working in infested sites.

Cultural practices surrounding initiation into manhood

Participants from Kidepo Valley and Pian Upe described men's exposure to disease through consumption of raw meat and blood as part of a cultural practice for initiation into manhood. Female and male participants alike described the importance of these cultural rituals. The ceremonies involve males of different ages, and different positions in the community (including community elders and boys) who take part in these practices. Women and girls are not allowed at these ceremonies.

> Ok I want to talk about men with regards to cultural beliefs like in Napore here they say that if you reach 40 years and you have not gone to shrines 'ATHAPAN' (Initiation to manhood mostly by the elders) to eat that raw meat that you're not a real man. So there they say it's a mandate you have to go and the meat you are supposed to eat there is not the cooked meat but the raw meat. Now even if you know that if I do this I will get the disease there is no way you will prevent yourself from getting the disease. (FGD, female student, Kidepo Valley)

> Sometimes in the shrine the elders drink raw blood without being boiled which means one is exposed to brucellosis. (FGD, Male cattle keeper, Pian Upe)

Respondents from the other regions in our sample did not describe these initiation ceremonies in their settings.

Our findings show that both females and males risk exposure to zoonotic infections through their gendered productive and reproductive roles. However, in addition, we found that the activities people undertake differ across the regions of the cattle corridor, which also affects exposure risk.

Discussion

Our results from different geographical and community settings across six conservation areas in Uganda highlight how gender roles and norms impact exposures to three zoonotic infections: brucellosis, CCHF, and RVF. The different daily activities performed by women and men lead to differential risks of infection, suggesting that behaviour targeted and gender-sensitive interventions are required to address the risks faced by people living in these settings. This is further complicated by variations in how climate change affects each of the six landscapes studied, as highlighted at the beginning of this paper, which continues to impact exposures to zoonoses in ways that may be different by gender.

Both women and men are exposed to the three diseases in all six study sites. Both men and women mentioned exposure to mosquitoes and ticks, which are vectors for RVF and CCHF respectively, and both women and men also described consumption of raw meat and raw milk, which are risk factors for brucellosis. However, the activities and behaviours that expose women and men to these risks vary due to, for example, the gendered division of labour within the household, such as women's roles in processing dairy products and fetching water, and men primarily tending to and slaughtering livestock, hunting and fishing. These findings are consistent with previous studies that highlighted the ways in which a gendered division of labour impacts exposure to zoonotic disease in Côte d'Ivoire (Babo et al., 2022) and South Africa (Coyle et al., 2020; Oruganti et al., 2023).

However, we found that while some of the activities that increased risk of exposure to zoonoses were similar across regions, the diversity of communities included in our study revealed important differences, often based on a particular community's primary form of livelihood, and the gendered aspects of such livelihood activities. For example, in some (although not all) communities where cattle-keeping is a primary activity, women were more engaged in dairy processing and thus more often exposed to brucellosis than women who live in communities where crop farming is more common, creating an increased risk of exposure to RVF and CCHF for the women in those areas. In regions where people have fishing as an important part of their livelihood, men, who are the fish-catchers, are at an increased risk of exposure to mosquito-borne diseases such as RVF. Understanding how the gendered nature of livelihood activities are shaped by culture and the surrounding natural environment is essential in order to develop tailored strategies to reach different populations across different settings in Uganda and elsewhere.

Our findings illustrate how the health of both women and men, and domestic and wild animals, and the environment are interdependent suggesting that we not only require a One Health approach to intervention, but that using a gender lens in One Health is critical not only in considering different risks to women and men, but also the different contexts for their behaviours. For example, in our findings, both women and men consume raw milk, exposing them to brucellosis. For men, it was reported that herdsmen and boys tend to consume raw milk while they graze their livestock as they are hungry and have no ability to boil fresh milk as animals are grazing, a finding also reported

as a reason for raw milk consumption in pastoral communities in Côte d'Ivoire (Babo et al., 2022). However, for women in our study, the reason for raw milk consumption is related to cultural practices and beliefs. A gender perspective considers not only the different behaviours of women and men, but the different reasons contributing those behaviours. Understanding the socio-cultural context of these behaviours is important for developing effective approaches to prevention.

The provision of accurate information to women and men on how to prevent zoonoses might require different channels where women and men access information from distinct sources. However, while it is critical, alone, this is insufficient: knowledge and awareness of behaviours that create exposure to diseases do not necessarily translate to improved practices. Babo et al. (2022) found that men were more aware of brucellosis risks and transmission routes than women, but equally engaged in risky activities. In our study, many participants were aware of the risks and often identified brucellosis as a disease associated with practices such as consuming raw meat or milk, but still engaged in those practices. In some instances, such as the initiation ceremonies described in Kidepo Valley or brides in the Lake Mburo-Nakivale area consuming raw milk ahead of a marriage ceremony, the cultural importance of practices that are a source of exposure has implications for ensuring that targeted messaging and strategies for prevention are both gender and culturally sensitive.

In different ways across our study sites, climate changes will lead to opportunities for viral sharing among previously geographically isolated species of wildlife, and increased pressure on human/wildlife/environmental interactions whether due to increased rainfall or prolonged periods of drought. Gender-responsive messages that anticipate and address these changing needs for information and behaviour change will be critical to successful responses.

Limitations.

The characterisation of our sample is incomplete as data on age was not collected from 122 participants from the Queen Elizabeth and Bwindi and Mgahinga Conservation Areas. Some participants in mixed groups from Queen Elizabeth and Bwindi-Mgahinga conservation areas were not free to openly discuss sensitive topics due to age, marital status and gender differences. The participation of students was limited because the study was conducted during the school term.

While our study focuses on exposure risks, it is also important to consider the implications of gender and sociocultural norms on disease perceptions and approaches to management, in order to inform One Health strategies that are gender sensitive across prevention, treatment, and control interventions (Fusco et al., 2022).

Conclusions

As we have shown in this paper, applying a gendered lens to a One Health approach to zoonotic infections, highlights the ways in which the different activities performed by women and men lead to differential risks of infection, suggesting that gender-sensitive interventions are required to address the risks faced by people living in settings with inter-species contact. In the context of a changing climate and increasingly frequent environmental shocks creating new pressures on land use, there is likely to be an increase in inter-species contact, which can be anticipated to foster zoonotic disease transmission, with different impacts on women and men. Understanding the reasons underlying women and men's engagement in different infection risk behaviours can help inform co-creation of interventions with governments and communities that fill gaps in information and services and that meet communities' needs.

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Note

1. An administrative district in Uganda refers to a large geographical area overseen by district chairperson elected by local community, a chief administrative officer responsible for the civil administration and resident district commissioner representing the central government.

Data availability statement

To be provided in due course.

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