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Participation of livestock farmers and community animal health workers in one health intervention to control zoonotic diseases in Rwanda: a qualitative study

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Abstract

Background In zoonotic disease hotspots, engaging local communities in zoonotic disease monitoring and reporting is essential for effective prevention and early outbreak detection. In Rwanda, the Eastern Province has experienced nearly 90% of all zoonotic disease outbreaks. This qualitative study explored the participation of livestock farmers and community animal health workers (CAHWs) in One Health interventions aimed at controlling zoonotic disease outbreaks in Nyagatare district, Eastern Province, Rwanda.

Method Among livestock farmers and CAHWs, we collected qualitative data through in-depth interviews and focused group discussions. We held key informant interviews with district-level officials, namely district veterinary, district health, and district environmental health officers, to validate the data from livestock farmers and CAHWs. The data were transcribed verbatim and verified by replaying the audio recordings. Content analysis was performed.

Results Five major themes emerged as areas of participation: (i) capacity building focused on livestock management and livestock disease identification and prevention; (ii) community-level health education encompassing zoonotic disease risk communication and awareness raising; (iii) interruption of zoonotic disease transmission that comprised infection prevention and control, separation of sick and healthy livestock, quarantine, and zero grazing, adherence to guidelines, and the testing, treatment, spraying, and vaccination of livestock; (iv) collaboration with multiple sectors via training on zoonotic diseases, including its treatment, investigation, and prevention; and 5) zoonotic disease surveillance that included livestock monitoring and inspection for zoonotic diseases and the notification and reporting of zoonotic diseases to relevant authorities. The collaboration between the environmental health sector and the animal and human sectors was weak, while vaccination targeted mainly cattle but not small ruminants.

Conclusions Livestock farmers and CAHWs participate in several One Health interventions aimed at controlling zoonotic diseases, particularly in vaccination campaigns for cattle, community sensitization, and basic animal husbandry practices. However, collaboration between the environmental health sector and the animal and human

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sectors was weak, vaccination efforts largely excluded small ruminants, and some farmers relied on local herbs for treatment due to limited access to professional veterinary services. Efforts to sustain the major areas of participation are needed, while weaker areas need strengthening.

Keywords Community animal health workers, One health, Outbreak, Rwanda, Zoonotic diseases

Introduction

The East African region is biologically diverse, and the interactions between humans, domestic and wild animals are common, presenting an opportunity for zoonotic disease transmission and spread [1]. Evidence from Uganda's cattle corridor highlights that the human-livestock-environment interface, shaped by continuous livestock movements, contributes significantly to the emergence and spread of multiple infectious diseases. These include outbreaks of diseases such as trypanosomiasis, brucellosis, and anthrax, among others [2, 3]. To effectively prevent and control such zoonotic threats, it is crucial to involve community actors engaged along the livestock value chains, as their participation can enhance disease monitoring, reporting, and intervention strategies.

Globally, it is widely acknowledged that community involvement is a critical component of One Health interventions, particularly in the control of zoonotic diseases. Zoonotic diseases are infections that can spread from animals to humans and pose significant threats to public health, livelihoods, and food security. These diseases highlight the close interconnection between human, animal, and environmental health. The spread of zoonotic diseases resulting from livestock movements is prevalent in the Eastern province of Rwanda, particularly in Nyagatare district. The district frequently experiences zoonotic disease outbreaks, with the Rift Valley Fever outbreak in 2018 being the most recent and widespread [4]. Besides, the region has inadequate veterinary extension services and a shortage of water and feeds [5], hence worsening the risk of zoonotic disease outbreaks. Rift Valley Fever is also prevalent, as the majority of livestock farmers lack knowledge about its transmission and do not vaccinate their livestock despite existing vaccination campaigns [6].

Rwanda has institutionalized and operationalized the One Health concept, but effective community-level implementation has not been fully realized. The approach involves national coordination of interdisciplinary teams along with government collaboration, strengthening of surveillance systems for early zoonotic disease detection and response, and research at the interface of humans, animals, and the environment [7]. Additionally, there are efforts to control zoonotic disease outbreaks through vaccination and education campaigns. Despite existing efforts, zoonotic disease outbreaks remain prevalent in Rwanda, especially in Nyagatare district in the Eastern Province. Accordingly, we explored how livestock farmers

and community animal health workers (CAHWs) participate in One Health interventions that target the control of zoonotic diseases in Nyagatare district, Eastern Province, Rwanda.

In this context, One Health refers to a collaborative, multisectoral, and transdisciplinary approach that works at the interface of human, animal, and environmental health to prevent, detect, and respond to health threats [8]. This evidence will contribute to informing local efforts aimed at improving the control of zoonotic disease outbreaks in the district and the region.

Methods and materials

Study design and setting

This qualitative study was conducted in Nyagatare district in the Eastern Province, the largest and most densely populated province, with a total population of 3,563,145 people [9]. The province has seven districts, namely Bugesera, Gatsibo, Kayonza, Kirehe, Ngoma, Nyagatare, and Rwamagana, and the second-largest population of farmers [10]. Nyagatare district has the highest number of livestock and small ruminant animals compared to other districts in Rwanda. It borders Uganda's Kabale and Ntungamo districts, implying possible official and unofficial cross-border livestock movement and trade with Uganda to the north. Additionally, its proximity to the Akagera National Park increases its susceptibility to zoonotic disease outbreaks from wildlife animal reservoirs.

Ethical approval

This study received ethical approval from the University of Global Health Equity Institutional Review Board (Reference number: UGHE-IRB/2024/313, dated March 29, 2024). Administrative clearance was obtained from Nyagatare district before the data collection (Reference number: 3570/07/05/02/06/N.E, May 7, 2024). All participants gave voluntary and written informed consent after receiving information about the significance of the study, the benefits and risks, privacy, and confidentiality of information. Reporting of the findings adhered to the Consolidated Criteria for Reporting of Qualitative Research (COREQ) guideline [11].

Study population

We selected several stakeholders involved in livestock, namely livestock farmers, CAHWs, and district-level officials, namely Veterinary Officers, Health Officers, and Environmental Health Officers. Table 1 summarizes the

Table 1 Eligibility criteria

Participants	Inclusion criteria	Exclusion criteria
Livestock farmers	• Engaged in livestock farming for ≥ 5 years	• < 10 livestock (cattle and small ruminants)
District officers (veterinary, health, and environmental health)	• ≥ 5 years of work experience	• Newly transferred into the study area (< 12 months stay)
Community Animal Health Workers (CAHWs)	• ≥ 3 years of work experience.	• Newly transferred into the study area (< 12 months stay)

eligibility criteria. Livestock farmers and CAHWs were sampled by trained research assistants at milk collection centers, livestock markets, and small ruminant markets, while the district-level officials were sampled at their workplaces.

Livestock farmers were selected through a convenience sampling approach because it enabled easy access to the livestock value chain actors at the stated key points—milk collection centers, livestock and small ruminant markets, and workplaces. In addition, we focused on both large-scale livestock farmers and small ruminant farmers. CAHWs were selected via convenience sampling at the key points, as it eased their identification and access. All district officials were purposively selected as key informants. District officials with at least five years of experience were included to ensure sufficient practical knowledge and institutional memory regarding One Health and zoonotic disease control. Similarly, CAHWs with at least three years of service and livestock farmers with five or more years of farming experience were included to capture informed perspectives based on substantial field experience.

Data collection and variables

Data were collected via key informant interviews (KIIs), in-depth interviews (IDIs), and focus group discussions (FGDs). The KII guide (Additional file 1), IDI guide (Additional file 2), and FGD guide (Additional file 3) are attached as additional files. The topics for the KIIs, IDIs, and FGDs included what the participants knew about zoonotic disease outbreaks, whether they had ever heard about One Health including the source of the information, whether they had ever participated in the control of zoonotic diseases and what ways if they did, whether the human, veterinary/animal and environmental health professionals worked together with the community (livestock farmers and CAHWs) during zoonotic disease outbreaks and the importance of such participation. The data were collected by audio-recording of responses between June and July 2024 in a quiet and conducive place at the key points: milk collection centers, livestock markets, and small ruminant markets.

All data collection was conducted by trained and supervised research assistants with a minimum diploma in health or animal health sciences and extensive experience in qualitative research.

- a. **In-depth interviews (IDIs):** These targeted 12–20 CAHWs for inclusion in the study. The IDIs involved individuals who were not experts in One Health and explored their personal experiences and perspectives around One Health interventions. Interviews were conducted in the local language (Kinyarwanda) or English language depending on the preference of the participant. The IDIs, on average, lasted between 45 and 60 min. Some of the individuals who participated in the IDI were invited to voluntarily participate in FGDs thereafter.
- b. **Focused group discussions (FGDs):** We conducted four FGDs comprising 8–12 people per group to ensure productive discussion, ease the moderation, and foster active participation of all group members. To prevent idea suppression, no opinion was regarded as wrong. The FGDs were held for a homogeneous group of participants, one each for men, women, cattle farmers, and small ruminant farmers. In each FGD, participants were evenly balanced by sex, with a 1:1 ratio of men to women, to ensure that both male and female perspectives were equally represented. The disaggregation was needed because we anticipated the groups had unique challenges and different levels of participation in One Health interventions aimed at controlling zoonotic disease outbreaks. FGDs were conducted using an FGD guide that comprised open-ended and probing questions. Two individuals (JI and SH) conducted the discussion following participant mobilization by trained research assistants. JI holds a doctorate in public health and completed postdoctoral training in global health, along with significant experience in qualitative and mixed-methods research. SH holds a Master of Science in Global Health, specializing in One Health, and has a background in human medicine and surgery. SH has experience in qualitative research. Both JI and SH moderated the discussions, took field notes, and probed whenever needed. The field notes captured observations, contextual details, non-verbal cues, and reflections, and were analyzed alongside the transcripts to enrich interpretation and support data triangulation. The FGDs lasted 40–60 min.
- c. **Key informant interviews (KIIs):** This was conducted in English and targeted the district officials as experts or officials possessing specialized knowledge in One Health. The KIIs were held between 9.00 am and 2.00 pm, Monday to Friday,

lasting about 25–35 min. The time range was selected based on convenience for both the research assistants and the participants.

Statistical analysis

The sample size estimation was guided by the saturation principle—a point at which no new information emerges even when additional data are collected, as reported in previous studies [12, 13]. However, a priori sample size to reach the saturation principle was determined and comprised four FGDS, each with 8–12 people (overall, 32–48 people), three district officials (one District Veterinary Officer, one District Health Officer, and one District Environmental Health Officer), and 12–20 CAHWs.

For data analysis, the audio-recorded responses were transcribed verbatim (word for word) and verified by replaying and reading several times. Discrepancies between the audio recordings and the transcripts were identified and corrected. A few transcripts were first reviewed and coded, producing a preliminary codebook to guide the coding of the remaining transcripts. To prevent subjective bias, two analysts (JI and SH) analyzed the transcripts independently and thereafter harmonized the individual transcripts, producing the final codebook. In brief, the analysis included familiarization with the transcripts by reading and re-reading them several times, identifying common and important texts and patterns while allowing impressions to shape the data interpretations in different and unpredictable directions. The transcripts were coded using the preliminary codebook by flagging the relevant sections with meaningful words, followed by grouping similar codes to form categories and then grouping the categories to form sub-themes and themes. A third data analyst (AS) reviewed the final codebook. AS holds a doctorate in veterinary medicine and has several years of research experience in the study area. Data from FGDS, KIIs, and IDIs were analyzed both separately and collectively to identify overarching themes. Each theme was presented along with quotes from the participants.

Quality control measures

All the KII and IDI guides were pre-tested on a few participants in Burera district, a site that was outside and distant from the study area. The pretesting ensured the questions were appropriate and precise, as feedback was solicited and used to revise the data collection tools. The research assistants received three days of training focused on responsible research conduct, study protocol, and interviewing techniques.

Table 2 Characteristics of KIIs and IDIs participants

Variables	Level	Overall (n = 12)
Type of participant	CAHWs	8
	District Health Officer	1
	District Veterinary Officer	1
	Environmental Health Officer	1
	Para-veterinarian	1
Method of data collection	IDIs	8
	KIIs	4
Sex	Female	3
	Male	9
Age category (years)	Less than 40	3
	40 and over	9
	mean (SD)	46.3 (7.5)
Work experience (years)	5–9 years	2
	10 years and over	10
	Mean (SD)	9.67 (1.74)

Note: SD: standard deviation. Data for KIIs and IDIs are presented at the individual level. For FGDS, individual-level data were not collected or analyzed

Table 3 Summary of emergent themes and sub-themes

Themes	Sub-themes
A. Capacity building	A1. Livestock management. A2. Livestock disease identification and prevention.
C. Community-level health education	B1. Risk communication B2. Awareness raising
C. Interrupting zoonotic disease transmission	C1. Infection prevention and control C2. Separation of sick and healthy livestock. C3. Quarantine C4. Zero grazing C5. Adherence to guidelines. C6. Testing, treatment, spraying, and vaccination
G. Collaboration with multiple sectors	D1. Disease treatment, investigation, and prevention. D2. Training.
I. Zoonotic disease surveillance	E1. Livestock monitoring and inspection E2. Notification and reporting

Results

Characteristics of participants

From the KIIs and IDIs combined, 12 participants were interviewed (Table 2). Of those, eight were CAHWs, three were female, nine were aged 40 years and over, and 10 had ≥ 10 years of work experience. The overall mean age was 46.3 ± 7.5 . Additionally, we held four FGDS that comprised 8–12 people each. A total of 42 participants took part in the four FGDS (10, 11, 12, and 9 participants, respectively).

Emergent themes and sub-themes

We summarised the emergent themes and sub-themes in Table 3. Five major themes emerged as areas of participation: (i) capacity building focused on livestock

management and livestock disease identification and prevention; (ii) community-level health education encompassing zoonotic disease risk communication and awareness raising;

iii) interruption of zoonotic disease transmission that comprised infection prevention and control, separation of sick and healthy livestock, quarantine, zero grazing, adherence to guidelines, and the testing, treatment, spraying, and vaccination of livestock; iv) collaboration with multiple sectors regarding training on zoonotic diseases and its treatment, investigation, and prevention; and 5) zoonotic disease surveillance that consisted of livestock monitoring and inspection for zoonotic diseases and the notification and reporting of zoonotic diseases to relevant authorities.

Capacity building

Livestock management Participants indicated receiving training in livestock management that targeted animal health care and good pasture management practices. Training improved their understanding of zoonotic diseases and assisted them in preventing zoonotic diseases on the farm.

We learned (during the training on livestock management) about cattle rearing, pasture management, forage preservation, and how to prevent and treat diseases in cattle (IDI, CAHW, Female, 42 years).

I had the opportunity to attend training organized by an institution called RICA (Rwanda Inspectorate Competition and Consumer Protection Authority). RICA is one of the institutions that has helped inform us about certain diseases that can be transmitted from animals to humans. (FGD, Cattle Farmers Group).

Even though the participants were trained, not all of them had the same level of understanding about livestock and pasture management. A few participants mentioned that:

I have attended training in 'Animal Health Care,' so I have some idea about it. However, generally speaking, not all community members have the same level of understanding (IDI, CAHW, Male, 55 years).

Various training sessions have been conducted with the help of MINAGRI (Ministry of Agriculture and Animal Resources). Specifically, cattle farmers have gained knowledge about these diseases. However, there are still some farmers who may not fully understand; for example, if a cow dies possibly due to disease, they might still sell it to others who are

not livestock farmers and who have not undergone any training (IDI, CAHW, Male, 55 years).

Livestock disease identification and prevention The participants reported that the training they had received helped them to easily identify zoonotic diseases among the livestock, allowing them to take early preventive measures such as providing first aid.

The new thing we (people involved in livestock) do after completing the training is that we can recognize diseases that primarily affect cattle and administer first aid before the veterinarian arrives. This ability helps us to prevent diseases that cattle transmit to humans because we were trained. Specifically, in this area of Nyagatare, the training started with 200 individuals, and later, many were trained. This has had a positive impact, like the incidence of diseases (zoonotic diseases) has decreased by about 70% because now we have over 1,000 trained individuals in the district (IDI, CAHW, Male, 55 years).

The training sessions involved all levels of key stakeholders coming together in this activity. I think it was beneficial, helping people understand the impacts and issues in solving and especially preventing these zoonotic diseases that spread among both humans and animals. (KII, Para-veterinarians, Male, 49 years).

Community-level health education about zoonotic diseases

Risk communication Whenever there was a zoonotic disease outbreak, information was provided about its potential risk of transmission, severity, and impact on humans and animals. The participants stated that they actively engage in communicating the associated risks to the community. In particular, they mentioned the aims of risk communication as informing and educating livestock farmers and the community about zoonotic disease transmission risks, including the mitigation measures.

The first thing is that when an outbreak (zoonotic disease outbreak) occurs, we are the first to have a role in communicating it to the community. We talk about it in our neighborhoods and community meetings so that every resident is informed about these zoonotic diseases. (IDI 2, 47 years, Male).

We (small ruminants and cattle owners) notify the government, which then steps in to provide medication and set up quarantines to ensure that the infected cattle are kept separate and fed separately. If an animal does not recover, the government helps

us to sell it off and replace it with healthy ones. (FGD, Small ruminants, and cattle owners).

when to perform certain tasks. (IDI, CAHW, Female, 46 years).

Awareness raising Awareness raising involved the process of ensuring livestock farmers remained informed or knowledgeable about zoonotic diseases. The participants reported that awareness-raising campaigns were crucial in risk communication because they enabled them to understand and appreciate the risks of zoonotic diseases and the appropriate mitigation measures.

As public health authorities raise awareness and provide information about zoonotic diseases, although implementation can be slow, there are signs of progress where the community gradually becomes involved. (IDI, CAHW, Female, 42 years).

Awareness is key. When people are educated [made aware], they understand; when they understand, they can protect themselves; and when they protect themselves, about 80% of the time, they stay healthy. (IDI CAHW, Male, 54 years).

Our community has developed a high level of awareness. When they are advised to halt cattle movements, they comply; this is because the majority have participated in training programs. (IDI, CAHW, Male, 55).

Interruption of zoonotic disease transmission

Infection prevention and control Participants reported using personal protective equipment (PPE) to control zoonotic diseases. Certain PPE, such as hand gloves and aprons, was mentioned to have been stringently used during outbreaks. Environmental measures such as the cleaning of kraals have been highlighted as one of the approaches for preventing zoonotic diseases.

I immediately understand that there is a disease (zoonotic disease) and start protecting myself (using personal protective equipment) and my livestock. (IDI, CAHW, Female, 46 years).

Diseases are reduced by more than 90% because the primary method of preventing disease in cattle involves maintaining cleanliness and hygiene. So, in a well-maintained environment where it doesn't pick up diseases from various places because the ticks found in those woods originate from the grass in the pastures (KII, Male, 37 years).

The first step is cleanliness in livestock management—keeping the areas where they raise livestock clean. The second step is about timing—knowing

Separation of sick and healthy livestock The participants mentioned that zoonotic diseases spread when sick (diseased) animals/livestock are kept together with healthy ones, allowing easy transmission of pathogen-causing diseases from one animal to another. They mentioned that during zoonotic disease outbreaks, they separated the sick and healthy animals to interrupt disease transmission. They further stated that they separated animals that were suspected to be sick from the healthy ones.

Another important action is to isolate themselves (those infected animals) to prevent spreading the disease to other animals. (IDI 2, 47 years, Male).

The role of the livestock owner is to recognize that he needs to prevent further spread. He starts by isolating the affected area immediately, and then, the medications. The veterinarians are the ones who know how to treat with medications. (IDI, CAHW, Female, 46 years).

Then I would know for sure that if it is (livestock or cattle) suffering from brucellosis, and could isolate it before it affects other cattle, because a sick cow that tries to conceive can infect others (livestock or cattle) (FGD, Cattle Farmers Group).

Quarantine Quarantine ensures that diseased animals are not moved from one area with a zoonotic disease outbreak to another without the outbreak. The participants stated that whenever a zoonotic disease outbreak occurred, they participated in implementing quarantine.

It might be that one person reports a sick animal, and the government people from the district and people from the province all come together, they come to test the animals, quarantine the sick ones, and take care of them. The Ministry of Agriculture and Animal Resources really supports us closely" (IDI, CAHW, Male, 54 years).

Also, when they (livestock farmers) are told to stop movement (quarantine), they comply with the measures to ensure the quarantine period passes so the cattle can be moved again. Thus, the locals are the ones with the highest priority in compliance because if they don't, the issue won't be resolved. (KII, Male, 40 years).

Zero grazing Zero grazing was reported as a useful strategy that prevented the spread of zoonotic diseases. Using

this approach, the participants reported that livestock were kept their livestock under confinement and fed on harvested fodder rather than being allowed to graze on pasture:

During a livestock epidemic, especially for those who herd their animals like goats in public spaces—which is not allowed during an outbreak—we have specific measures. There was a person responsible here who would instruct those herding goats to put muzzles on them, made from a type of fabric, to prevent them from grazing near other animals. They are taught how to tether the goats close to their homes instead of letting them roam freely. (IDI CAHW, Female, 41 years).

The residents have fenced their properties, and we have noticed this has had an effect [reduce zoonotic disease spread] because the cattle no longer stray outside. For instance, there was an outbreak of Rift Valley Fever in 2020, but we have not seen it recur in the last 4 years. (IDI, CAHW, Male, 55).

Zero grazing by encouraging the policy of breeding in sheds and placing the cattle in sheds, but also ensuring that the cattle have what they need close by, water, and grass they can graze on. It is not about them [Cattle] wandering off far. (KII, Male, Age 39 years).

Adherence to guidelines The participants indicated that they adhered to zoonotic disease guidelines. They indicated that adherence to the guidelines protected both human and animal health by preventing outbreaks and maintaining a safer and healthier environment. Other notable advantages mentioned included the prevention of disease transmission and the reduced risk of outbreaks.

The primary role of a community member when there is an issue like this is to implement the guidelines provided. That was the only role they had when there was an outbreak. The authorities set the guidelines, but it's up to the community members to follow them. There's also a need to ensure that these guidelines are being followed by the community members. (IDI, CAHW, Female, 42 years).

Their (Livestock farmers) role during an outbreak or even before, is to follow the guidelines provided by local authorities or us who often talk about primary authorities or livestock officers. (KII2, Male, Age 39 years).

At that time [during zoonotic disease outbreaks], authorities issued guidelines and restrictions informing community and livestock owners not to move or pass through certain areas to contain the

problem and prevent its spread. (FGD, Cattle Farmers Group).

Testing, treatment, spraying, and vaccination Testing of livestock and humans for zoonotic diseases and early treatment of diseased livestock were reported as critical One Health activities aimed at preventing zoonotic disease. The participants reported that they ensured cattle that appeared sick were tested for diseases and those found sick were treated early. At the community level, they reported that whenever the livestock farmers felt sick, the formal healthcare system was contacted to enable early testing and diagnosis. They said such actions contributed to preventing zoonotic diseases in the area:

(...)... People agreed to be tested for zoonotic diseases at the location [where the cases had occurred and even those around there] because many fear zoonotic diseases, saying “let me get tested, you never know, I might also have it”. So, participation in getting tested was at a high level, nobody refused to provide samples (KII, Male, Age 39 years).

The community [especially since someone grows up with livestock from childhood] gains experience—even without formal education—and starts to recognize symptoms. They primarily rely on observable signs to say things like when a cow behaves like this, it usually means it has mastitis or something like zoonotic disease. They try to find treatments on their own, although there are things they might not fully understand, and sometimes they attempt to handle it with whatever medicine they can get. That's the kind of role I think people play. (IDI, CAHW, Female, 42 years).

For me, it's the disease of tuberculosis (TB). It was from this sector of Tabagwe. I was the one who took that child to the hospital, and they told me it was tuberculosis caused by drinking milk from an infected cow. That's what happened. (FGD, Small ruminants, and cattle owners).

Livestock disease treatment was done mostly by veterinarians and para-veterinarians, especially if the livestock farmer was able to pay for the veterinary services. However, the treatment of livestock using local herbs was equally reported by some of the participants, especially if the farmer had no money to pay for professional veterinary services:

We (the livestock farmers) usually treat (zoonotic diseases) with the help of the sector veterinary doctor who comes to assist us. He administers medicine to the cattle and any other animal, and if an animal

has a problem, maybe if it has died, they bury it to prevent the community from eating it and getting infected (IDI CAHW, Male, 44 years).

Regarding treatment, we have breeders who can administer treatments themselves—not that it is allowed, but because they have been doing it for a long time. For example, if a breeder knows his cow might have a fever, like Rift Valley Fever or other diseases, he could go to a pharmacy, buy medicine, and administer it himself (KII, Male, 39 years).

We also have what we call the paravets (Para-veterinarians) here, who are individuals with some basic veterinary training who can treat their livestock. But we still have a gap because the number of breeders we have and the staff available to provide services to them is still small, so this gives room for a breeder who might not find someone to help him to do it himself. (KII, Male, 39 years).

Vaccination and chemical spraying have been mentioned as measures that were implemented to protect both animals and humans, hence preventing zoonotic disease outbreaks.

(...). the policy is to vaccinate. You see, the practice of vaccination ensures that no new cases of brucellosis occur. Once an animal (cattle) is infected, it is done, but those not infected will not get infected. (IDI, CAHW, Female, 46 years).

When there's an epidemic, the community members do not treat themselves. I saw a good system the other day where doctors came to the village and went from house to house to vaccinate. It is not like they just come and vaccinate the cows and leave. They come to your house to vaccinate, then to my house, and so on, ensuring everyone is covered. So, during an epidemic, community members don't treat themselves. (IDI, CAHW, Female, 42 years).

We noted gaps in vaccination during the FGDs. It emerged that vaccination mainly focused on cattle, but the small ruminants were often forgotten:

Even the veterinarians, when they vaccinate, they focus on cows and dogs, but not goats. The small livestock, like sheep, unless you have a farm specifically for them, but for those of us who have goats, cows, and sheep, they focus on the cows. We do not care much about the goats. If it dies, it dies and is eaten. (FGD, Small ruminants, and cattle owners).

Certain participants indicated chemical spraying on the farm as one way through which they participated in One Health activities that targeted zoonotic disease outbreak

prevention. In particular, chemical spraying of livestock under the guidance of veterinarians, para-veterinarians, and CAHWs was emphasized:

Farmers of this place (Nyagatare) know that spraying (using chemicals) is a must and that it should be timely; so, we use insecticides that fight some of the pathogens that cause zoonotic diseases, and secondly, we follow up the animals daily. (IDI, CAHW, Female, 46 years).

Collaboration with multiple sectors

Disease treatment, investigation, and prevention Participants indicated that the human, animal, and environmental health sectors worked together whenever there was a zoonotic disease outbreak. They mentioned livestock treatment, outbreak investigation, and the implementation of preventive measures as the main areas for collaboration with multiple sectors:

Interventions often happen simultaneously. Just like here in the district, if that illness is detected, we immediately collaborate with people from hospitals. Even though it has not reached a satisfactory level yet, now if a disease known to affect humans arises and if we have a livestock issue, they must also be aware, so we can fight it together [multi-sectoral collaboration]. (KII, Male, Age 39 years).

We had two cases of cattle bleeding, and it was necessary for RAB (Rwanda Agricultural Board), together with the hospital, to take samples from these cattle. We also took hospital staff to take samples from the animals and the people living with these animals, starting with the herders and the owners, to confirm and ensure there was no problem after a case of Rift Valley fever that had spread across the country (KII, Male, Age 39 years).

For me, it is the disease of tuberculosis (TB). It was from this sector of Tabagwe [a village in the district]. I was the one who took that child to the hospital, and they told me it was tuberculosis caused by drinking milk from an infected cow. That is what happened. (FGD, Women's Group).

Challenges regarding collaboration with multiple sectors were raised, however. For example, the participants indicated that the collaboration between environmental health and the animal and human sectors was weak.

We mostly worked with the Ministry of Agriculture and Animal Resources (MINAGRI). We did not see any involvement from the human health or environmental sectors (KII, Male, 47 years).

I have not seen environmental experts in such settings. Our meetings typically include representatives from MINAGRI (Ministry of Agriculture and Animal Resources), RAB (Rwanda Agricultural Board), and sometimes medical personnel, but not those from environmental sectors. (FGD, Men's Group).

Training The participants mentioned that the human, animal, and environmental sectors collaborated during the training of livestock farmers about zoonotic diseases. It also emerged that private and public partnerships, although not common, were used to ensure the training reached all livestock farmers to prevent zoonotic diseases.

People often meet during training sessions. We have various training sessions, whether for community health advisors or community animal health workers; we bring them together depending on the training they are about to receive, in collaboration with various partners (human, animal, and environmental sectors, and private and public sectors). (KII, Male, 37 years).

We train community health advisors and meet with community animal health workers in agriculture to prevent these (zoonotic) diseases. You see, that was an activity that brought together different sectors, both those working in agriculture and those in health, and we would bring them together for training. (KII, Male, 37 years).

I have attended training in animal health care, so I have some idea about it. However, generally speaking, not all community members have the same level of understanding (FGD, Cattle Farmers Group).

Zoonotic disease surveillance

Livestock monitoring and inspection Routine monitoring and inspection of livestock was mentioned as one of the One Health activities aimed at controlling zoonotic diseases. Livestock farmers reported that they monitored their livestock for certain zoonotic diseases, but the largest role was played by veterinarians, CAHWs, and para-veterinarians. Monitoring and inspection were reported to have contributed to the early identification of zoonotic diseases, including supporting efforts to prevent the spread. Inspection of dead animals for zoonotic diseases was another activity mentioned.

Nowadays, where people often interact with veterinary doctors, no one is allowed to eat an animal (cattle) that has died of disease or one that has not been inspected. We have been fortunate in that

regard. Previously, we would eat them without any concerns. (IDI CAHW, Male, 54 years).

Residents (cattle keepers) play a key role (in prevention and protection efforts against diseases) by monitoring and reporting any unusual occurrences with their livestock, ensuring any issues are addressed quickly. (IDI CAHW, Male, 44 years).

Notification and reporting Zoonotic disease notification and reporting are essential components of disease surveillance and control efforts. The participants stated engaging in zoonotic disease identification by working with healthcare providers and veterinarians to suspect the diseases. They mentioned participation in zoonotic disease notification by informing appropriate authorities, such as the local human and animal health authorities, and reporting the diseases to national authorities, such as the Ministry of Agriculture and Animal Resources and the Rwanda Agriculture Board.

The primary role of a community member should be to act as a watchdog for their peers (livestock keepers) and the community. They should report information promptly so that those responsible for treating these diseases can do so on time before they spread further. I believe this is the role that a community member should play. (IDI 2, 47 years, Male).
When there is an outbreak of a disease, we have a community informer who goes door to door informing people about the outbreak. Once everyone is aware, we exchange information to ensure everyone knows how to protect their homes. (IDI CAHW, Female, 41 years).

Discussion

This study explored the participation of livestock farmers and CAHWs in One Health interventions aimed at controlling zoonotic disease outbreaks in Nyagatare District, Eastern Province, Rwanda. The study showed that livestock farmers and CAHWs mainly participated in capacity building, community-level health education, and activities that interrupted zoonotic disease transmission, including collaborating with multiple sectors and zoonotic disease surveillance. Livestock farmers and CAHWs also engaged in capacity building activities that focused on livestock management and disease identification, and prevention. The participants emphasized that the capacity building activities improved the community ownership of One Health interventions aimed at controlling zoonotic disease outbreaks.

The study findings are consistent with another study conducted in Cameroon that found informal education

among poultry farmers through training workshops and seminars improved their knowledge and skills on zoonotic disease transmission risk and prevention [14]. Training is also crucial in halting risky practices such as the sale of infected or condemned beef to the public, as it places the public at risk for zoonotic diseases [15], including raising awareness about zoonotic diseases. Participation in community-level health education included risk communication and awareness raising about zoonotic diseases in the community, consistent with a past study [16]. In particular, risk communication and awareness raising are important for zoonotic disease control measures as they improve the adoption of existing preventive health measures and adherence to guidelines by reducing community-level resistance [17].

The study also showed that livestock farmers and CAHWs participated in disease transmission preventive activities such as infection prevention and control measures, separated sick and healthy livestock, strict adherence to quarantine, and adopted zero-grazing practices. Personal protective equipment (PPE) and environmental cleanliness were used to interrupt zoonotic disease transmission, and this finding is consistent across several studies in Africa and beyond [14, 18–22].

PPE like gloves and face masks, hand hygiene practices such as frequent handwashing with soap and water, and the invitation of veterinary professionals for farm visits helped to control zoonotic diseases. These findings are consistent with a past study that showed the maintenance of good hygiene practices in cow enclosures through regular cleaning prevents infectious disease outbreaks [23].

The findings regarding the separation of sick and healthy livestock and adherence to quarantine measures are consistent with the One Health approach that emphasizes the significance of maintaining barriers between natural animal reservoirs and humans when preventing spillover of viruses and other pathogens [24, 25]. Additionally, these measures are key aspects of the One Health framework aimed at effectively preventing and controlling zoonotic diseases [26]. However, it is important to recognize that separating sick animals largely reduces animal-to-animal transmission and may not fully protect humans, especially when handlers do not use PPE. These findings underscore the need for integrating safe handling practices and protective measures to prevent zoonotic transmission.

Zero-grazing is widely used to prevent zoonotic disease outbreaks because it ensures livestock are confined, allowing them to feed on a diet of hay, silage, or other types of harvested fodder, hence preventing them from mixing with other livestock. Besides, zero grazing has added benefits such as improved animal health and welfare, increased milk and meat production, reduced land use and soil erosion, better manure management,

and reduced labor requirements. Conversely, quarantine prevents the movement of diseased livestock, including their products such as meat and milk, from places known to have zoonotic disease outbreaks to places without such outbreaks, thus preventing disease spread. Quarantine is thus a useful tool for preventing the transmission of not just zoonotic disease outbreaks but several other outbreaks that have the potential to reach significant proportions at the population level. Vaccination and chemical spraying have been highlighted as approaches that prevent zoonotic disease outbreaks. These findings are consistent with one study in Uganda that reported pyrethroid-treated netting around zero-grazing units as being effective in protecting dairy cattle from diseases such as trypanosomiasis [27].

Adherence to zoonotic disease guidelines, early testing and treatment of sick livestock/animals, and the monitoring and inspection of livestock for zoonotic diseases have been highlighted to contribute to preventing and controlling zoonotic diseases, including adherence to existing guidelines. However, one study showed that infection and prevention control measures are not always adhered to, and factors that influence compliance are not exclusively based on knowledge and experience [28]. Therefore, community-level health education might play an important role in improving compliance with the guidelines, including overall infection prevention and control practices among livestock farmers by increasing knowledge and promoting risk-mitigating behaviors.

The present study revealed zoonotic disease notification and reporting as one of the One Health activities for controlling zoonotic diseases. The finding is consistent with previous studies [29–33]. Notification is important in alerting the public and animal health authorities about potential zoonotic disease outbreaks, enabling swift response and control measures, providing data for disease surveillance and monitoring, facilitating collaboration and information sharing between the human and animal health sectors, and informing policy and decision-making [32]. In particular, timely and accurate zoonotic disease notification and reporting contribute to preventing disease spread, reducing the risk of disease outbreaks, protecting human and animal health, and enabling effective disease management and control. Notable zoonotic diseases that require notification and reporting include rabies, avian influenza, salmonellosis, leptospirosis, and brucellosis, among others.

Our study revealed that collaboration among the human, animal, and environmental health sectors occurs primarily during zoonotic disease outbreaks, but it is limited and particularly weak between the environmental sector and the other sectors. The collaboration focuses on zoonotic disease treatment in both humans and animals, epidemic investigation, and zoonotic disease prevention,

including the involvement of the human, animal, and environmental sectors in training livestock farmers and CAHWs. This finding is consistent with the One Health approach to disease prevention and control. The downside of the collaboration was the limited involvement of the environmental health sector with the animal health sector, which is a common trend across the One Health spectrum [34]. The environmental health sector tends to disassociate itself, although it has immense relevance when it comes to animal-assisted interventions.

Collaboration with multiple sectors has the benefit of fostering effective coordination and communication among professionals in the human, animal, and environmental health disciplines at the national, regional, and global levels in tackling zoonotic diseases [35]. This does not require further emphasis, but must be upheld. For example, Rwanda adopted a multi-sectoral approach that relied on the establishment of a strong, well-coordinated response mechanism comprising professionals in healthcare, public health, health policy, epidemiology, veterinary, virology, and others in the human, animal, and environmental health domains to successfully control the COVID-19 pandemic [17, 36]. In Uganda, the collaboration between the Ministries of Agriculture, Animal Industry, Fisheries, Wildlife, and Health led to the successful control of brucellosis and was more cost-effective than conducting two separate investigations (one by the Public Health Team and the other by the Animal Health Team) on the same farms [37]. Therefore, with the majority of zoonotic diseases having a connection between humans, animals, and the environment, the significance and role of a multidisciplinary collaborative team approach cannot be overstated. A typical multidisciplinary team would comprise epidemiologists, microbiologists, veterinary pathologists, wildlife ecologists, physicians, veterinarians, laboratory technologists, and media specialists. Such teams have successfully controlled brucellosis in Uganda [37]. The study findings, therefore, emphasize a need for healthcare providers, veterinarians, and the public to collaborate in zoonotic disease prevention and control, including surveillance and training, among others.

Future directions

Future research should focus on strengthening multidisciplinary collaboration within the One Health framework, particularly by more actively involving the environmental health sector. Pilot initiatives that integrate environmental, human, and animal health expertise through joint training, coordinated outbreak investigations, and shared surveillance systems could be explored and evaluated for impact. There is also a need to assess the effectiveness and scalability of capacity building and community-level health education interventions.

Observational or experimental studies could evaluate how these activities may influence zoonotic disease incidence and identify approaches to reach more diverse farmer and CAHW populations. Lastly, monitoring and innovation in preventive practices (quarantine, zero-grazing, vaccination, and PPE use) should be prioritized, with research identifying barriers to consistent implementation of these measures by farmers and CAHWs and strategies to improve compliance.

Study strengths and limitations

This study is the first to report on the participation of livestock farmers and CAHWs in One Health interventions aimed at controlling zoonotic diseases in Nyagatare district, where nearly 90% of zoonotic disease outbreaks in Rwanda have originated over the years. We collected data from key individuals such as professionals in the animal, human, and environmental health sectors to triangulate the findings from livestock farmers and CAHWs and improve the reliability of the results. The data analyzed were collected until saturation was reached, ensuring the evidence generated was adequate and detailed. The study limitations include possible self-reporting bias, which we mitigated through rigorous follow-up and probing questions. Interviewer biases were likely, although all research assistants received training about the study protocol and data collection tools, and pre-testing of the data collection tools. Furthermore, some of the audio recordings were reviewed daily, and feedback was given to the research assistants to ensure rigorous data collection. We verified all transcripts for accuracy before the data analysis to minimize errors. We employed a non-random sampling approach, which might have introduced sampling bias. However, the sampling approach was the most appropriate, and the limitations were minimized by reaching data saturation. Another potential limitation of our study is that, while we documented several ways in which farmers and CAHWs engage in activities reflecting the One Health approach, not all interventions fully implemented a multidisciplinary collaboration across human, animal, and environmental health sectors. This may have limited the extent to which the observed activities represent the complete spectrum of One Health interventions.

The data analyzed are based on opinions and self-reports from farmers and CAHWs rather than observational or experimental measurements. Also, although we made efforts to recruit participants who represented the diversity of these groups, the sample may not fully capture the heterogeneity of experiences and perspectives within the broader population of farmers and CAHWs. Therefore, the findings should be interpreted within the context of the sampled population, and caution is warranted when generalizing to other settings or groups.

Conclusions and recommendations

The study revealed that livestock farmers and CAHWs participated in several One Health interventions aimed at controlling zoonotic diseases, particularly in vaccination campaigns for cattle, community sensitization, and basic animal husbandry practices.

However, collaboration between the environmental health sector and the animal and human sectors was weak, vaccination efforts largely excluded small ruminants, and some farmers relied on local herbs for treatment due to limited access to professional veterinary services. Efforts to sustain the major areas of participation are needed, while weaker areas need strengthening.

Abbreviations

CAHW	Community Animal Health Workers
FGD	Focused Group Discussion
IDI	In-depth Interview
KII	Key Informant Interview
PPE	Personal Protective Equipment
SD	Standard deviation
FMD	Foot-and-Mouth Disease

Supplementary Information

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Supplementary Material 1

Supplementary Material 2

Supplementary Material 3

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Author contributions

JJ, SH, and AS conceptualized the study. JJ and SH collected the data. JJ analyzed the data. JJ and SH interpreted the results. JJ drafted the manuscript. All authors (JJ, SH, and AS) reviewed and approved the final version of the manuscript for submission.

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Data availability

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval

This study received ethical approval from the University of Global Health Equity Institutional Review Board (Reference number: UGHE-IRB/2024/313, dated March 29, 2024). Administrative clearance was obtained from Nyagatare district before the data collection (Reference number: 3570/07/05/02/06/N.F,

May 7, 2024). All participants gave voluntary and written informed consent after receiving information about the significance of the study, the benefits and risks, privacy, and confidentiality of information.

Consent for publication

No consent for publication was required for this work.

Competing interests

The authors declare no competing interests.

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