Odessa centre | Pastoralism Research, Policy and Practice

TYPE Original Research
PUBLISHED 24 September 2024
DOI 10.3389/past.2024.13468

OPEN ACCESS

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RECEIVED 30 June 2024
ACCEPTED 11 September 2024
PUBLISHED 24 September 2024

CITATION
Sentamu DN, Arasio RL, Akala H, Makau DN, Wasonga OV and Onono JO (2024) Stakeholder analysis and their roles in livestock disease reporting and response in Northern Kenya. *Pastor. Res. Policy Pract.* 14:13468. doi: 10.3389/past.2024.13468

Stakeholder analysis and their roles in livestock disease reporting and response in Northern Kenya

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Introduction: Livestock are central to pastoral livelihoods. A major constraint in pastoral production is livestock diseases, which is often exacerbated by inadequate surveillance systems. Reporting of disease outbreaks from pastoral communities to animal health workers is one of the challenges that affects effective and timely response to disease outbreaks. This study aimed to understand animal disease reporting and response in pastoral areas of Northern Kenya. Stakeholders, their roles, information flow among them and methods used for both livestock disease reporting and response and their strengths and challenges were identified.

Methods: The study was carried out in Marsabit County, a pastoral county in Kenya. Pretested tools were used to guide data collection through Focus Group Discussions, Narrative and Key Informant Interviews with pastoralists, County government Animal Health Workers, agrovets and private animal health workers, Community Disease Reporters, Chiefs, County Public Health Officers and local Non-Governmental Organization staff. Net mapping was further used where participants drew links among the various stakeholders and assigned them perceived influence and power. Output from thematic analysis, notes taken during data collection and net maps were used to produce a network of stakeholders and their links using Gephi software. Centrality measures were generated and recorded. Perceived power and influence scores were used to produce a graph and the reasons for the scores documented. Methods used for livestock disease reporting and response were obtained from thematic analysis.

Results: A network of 19 stakeholders with 67 links among them was identified. Major stakeholders were the Animal Owners/Pastoralists, Government Animal Health Workers, County Director of Veterinary Services, the Chief and radio based on network indices of Total degree and Betweenness Centrality, and also based on perceived scores of influence and power. Pastoralists had pivotal roles in both livestock disease reporting and response, Government Animal Health Workers (GAHWs) were mainly involved in disease surveillance and mass

interventions including treatment and vaccinations. Non-state actors like NGOs and iNGOs collaborated and supported the County Government with resources to manage outbreaks. Various methods were used for reporting diseases, with use of mobile phones highly mentioned while for response to disease occurrences, the methods included trainings and treatment by both Government and Private AHWs and use of alternative veterinary practices by pastoralists. Various challenges constraining livestock disease response were highlighted, the most frequent challenges centered around low numbers and under resourcing of Animal Health Workers.

Conclusion: These findings show that designing an efficient livestock disease surveillance system in pastoral areas requires recognition and utilization of all stakeholders and understanding of their roles. Gaps highlighted in disease response should be prioritized by the government and its development partners for improved animal health service delivery in pastoral areas. These inadequacies in livestock disease response have a direct effect on veterinary practice as mandated by the Government of Kenya Veterinary Surgeons and Para-professionals Act. The results are important for guiding policy formulation to support mitigation of disease impacts in similar areas with limited access to quality veterinary services.

KEYWORDS

pastoralists, livestock, disease, reporting, response, livestock disease surveillance

Introduction

Livestock diseases are a major challenge to production and productivity in the pastoral areas, rendering regressive costs to pastoralists through production losses, healthcare expenses and mortalities in both animals and humans, with further effects on the environment (Lamuka et al., 2017; Lelenguyah et al., 2023; Mburu et al., 2022; Onono et al., 2019). Social, economic and political impacts of livestock diseases manifest inclusively as intervention costs, trade losses that often lead to market shocks, amplification of already existing political tensions and undermining of the public's confidence and trust in governance systems (Evans, 2006; Rushton and Gilbert, 2016; Sabitini, 2003; Whatford et al., 2022). Furthermore, marginalized pastoral communities, whose livelihoods are culturally defined by and are largely reliant on livestock, in highly unpredictable environments, have higher vulnerability and susceptibility to these impacts. Livestock are pastoralists' assets and are also used for draft power, transport, household nutrition security and they provide various socio–cultural benefits to the communities (Nyariki and Amwata, 2019). Pastoralists are faced with numerous production constraints such as limited resources, political and geographical isolation, longstanding ethnic conflicts, porous borders and high mobility that exposes their large livestock herds to a variety of environments with varied pathogens (Bouslikhane, 2015; Darlington and Ateyo, 2007; Mulugeta, 2017; Nori and Scoones, 2019; Pavanello, 2009; Turner and Schlecht, 2019).

Surveillance is an important pillar in disease control efforts and it supports early detection and response to disease outbreaks before they progress along the epidemic curve (Guitián et al., 2023). Regrettably, most livestock disease surveillance systems in developing countries are often impaired, largely due to resource constraints and weak governance in the institutions, leaving the national herd exposed to the various production constraints (FAO, 1999). A comparative analysis of disease surveillance systems in humans and animals in Tanzania revealed low ranks for the animal health systems, on the surveillance attributes of timeliness, completeness, simplicity, flexibility, stability and acceptability (Mremi et al., 2023). The devolved system of governance in Kenya has also been identified as a challenge to the operationalization of livestock disease surveillance in the country (Omondi et al., 2016; Thomas et al., 2021; Woodford et al., 2015). Responsibility for animal disease surveillance in Kenya lies in the autonomy of the counties as laid out in schedule 4 of The Constitution of Kenya 2010 (Government of Kenya, 2010). However, an evaluation of this system revealed no clear-cut resource allocation for surveillance activities and no effective structures for sharing information on animal disease between the national and county governments. The costs of animal disease surveillance are therefore left for the devolved units to cater for from their already constrained resources allocations and hence it is not a priority in most counties (Kahariri et al., 2024; Omondi et al., 2016). Yet, because of the key importance it plays in livestock disease control, surveillance is espoused as a strategic objective for the World Organisation for Animal Health, (2021).

Thrushfield et al. (2018) breaks down surveillance into three important elements; gathering, recording and analysis of data,

dissemination of information to interested parties and action being taken to control disease. These elements provide a framework for documenting/describing disease surveillance systems. With these elements, disease surveillance can be defined as an intricate and complex system that comprises of various stakeholders exchanging information and offering various services. Improvement of any system primarily requires a thorough understanding of its functionality.

A few studies have documented various stakeholders and their roles in livestock disease surveillance, reporting and response (George et al., 2021; Hayes et al., 2017; 2021). In Kenya, stakeholders, their roles and linkages within the One Health space (Omondi et al., 2016; Thomas et al., 2021) and their reliability in responding to livestock disease outbreaks have been documented (Tasker and Scoones, 2022). These studies were carried out in Western and Northern Kenya and broadly, identified stakeholders included government workers and institutions, Community Disease Reporters, Non-Government Organizations, private practitioners, political leaders, animal owners themselves, chiefs and agrovets. To supplement these efforts, this study was carried out to determine how information regarding livestock disease is shared amongst pastoral communities in Marsabit County and to determine the types of response to occurrence of livestock diseases. The findings will be useful for informing policy changes in livestock disease reporting and response within underserved areas, in addition to guiding interventions from practitioners and other development partners.

Materials and methods

Ethics statement

Research ethical review and approval for this study was obtained from the Faculty of Veterinary Medicine, Biosafety, Animal Use and Ethics Committee (FVM BAUEC) from the University of Nairobi, Kenya. Research permits were obtained from the National Commission for Science, Technology and Innovation (NACOSTI), in Nairobi, Kenya. Permission was sought from the office of the County Directorate of Veterinary Services, Marsabit and the community leadership within the study areas. Furthermore, informed consent was obtained from all research participants by signing an informed consent form, and a locally recruited research assistant read and translated the study objectives and purpose to inform participants' consent.

Study area and sampling strategy

The study was conducted in Marsabit County, located in northern Kenya. It has a total area of 70,961.2 km^2. It has an international boundary with Ethiopia to the north, borders Turkana County to the west, Samburu County to the south and Wajir and Isiolo counties to the East. It lies between latitude 02° 45° North and 04° 27° North and longitude 37° 57° East and 39° 21° East. Marsabit is characterized by a highly variable environment that experiences extreme weather events such as droughts, floods and strong winds (Marsabit County Government, 2018).

The population of the County was estimated at 459,785 with a population density of 6 people per km^2 and an annual growth rate of 2.8%, as of 2019. Marsabit is a major trading point between Kenya and Ethiopia with the major economic enterprises as livestock. The livestock populations estimates include Cattle: 218,755 goats: 1,186,482 sheep: 2,029,490 camels: 217,368 donkeys: 63,861 poultry: 45,857 and rabbits: 68 (KNBS, 2019).

The study area was Laisamis subcounty, Korr/Ngurnt and Laisamis Wards, where the larger project, "Increasing efficiency in rangeland-based livestock value chains through machine learning and digital technologies" (InfoRange), is implemented. Laisamis subcounty consists of 5 wards and has a landmass of 20,290.5 km^2 with a population of 65,376 as of 2019. They are predominately Rendille/Ariaal pastoralists. Livestock keeping is the major economic and income generating activity in the region, which precisely involves sale of livestock and livestock products. However, a small proportion of the populace engages in formal and other various forms of self-employment (Grasso, 2020; KNBS, 2019; Marsabit County Government, 2013; Nyariki and Amwata, 2019). The final study sites were sublocations from the wards. These were determined using simple random probability sampling. All sublocations were written on sheets of paper which were folded, shuffled and randomly selected from (Figure 1).

Interviews targeted pastoralists and other known actors engaged in livestock disease surveillance. Pastoralists were selected from different *manyattas* (a collection of households) with a maximum of two individuals selected from each *manyatta,* for interviews and two individuals for focus group discussions. Other stakeholders were known by the community, these were identified, contacted, briefed about the work and requested for time for an interview at a place of their convenience. Interviews included both men and women but however FGDs were with men as they hold the central role in livestock keeping and management.

Data collection

Data was collected through Focus Group Discussions (FGDs), Key Informant and Narrative Interviews, using data collection tools. The data collection tools were developed, reviewed by the research team and pretested in one of the sublocations in Laisamis Location, Marsabit where data was

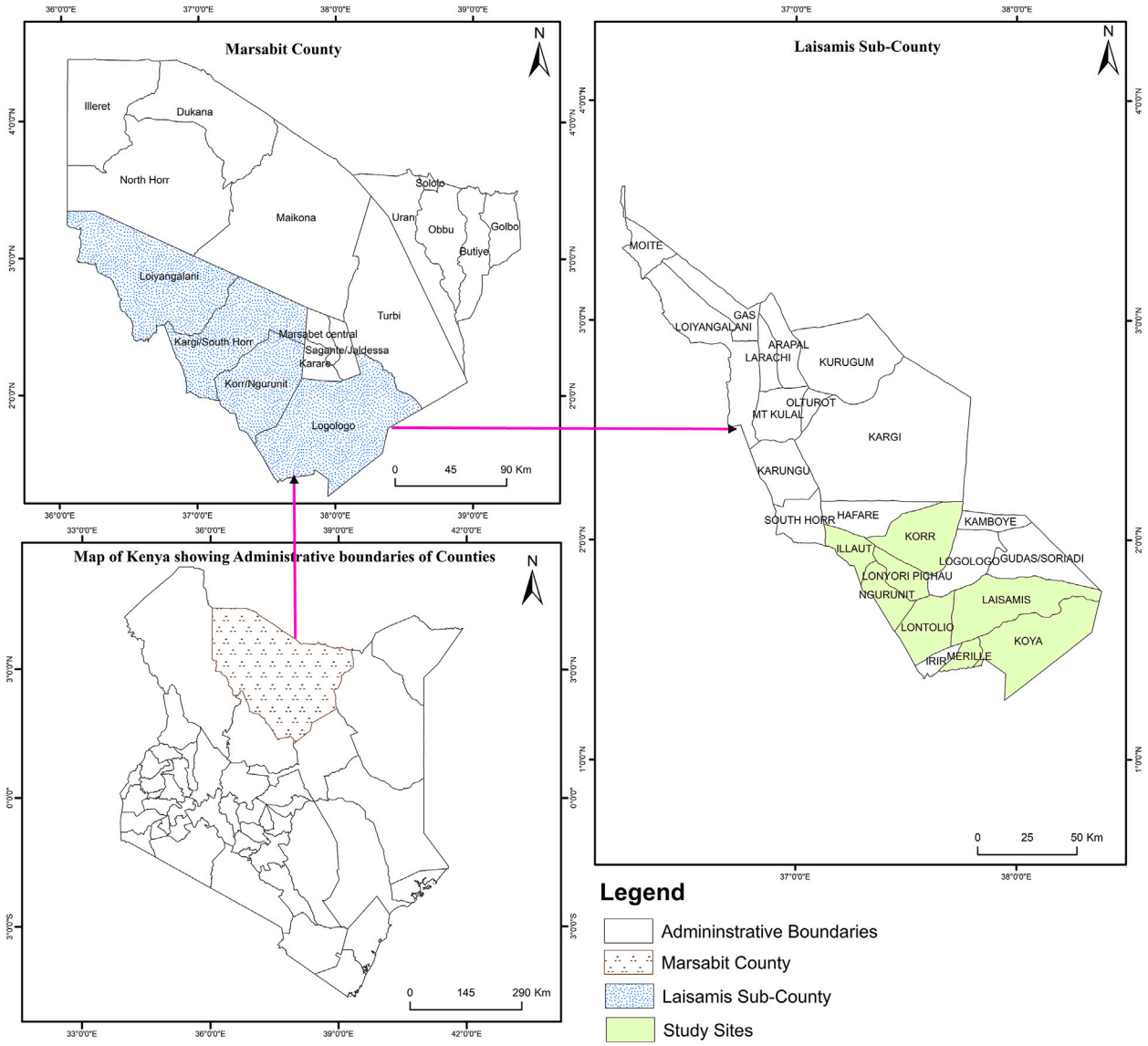

FIGURE 1
An image showing the study sites (QGIS.org, 2022).

not to be collected. Data on household demographics were then collected from participants using KOBOCOLLECT and stored on an online server. The respondents spoke Rendille, Samburu or Ariaal dialects, the researcher conducted the interviews in Kiswahili which was translated to the appropriate dialect by a locally recruited Research Assistant. The interviews lasted between 30 and 80 min. The researcher recorded all sessions, wrote notes and drew a map of the information flow as explained by the respondents as the interviews and discussions proceeded. A total of forty interviews were conducted with 10 in depth narratives held and 30 KIIs. Narrative interviews were important in letting the respondent speak unreservedly and without interruption on the topic of discussion/subject matter, occasionally the researcher guided or probed as necessitated. Key Informant Interviews on the other hand were carried out for a deeper dive into the specific topic of discussion. Of these forty interviews, 10 were held with women and 30 were held with men. The key informants included 27 pastoralists, 3 Government Animal Health Workers, 2 Chiefs, 1 Member of County Assembly (political leader at ward level), 2 representatives NGOs, 3 Agrovet workers/private practitioners, 1 Public Health Officer, 1 Community Disease Reporter (CDR). Three FGDs, each comprising 6 pastoralists were conducted in three of the study sites and predominantly comprised of men. The ages of

the participants ranged from 23 to 80 years. 59.46% of the respondents had no formal education, 27.03% had tertiary level education, 8.11% had secondary school level education while 5.41% had primary school level education.

Net – mapping

Net – Mapping was carried out to triangulate the interviews and the FGDs. Net – Mapping is a participatory method where participants are able to visualize, discuss, determine linkages, levels of influence and power in a network where people, groups or organizations interact to achieve a common or conflicting goal (Schiffer, 2007; Schiffer and Hauck, 2010). The Net – Mapping was pretested, in Bori sublocation, Moyale Constituency Marsabit with community members. Two sessions were held in the study area with community members. Each of these two comprised of: three pastoralists, a chief, a community disease reporter, a private animal health worker or agrovet, a traditional healer and an elder. One session was held in Nameirei sublocation where participants were invited from Nameirei, Ngurnt and Lokshura sublocations. The second session was held in Sakardalla sublocation where participants were invited from Sakardalla, Ndikir and Merille sublocations. One net mapping session was held at the County Veterinary Office with the County Livestock Disease Surveillance Officer.

Conducting the net – mapping session

The goal of the sessions was to determine the social organization of disease reporting and response and for participants to allocate their perceived power and influence to the different stakeholder nodes in regards to livestock disease reporting and response. Each session began by explaining this goal to the participants. This was followed by explaining to them how the method is conducted. Participants were then requested to mention all stakeholders involved in this process. Each stakeholder was written on a colored paper and pinned on a larger sheet of paper. For disease reporting, a red colored marker was used to draw arrows from the point where the report is initiated and how this information is then distributed among the various nodes. Participants were asked if they were satisfied with the information pathway before they were handed bottle tops to use in assigning scores of perceived influence (0 being the lowest and 10 being the highest) for the various stakeholders in the reporting process. Participants were encouraged to adjust if they all agreed to do so. For each of the stakeholders, participants discussed the reasons behind the assigned rank. For disease response, the same procedure was followed as in disease reporting but a blue marker was used to draw the pathways. Bottle tops were used to assign the perceived power a node held in the livestock disease response process. All the while, the researcher wrote down notes and recorded the sessions. An example of output from the sessions is displayed in (Supplementary Material S2).

Data management and statistical analysis

Audio files were manually transcribed into written transcripts. Clean verbatim transcription was done as the focus was on the content analysis of the speech rather than the style or manner of speaking. All transcripts were re-reviewed and cross checked alongside their audios for accuracy and data familiarization, before transferring them into Atlas.ti Scientific Software Development GmBH (2023) for thematic analysis. Mixed coding, that involves both inductive and deductive coding was utilized for a more holistic analysis that builds on existing knowledge while generating new knowledge about the less familiar aspects.

Data from the interviews, FGDs and Net maps on stakeholders and their interactions (links) was obtained from Atlas.ti, fieldnotes and Net map outputs and organized into Microsoft Excel for further analysis in Gephi, an open source software for graph and network analysis (Gephi.org, 2023). A list of nodes consisting of all stakeholders and list of edges indicating directed links between the nodes, as a collection of sources and targets, were developed. The data files were imported into Gephi in.csv format in order to generate the network presented in Figure 2, using the Yifan Hu Proportional network layout algorithm. Normalized network statistics were generated by the software, where the total degree centrality is proportional to the node size. Average scores from the net maps were used to produce a graph of influence and power from Microsoft Excel.

Results

Stakeholders and their roles in livestock disease reporting and response

Various stakeholders' involvement in animal disease reporting and response were identified and they included: Herders, Animal Owners/Pastoralists, Agrovets and Private animal health workers, Chiefs, Elected Ward Political leader (Member of County Assembly (MCA)), Elders' Council (Nabo), Government Animal Health Workers (GAHWs), Community Disease Reporters (CDRs), Non state actors, National and County Directors of Veterinary Services (CDVS), County Director of Medical Services (CDMS), National Director of Veterinary Services (NDVS), the radio, County Executive Committee, Traditional animal health experts, Public Health Officers, Assistant County Commissioner, National Parastatals and the Department of Health Services.

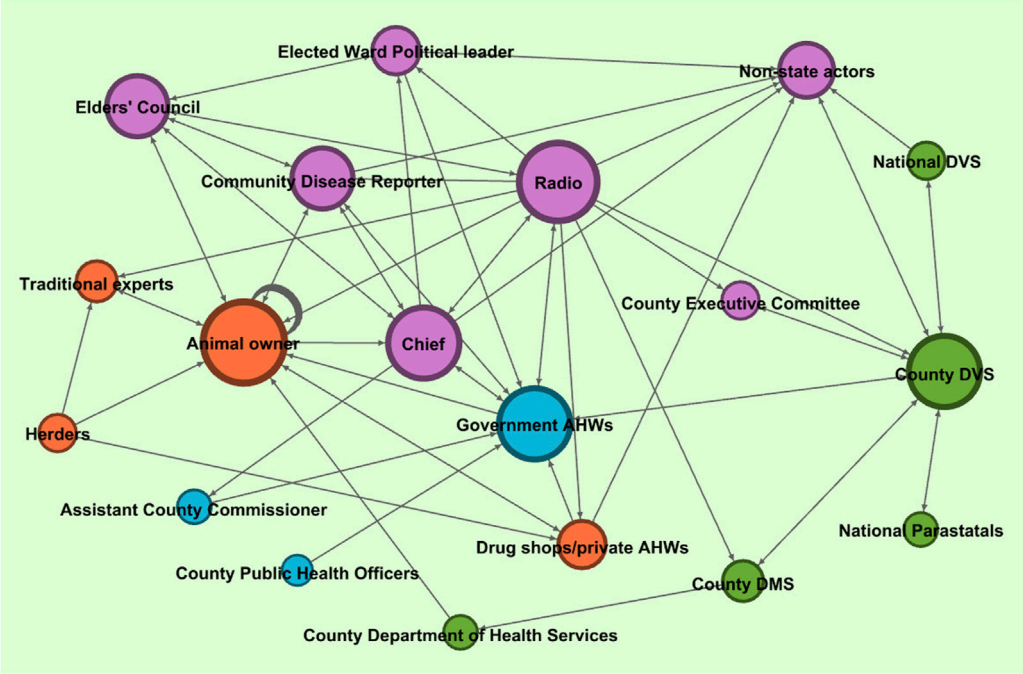

FIGURE 2
Interaction among stakeholders in livestock disease reporting and response in Laisamis Subcounty. Prepared using (Gephi.org, 2023). Key/Legend. Single pointed arrows: - A form of reporting/response to a given stakeholder; Double pointed arrows: - Reporting and form of response happening between stakeholders; Self-loop (On the Animal owner): - Shows that the animal owner themselves is involved in providing a form of response to their animal; Size of nodes: - The larger the size of the node, the higher the degree/involvement in both reporting and response.

Herders are employed by pastoralists to take care of their animals, they move with the animals to locations of pasture and water. They observe the animals for any signs of disease and report these to the animal owners. Animal Owners/Pastoralists were the primary stakeholders to whom the animals belonged and were concerned about the welfare of their animals, they reported disease symptoms to other stakeholders they perceived to offer a form of response and they also treated their animals with both synthetic and herbal medicines. Agrovets and private practitioners owned animal drug shops and offered private veterinary services, made tentative diagnoses, prescribed and sold drugs to pastoralists, treated sick animals, usually low in number. Chiefs were government civil servants in charge of a given administrative unit named a location or sublocation, they were an intermediary that received information from the community regarding disease and passed it on to/referred the pastoralist to the AHWs. They also mobilized residents under their jurisdiction for mass treatments/vaccinations. The Member of County Assembly (MCA) who is an elected ward level political leader, regularly received reports of livestock disease outbreaks and communicated these to the government AHWs. The MCA could escalate these reports to higher political leaders in cases of severe outbreaks. They also assisted in seeking support from Non-Governmental Organizations for response to disease outbreaks. The Nabo is a local name used to refer to a special meeting called by trusted community elders that they held every evening in the manyatta environs where all men in the community must attend. Livestock disease information was shared in this forum and advice on management was given, if the Nabo attendees had no or limited knowledge on management of the disease they could escalate it to other stakeholders that could offer a form of response. The Nabo is a point of command for community disease control measures, for example, elders could decide that all animals shouldn't use a given grazing area because of presence of a reported disease outbreak there. Non-adherence to this can elicit a penalty/form of punishment. Traditional animal health experts are community members with knowledge and experience of using medicinal herbs and alternative veterinary practices in managing livestock disease conditions. They offered livestock health services by use of herbs and alternative veterinary practices.

Government Animal Health Workers are employed by the Government of Kenya at County and subcounty level. They offered technical advice on control, management and prevention of livestock diseases, both at individual pastoralist and community level trainings, routinely diagnosed and treated sick animals at household level, verified outbreak reports, mobilized resources and the community and carried out mass treatments or vaccinations. Community Disease Reporters (CDRs) are community-based individuals with a primary role of receiving

and scouting for livestock disease outbreaks and sharing this with the County Veterinary Office, they were crucial in syndromic and event-based disease surveillance and offered technical advice in disease management, control and prevention. The Director of Veterinary Services (DVS) at the National level receives reports from the county and assisted in mobilizing for resources for response. Public Health Officers are civil workers employed by the government and were involved in meat inspection for which they shared reports to the veterinary department. The Department of Health Services was in charge of human health. They offered joint response with the veterinary department during zoonotic disease outbreaks. They worked together to sensitize the community.

Non-state actors include Non-Government Organizations (NGOs) and Intergovernmental Organizations/iNGOs. These are nonprofit entities involved in improving livelihoods of pastoralists across a spectrum of fields. Active ones mentioned in animal health included USAID, Food and Agricultural Organisation (FAO), Caritas Kenya, Indigenous Movement for Peace Advancement and Conflict Transformation (IMPACT), Washington State University, Pastoralist Community Initiatives and Development Assistance (PACIDA), CONCERN, RedCross, Veterinaires Sans Frontiers (VSF), International Centre of Insect Physiology and Ecology (ICIPE), International Livestock Research Institute (ILRI), World Bank. They supported the government stakeholders with various kinds of resources as they carried out their duties, especially response to outbreaks at mass level and are engaged in livestock disease surveillance. Table 1 shows more details of these roles.

Interaction among stakeholders on disease reporting and response

19 stakeholder categories/nodes were identified with 67 edges/links among them as shown in Figure 2. For disease reporting, reports are initiated by the herders, these are individuals who stay with the animals. They move with the animals through different grazing sites. Herders are usually employees, children or relatives of the animal owner. Herders report to the owner of the animal. Under rare and special cases, herders can report a case directly to the traditional healer or a private animal health worker/agrovet. They report to a traditional healer in cases of a fracture, necessity for assisted delivery or for diseases that are known to have local remedies. Herders reporting to these other stakeholders rather than the animal owner happens in special cases. This can be when: the herder is a relative and the animal owner is so far away from the animals/grazing area, unreachable due to especially poor network. Participants explained that the animal owner can double as the herder.

On receiving the disease report from the herder, the animal owner progresses this report to several other nodes based on the nature of the disease condition and the type of assistance that is required. As it is with the herder, they can report to the traditional healer. If it's a disease whose synthetic drug they know, they can report directly to the agrovet/private animal health workers. If it's a new disease or one with high morbidity and mortality they report to the CDR, the chief or the elected ward political leader because these three stakeholders can quickly progress this information to the GAHWs. Animal owners continually make disease reports to the Council of elders (called the Nabo in the Rendille) despite the nature of the disease, because these are fora that meet frequently, in Rendille/Ariaal Communities, the council meets every evening. The council of elders can progress the report to the local politician, usually given a severe disease outbreak, or in the absence of quick response especially from GAHWs. They make the decision to call the radio to report a disease, this is usually for the purpose of letting fellow pastoralists know about the outbreak. They mentioned that it is very rare for animal owners to report directly to GAHWs because of language barrier, not having GAHWs' contacts and the high costs that may be incurred if they sought their services individually. For traditional healers, when they fail, they can refer the animal owner or herder to the agrovet. The agrovets and private animal services providers are at times contracted by Non-Governmental Organizations and can communicate information on diseases of interest to them.

The Chiefs are obligated to report these cases to their line supervisors who are the Assistant County Commissioners who then report to the GAHWs. The Chiefs report to the Elected Ward level political leader and can directly report to the GAHWs. The Elected Ward level political leader sometimes communicates with Non-state actors about an outbreak, however, this is informal. Public Health Officers share their disease reports to the GAHWs. In very few cases, radios and Non-State Actors can passively and directly share information to GAHWs on disease outbreaks, as a result of observations from their work with the community.

Among the GAHWs these reports are first received by the subcounty government animal health workers. These forward the reports to the county livestock disease surveillance officer who collates and analyzes them. This information is shared with the County Director of Veterinary Services (CDVS). At this county level, prioritization is made on which diseases to respond to through mass intervention. The CDVS can then formally communicate this decision to Non-state actors, the NDVS, national parastatals and the County Executive Committee. This is done in search of support to mount mass response interventions. The CDVS also communicates to the County Director of Medical Services in cases of zoonoses.

Recommendations by participants for improvement of the reporting system:

1. Community Disease Reporters requested for more facilitation given the work they do. However, a discussion with the GAHWs revealed that reporting by the CDRs should be

TABLE 1 Stakeholders and their roles in livestock disease reporting and response.

Stakeholder	Roles
Herders	• Employed by the animal owners to look after their animals, they move with the animals to places with pasture and water • Observe the animals and report disease syndromes to the animal owners •If knowledgeable, they can look for assistance to animals from agrovets and traditional healers
Animal Owners/Pastoralists	• Buy drugs and treat the animals • Report disease conditions to a range of stakeholders perceived to offer a form of assistance
Agrovets and private practitioners	• Make diagnoses, prescribe and sell drugs to pastoralists • Treatment of animals, usually in low numbers • Offer technical advice on disease control and prevention • Report disease outbreaks to county veterinary department (routinely when challenged and monthly)
Chief	• Offer advice on management of disease conditions • An intermediary that receives information from the community regarding disease and passes it on to/refers the pastoralist to the AHWs • In cases of mass response/interventions by the County veterinary department and non-state actors, the chief is informed to share this information with and mobilize the community. They do this through fora like *barazas* and the *nyumba kumi*
Assistant County Commissioner	• Immediate supervisor to the Chief • Communicates disease report information from the Chief to the GAHWs
Member of County Assembly (MCA) Elected Politician at Ward Level	• Receive reports of livestock disease outbreaks and communicate this to the government animal health workers • Assist in seeking support from non-state actors for response to disease outbreaks • Can mobilize communities for planned interventions • Could escalate reports to higher political leaders in cases of severe outbreaks
Elders' Council	• Receive information regarding animal diseases and share it with a range of stakeholders that are perceived to offer a form of response • In cases of mass response/interventions information is shared to the men that attend this forum, these then disseminate the information to their households • Advice is shared on management of a reported disease condition • This is the point of command of disease control measures at community level for example, elders can decide that all animals shouldn't use a given grazing area because of a reported disease outbreak there. Non-adherence to this elicits a penalty/form of punishment
Government Animal Health Workers (GAHWs)	• They offer technical advice on control, management and prevention of livestock diseases, both at individual pastoralist and community level training • Majorly involved in mass disease response interventions • On few occasions, they diagnose and treat sick animals at household level • Verify outbreak reports, mobilize resources and the community and carry out mass treatments or vaccinations • Verification of animals at livestock markets and offering movement permits • Train community-based animal health workers and disease reporters in various aspects of livestock disease control and management • Receive, analyze and summarize monthly disease surveillance reports
Community Disease Reporters (CDRs)	• Crucial in syndromic disease surveillance by actively reporting diseases using the Kenya Animal Bio surveillance System, a mobile application used by the National Government in livestock disease reporting • Offer technical advice in disease management, control and prevention • They play a support role during mass treatments or vaccinations • They verify disease reports on the request of county and subcounty veterinary department
Non-state actors	• They support the government stakeholders with various kinds of resources as they carry out their duties, especially response to outbreaks at mass level • Are engaged in livestock disease surveillance, they receive outbreak reports and share these with the government stakeholders • Involved in livestock health research activities • Routine vaccinations • Train community disease reporters on how to carry out surveillance • Train communities regarding livestock disease management, control and prevention
County Director of Veterinary Services (CDVS)	• Supervises all GAHWs in the county • Reports from the county are received by the CDVS who coordinates the process of mobilizing for resources for response • Organizes and dispatches the county veterinary team for mass interventions
County director of medical services	• Receives official information from the CDVS regarding zoonotic outbreaks • Prepares the medical team for joint One Health response towards these zoonotic outbreaks

(Continued on following page)

TABLE 1 (*Continued*) Stakeholders and their roles in livestock disease reporting and response.

Stakeholder	Roles
Traditional animal health experts	• Offer livestock health services by use of alternative veterinary practices
Public Health Officers	• Carry out meat inspection and provide reports to the veterinary department
Department of Health Services	• Offer joint response with the veterinary department during zoonotic disease outbreaks. They work together to sensitize the community
National Parastatals	• This is specific to those whose operations overlap into disease management. The example given was the National Drought Management Authority • They passively report to the GAHWs disease outbreaks they come across during their work with the pastoralists • They can support the county veterinary department with resources during mass interventions
National Director of Veterinary Services (NDVS)	• Receives information from the county regarding disease outbreaks, through the Kenya Animal Bio surveillance System (KABS) • Could be contacted by the CDVS to offer support in response to major outbreaks
Radio	• The community can call the radio to broadcast information on a given disease outbreak, this is to inform other distant community members • Broadcasts information on plans of disease response interventions from and by the County Veterinary Department
County Executive Committee	• Comprised of members of the county in charge of administrative duties • Support the Veterinary department with resources for disease response

passive. The personal internet bundles and airtime loaded can be used to make reports to GAHWs.

2. Given their importance in the reporting pathway, it was suggested that all community members, especially leaders should be consulted in the process of selecting CDRs. This is to ensure selection of individuals that are always within the community, and are responsible and committed to their work.
3. Livestock traders are a node from which information regarding diseases should be shared, because they interact with animals from varied locations on a daily basis. It was speculated that they do not share this information as a way of protecting their income source.
4. Pastoralists need training on how to make complete reports to facilitate better response. Epidemiological information regarding the disease is important and required by animal health service providers but rarely given and if given, its rarely accurate.
5. Installation of more telecommunication boosters to improve telecommunication network.

At community level, pastoralists can respond to livestock diseases by themselves or seek assistance/response from their friends and elders especially for diseases that are endemic and whose traditional or synthetic remedies are known. For instance, traditional healers can manage fractures and cases of assisted delivery. Private animal health workers and agrovets are usually called to treat animals with synthetic drugs usually in situations that the animal is not responding to treatment from the animal owner. The Elected Ward level political leader can offer personal financial assistance to help a pastoralist obtain treatment for their animal.

From GAHWs, when information is received by the County Livestock Disease Surveillance Officer, it is analyzed for prioritization on which diseases can be responded to by the Veterinary team. Communication is made to the CDVS. The NDVS is aware of these reports through their access to reports from the Kenya Animal Bio surveillance System, a national government mobile phone application used for syndromic surveillance. Initial verification of reports is done through calls from the county to especially CDRs. This is followed by participatory disease surveillance with the community and collection of appropriate samples for further analysis. Samples can be analyzed from the County Laboratory if the resources (equipment and laboratory reagents) to test the suspected diseases are available. If more advanced analysis is required the samples can be sent to the National Central Diagnostic Veterinary Laboratory in Kabete. The laboratory results enable the Veterinary team to communicate to the community on prevention control and management of the disease condition through the subcounty veterinarians, the CDRs, chiefs and through the radio. These findings are further used by the Veterinary team stationed at the county, led by the CDVS, to prepare proposals for engagement of partners to pool resources in preparation for mass response. These collaborations are usually sought from Non-state actors, National Parastatals especially the National Drought Management Authority and from The National Executive Committee. When all resources needed for response are obtained communication is made to the community through radio, social media, CDRs and chiefs concerning the dates and venues where veterinary teams will be stationed as mass interventions are carried out. CDRs and private animal health workers can be called upon to assist the teams during the response activities.

Recommendations given for improvement of livestock disease response.

1. A readily available and adequate contingency fund should be made present at county veterinary department to facilitate quick response to reported outbreaks.
2. Communication experts should be employed to oversee the process of all feedback given to the community, this would help to avoid panic in cases of disease outbreaks.
3. Community vaccine hesitancy needs to be addressed for more members of the community to participate in mass response interventions.
4. A lot of response happens at community level, calling for a need for capacity development of community-based stakeholders in disease control, management and prevention. Suggestions for regular community trainings were proposed by the participants.
5. Mass vaccinations and treatments should be carried out more often within the year and not only in response to outbreaks.
6. More research was encouraged into prevalent livestock diseases but with more feedback to the community.

Network/graph properties

The graph is directed and has a graph density of 0.196. Graph density is the proportion of links within the network divided by the number of total possible links. Therefore, a graph density of 1 would show that all stakeholders within the network communicate directly with each other. Given a graph density of 0.196, it's indicative of groups of stakeholders interacting more with each other than others. This is further evidenced by the modularity of the graph, which is 0.213.

Modularity is the extent to which a network is organized into multiple communities/modules. A community in the context of this study are nodes that are connected more densely to each other than to the rest of the network. Modularity is the fraction of edges that fall within the given communities minus the expected fraction if edges were distributed at random. Four communities were detected, as seen with the different colors, each color represents a community which has more edges between each other than with other nodes. From the modules in this network we can gather that there are stakeholders at community level, those at county level and external stakeholders.

The network diameter was 5. This is the shortest distance between the two most distant nodes in the network. This is a low value given the total number of nodes in the network. In the context of this study this would mean that it would not be difficult for the most distantly linked stakeholders to share information/services with each other.

For normalized centrality measures, the total degree centrality is the total number of direct links connected to a given node. It is a sum of the links to the node (indegree) and the links from the node (outdegree). The higher the total degree, the more a node is likely to receive and also distribute information to others in the network. The animal owner had the highest degree, 16, followed by the Radio, 15. The GAHWs, Chief and CDVS all had a degree of 13. This shows a high level of involvement of these stakeholders in the network and in both disease reporting and response.

Another network index is the betweenness centrality, this is the measure of how often a node occurs on all shortest paths between 2 nodes. It is obtained by dividing the number of shortest paths that pass through the node by the total number of shortest paths between all pairs of nodes. Nodes with high betweenness centrality lie on many communication paths and can control information flow. When nodes with high betweenness centrality are removed from the graph or are non-operational, they disconnect a high number of nodes from the rest of the graph. Highest among these were the CDVS, GAHW, animal owner, radio and chief with the values of 0.30, 0.30, 0.18, 0.15, and 0.12 respectively. Details on these statistics are presented in Supplementary Material S1.

Perceived influence and power in livestock disease reporting and response

Influence was defined by the participants as the importance of a stakeholder based on their roles in sharing information on a disease outbreak and power was defined as the importance of a stakeholder based on the roles they play in managing a disease outbreak. Herders had the most perceived influence (8/10) in reporting because they are closest to the animals, they observe them more than even their owners. Participants argued that in the absence of herders, the reporting network would be unstable. However sometimes they do not report all that they observe. Herders' power in response was perceived as one of the least (2/10) because they do not make decisions on how the disease condition is managed. But in emergencies they can seek for assistance from a nearby private animal health worker, agrovet or traditional expert.

Animal owners had a high influence in reporting (7/10), they have the resources and motivation to inform several other stakeholders, because they wouldn't want to lose any animal. Animal owners also had high perceived power in response (8/10) because they can manage/treat disease conditions by themselves, which comes with costs that are incurred in management. They make the decision on whether their animals should receive mass vaccination/treatment.

CDRs had a high influence in disease reporting (6/10). They are trained by GAHWs to report disease conditions and can easily reach the GAHWs. CDRs are also close to the community. They had a high perceived power in regards to response (6/10). CDRs are important in verification of disease reports. They communicate to the community regarding upcoming interventions by GAHWs, mobilize the community to bring their animals for mass interventions, can be called upon by GAHWs for various forms of support during mass interventions and convince fellow community members to accept livestock vaccinations in cases of vaccine hesitancy.

GAHWs were scored with (5/10) for their influence in reporting. They have a responsibility of receiving all the information from the entire county which they analyze for further decision making. Furthermore, it's because of GAHWs, that other important nodes such as the CDR exist. GAHWs had very high perceived power in regards to response (9/10) as they are considered as the experts that are well able to manage any disease condition, they carry out mass interventions that benefit the whole community. However, pastoralists think sometimes information gets to the GAHWs and is not processed or acted upon. Furthermore, it is rare for GAHWs to manage single cases.

The CDVS was moderately influential (5/10) because of his importance in sharing disease information with partners in preparation for response. The CDVS had the highest perceived power (10/10) when it comes to disease response because he coordinates all field veterinary team activities and is involved in the process of engaging partners to pool resources for mass response and its subsequent allocation.

The chiefs' perceived influence (4/10) in reporting, was because they are always informed of all that is happening within their communities and they always share this information with the relevant stakeholders including the GAHWs. Chiefs are also close to the community. Their perceived power in response was 3/10, they share information to the community regarding mass response activities, mobilize the community during interventions and are trusted, therefore any stakeholder, including GAHWs go through the chief to be received/welcomed into the community.

The Elders' Council had a similar perceived influence as the chief (4/10) in reporting, they make the decision to escalate a report higher above the community level especially to the elected ward level political leader and to the radio. From amongst themselves they assign members to follow how the report progresses and its feedback. Their perceived power in response was 3/10, as they receive information regarding mass response activities and distribute it to fellow community members. In cases where a fellow community member is marginalized but needs to treat their animals, this council can urge community members to contribute money for that member to buy drugs/look for assistance for their livestock.

The radio had a similar rank of influence in reporting (4/10) because a large proportion of the population have access to it, therefore a disease report made can be heard by everyone. The radio was ranked with a perceived power of 5/10 in response as its used to communicate to many, regarding mass disease response interventions.

The elected ward level political leader was considered important when the community has failed to get assistance for a given disease outbreak, the leader is contacted in hopes that he/she can use their political influence to get them assistance. He was ranked 3/10 for influence. The political leader was among those with the least perceived power in disease response, (1/10), because they are rarely involved in this process, the few times they are, they share information from GAHWs about planned dates and venues for mass interventions, this information can be received from many other stakeholders.

Non-state actors had a similar rank to the political leader (3/10) for reporting, as these just occasionally and passively share information with GAHWs as a result of observations from the work they do within the community. Their perceived power in response was high (8/10) because they avail their resources to support livestock disease response and train CDRs and GAHWs to increase their capacity to manage disease outbreaks.

Agrovets/private animal health workers ranked among the least (3/10) as they were not considered to progress information on disease any further. Their perceived power in response was 5/10, because they sell drugs that the pastoralists use to treat animals and are usually close to the community. However, sometimes they are not sufficiently knowledgeable about drugs and disease management and for some it's just business.

Public Health Officers had low perceived influence in reporting (2/10), they share information on zoonotic diseases spread through meat consumption, their perceived influence in disease response was also low (2/10), they are involved in creating awareness about zoonoses as the GAHWs carry out mass interventions.

The district officer was perceived to have the least influence and power (1/10) as they only share this information because it's their duty to do so, if they are removed from this network, the network can still exist.

Traditional experts were not scored for reporting as the cases meant for them are not progressed further to any other stakeholders. They had a perceived power of (4/10) in disease response because of their role in managing fractures, assisted deliveries and herbal/traditional remedies.

The County Executive Committee, the NDVS, Assistant County Commissioner, CDMS, the County Department of Health Services and National Parastatals were ranked only for response, with low ranks. They occasionally play varied roles in supporting interventions towards livestock diseases. Figure 3 shows the rankings by the participants and further details on the same are available in Supplementary Material S3.

Livestock disease information sharing methods, their strengths and weaknesses

Various methods, their strengths and weaknesses were mentioned to be used by stakeholders in sharing information on livestock diseases. Pastoralists used ancient methods like blowing horns and use of fire and smoke that had benefits of being freely available but had a challenge of reaching a limited number of individuals. They mentioned that these methods have largely phased out. Pastoralists mostly walk

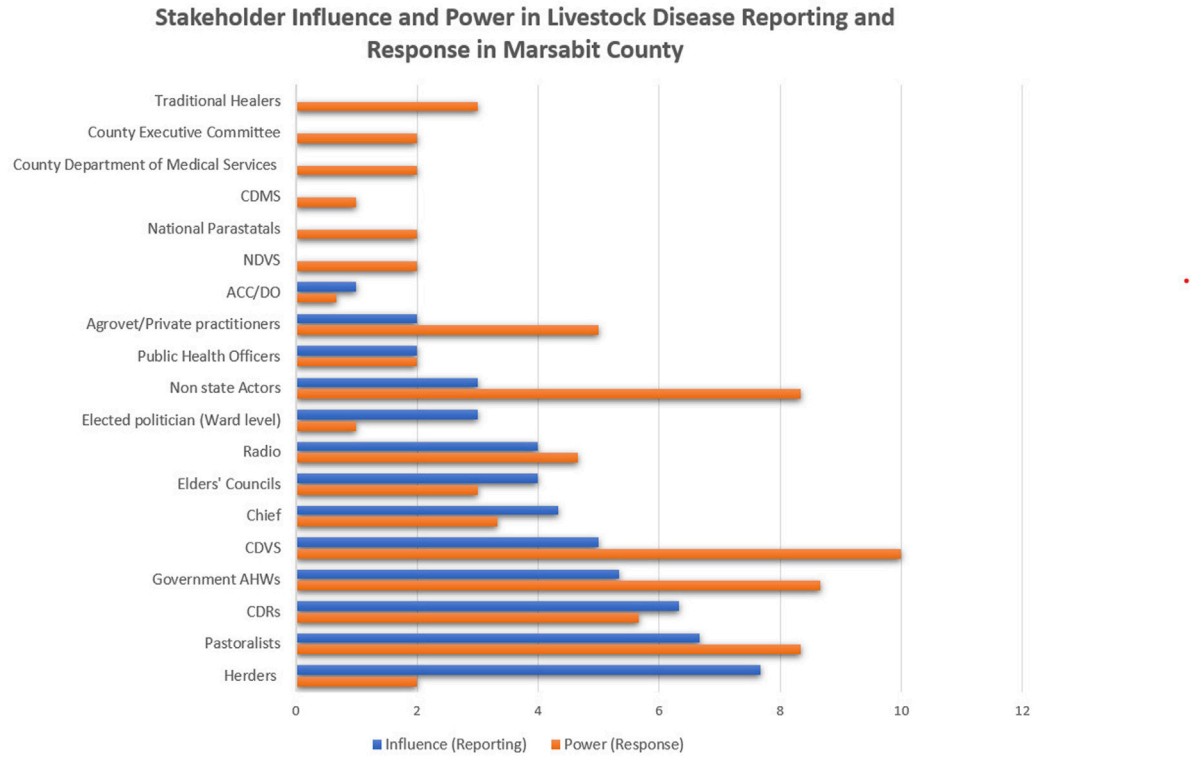

FIGURE 3
Perceived stakeholder influence and power in livestock disease reporting and response in Marsabit county.

on foot because this is a means that is freely available, however it is very tiring as very long distances that take 2 – 3 days are often trekked for example, as they go to the agrovets. Pastoralists mentioned that it is challenging to walk these long distances under the hot sun and that sometimes they can fall sick. On rare occasions, pastoralists stand risks of attacks from wild animals, thugs and bandits while walking.

GAHWs used paper-based tools to collect information on disease outbreaks, this method has been used for a long time and has a wide coverage, many disease reporters are acquainted with its use. The challenge with this method is that in the sending and receiving process, the papers can easily get lost or damaged. When these papers are received, information from them is digitized, this is a laborious and tedious process. This method however has been replaced with use of Kenya Animal Bio surveillance System (KABS), a mobile phone application used by CDRs to report information on disease. These reports are received directly by GAHWs. It improves livestock disease reporting in that the reports are complete and accurate. However, the reports may not be timely as CDRs mentioned that sometimes they don't have mobile phone data to send the reports. GAHWs can communicate to each other, with partners and with other county government departments using electronic mail.

Pastoralists mentioned use of more modern methods like motor bikes and motor vehicles that are comparatively faster. However, these methods are costly and expose the users to fatal accidents.

Pastoralists can report disease outbreaks on local Radio stations, usually after consultation with the Elders' Council. The purpose of such a report is to pass the outbreak information to fellow colleagues or to let GAHWs know about it. GAHWs communicate on planned mass interventions, their dates and venues on radio. Radio stations are used because they spread information to many. However, they also have a challenge that their coverage does not get to all areas.

Lastly, mobile phones are used for information exchange by all stakeholders. Mobile phones aid in fast communication and a large proportion of the population own a personal phone. Challenges with phones are that costs are incurred in purchasing airtime, low network and electricity coverage and high illiteracy levels that pose challenges in mobile phone operation. More details on these methods are documented in Table 2.

TABLE 2 Livestock disease information sharing methods, their strengths and weaknesses among stakeholders in pastoral areas.

Method	Frequency	Strengths	Frequency	Weaknesses	Frequency
1. Blowing a horn	1	• Freely available, easy to use and can quickly alert individuals close by	1	• Informs a limited number of individuals	1
2. Use of fire and smoke	1	• Freely available, easy to use and can quickly alert individuals close by	1	• Informs a limited number of individuals • Poses risks of wildfires	1 1
3. Walking on foot	19	• Freely available • Used in case of lack of access to a better means	2 4	• Long distances are trekked, these sometimes take 2 – 3 days • Very tiring • People become sick due to walking long distances • Leads to delayed response, sometimes the animal dies before one gets back to the herd • Risky encounters with wild animals, thugs and bandits and braving extreme weather conditions • Hunger and thirst en route	14 5 2 7 4 5
4. Use of motorbikes	9	• Is a faster means of delivering information • Used to deliver drugs to herders in distant grazing sites	5 3	• Costs have to be incurred in the use of this means for example, fuel, hiring, repairs • Risks of accidents • Mechanical breakdowns while *en route* leading to delay • Not readily available (for hiring) as few people own bikes • Bike owner dictates itinerary which causes delay in delivery of disease information, hence delayed response	9 5 4 1 10
5. Use of motor vehicles	6	• It's a faster means of transport	1	• It's an expensive method • Risks fatal accidents • Mechanical breakdowns while en route lead to delay • Not always readily available when needed	1 2 1 1
6. Use of radio stations	7	• Information shared on these platforms is able to reach a wide audience	6	• Limited network in some of the places	2
7. Use of mobile phones	24	• Faster and more efficient means of sharing information with a range of individuals	9	• Low network coverage in some places • Costs of buying airtime • Low electricity coverage • Illiteracy leading to difficulty in phone operation	4 6 4 3
8. Paper based reporting	7	• Has been used for a long time, therefore many individuals are well versed with how to use it • A good alternative to technology options where people who are not tech savvy can use them, because of the poor electricity coverage, papers can be used	1 1	• Expenses involved in moving the copies to a central point • They can easily be lost or damaged • Compiling the data is laborious	1 3 1

Frequency is the number of respondents that mentioned a given item.

Current livestock disease control and management approaches by the pastoralists

Self-treatment of sick animals by pastoralists

Treatment of livestock by pastoralists themselves happens in two main ways including: using synthetic drugs or using alternative veterinary practices. The list of drugs which the pastoralists carried in their drug carriage bags/displayed or mentioned to be kept by the pastoralists included Injectable antihelmintics like Ivermectin and Noromectin, drench antihelmintics like albendazole 2.5% and 10%, antibiotics like penstrep, tylosin, doxymycin eye powder, oxytetracycline 10% and 20%, antitrypanosomes, and injectable multivitamins. They also possessed syringes and needles used for administration of these drugs.

> *"These days motorbikes are available we can use them to go buy drugs which we keep in our houses. When we move with the animals we move with these drugs. The herders may fail to move with food but move with drugs..."* (Pastoralist, Laisamis Town, 28/08/2023)

Vaccination campaigns and treatment

Mass management of animal health also happens in two ways, by treatment and by vaccination organized by the government veterinary departments with support from the non-state actors and national parastatals

> *"...people will be sent to fora to spread information on the day the doctors were going to come, and they will bring the cattle home for treatment and after they are treated, they will be taken back to Fora..."* (Pastoralist, Lonyerpeshau, 06/09/2023)

Routine visits by veterinary personnel

These are mostly made by private practitioners/agrovets to offer veterinary services to animals in lower numbers. In very few cases, GAHWs can also do the same.

> *"...for now, we have animal doctors that we will go to if our animals fall sick..."* (Pastoralist, Sakardalla, 30/08/2023)

> *"...I have seen some people who hire their own doctors who come to treat the sick animals for them..."* (Pastoralist, Ndikir, 28/08/2023)

Public education and increasing awareness on livestock diseases

Pastoralists can be sensitized about disease control and management through one-on-one advice from their fellow community members and from AHWs. Training sessions are also usually held by AHWs where a number of people are invited to be educated on various livestock health related issues.

> "*...the elders were also informed because they have interacted with quite a number of diseases, so the household head will inform them if the disease is not familiar to him, and the elders will advise on the disease and the best treatment either herbal or from the agrovet...*" (Public Health Officer, Laisamis town, 27/08/2023)

> "*...the only thing I can do is to advice especially on the dangers of the diseases, for example in case of rabid animals, I will advise them that the infected animal can bite human beings and the person can be infected...*" (Agrovet, Laisamis town, 31/08/2023)

> "*...the government came and taught about drugs that are used to treat animals and truly when we started using them, our animals got healed. We also knew about agrovets where to go and buy drugs instead of going to the office with a sick animal...*" (Pastoralist, Lependera, 07/09/2023)

Use of alternative veterinary practices and knowledge

Alternative veterinary practices are traditional methods used in management of animal diseases. A range of alternative veterinary practices like bleeding, cauterization, drenching with liquefied fats and use of traditional practices like migrating from a disease-infested zone. This knowledge is passed down from generation to generation and also through peer-to-peer exchanges.

> "*...when the herder discovers that there is a sick animal, he will tell the parents, the parents will look for other elders (Wazee) and they will discuss about the sick animal's clinical signs, and they will propose which herbal medicine to use...*" (Pastoralist, Farkoren, 08/09/2023)

> *"...Back then when a goat got sick and died, we would shift from that place to another one, we wouldn't even drink the water we know it drank..."* (Pastoralist, Mpagas, 05/09/2023)

Challenges and aspirations in disease response

The challenges majorly voiced by the respondents in disease response included a huge time lag between reporting and response, deep inland grazing areas that are often inaccessible by AHWs, a low number of AHWs and an under resourced animal health department. The aspirations mentioned by most respondents included: encouraging agrovets to set up closer to settlements, increasing numbers of AHWs and their better facilitation for improved mobility and animal health service delivery. Details on challenges and aspirations from respondents are in Table 3.

Discussion

Our findings show that livestock disease surveillance in pastoral areas is a multi-stakeholder process with various stakeholders linked and communicating amongst each other. A similar network was observed in a study by Tasker & Scoones, (2022) that explored knowledge networks in response to a highly variable animal disease setting in the same study area. A lot of information and service exchange happens at community level, while GAHWs majorly intervene during severe disease outbreaks, through mass interventions. Among the community level stakeholders, animal owners had a high perceived influence when it came to disease reporting, this is in contrast to findings from Limon et al. (2014) in Bolivia who found that animal owners were extremely unlikely to report disease outbreaks to their GAHWs, because of lack of institutional credibility and conflicting priorities. This contrast could exist because, in our study, animal owners expressed their confidence in the skills of the GAHWs whom

TABLE 3 Challenges and Aspirations in livestock disease response.

Challenges	Frequency (n = 47)	Respondents	Aspirations	Frequency (n = 23)	Respondents
1. Deep inland grazing areas often inaccessible by AHWs	9	4 Pastoralists, 1 CDR, 2 Chiefs, 1 private AHW, 1 Meat slaughterer	1. Encourage agrovets to set up closer to settlements	7	6 Pastoralists, 1 CDR
2. Low number of AHWs, the ratio of AHWs to pastoralists is very high	6	3 Pastoralists, 2 Private AHW, 1 meat slaughterer	2. Improve pastoralists' knowledge in livestock disease management and prevention	4	3 Pastoralists, 1 CDR
3. The marginalization of the pastoralists in that some are unable to afford treatment costs	3	1 Pastoralist, 1 Pastoralist FGD, 1 meat slaughterer	3. Increase numbers of Animal Health Workers	5	5 Pastoralists
4. Under resourced animal health department	6	3 Pastoralists, 1 Pastoralist FGD, 1 Private AHW	4. Managed communication barrier between the community and the animal health workers	2	2 Pastoralists
5. No official means of communication between the CDVS and the County Public Health Department	2	1 Public health officer, 1 Government AHW	5. Improved mobile phone network	1	1 Pastoralist
6. Unavailability of AHWs at the time they're needed by pastoralists	5	3 Pastoralists, 1 Pastoralist FGD, 1 Private AHW, 1 MCA	Better facilitation for Animal Health Workers (mobility and drugs)	4	4 Pastoralists
7. Huge time lag between reporting and response	11	8 Pastoralists, 1 Government AHW, 1 Private AHW, 1 CDR			
8. No response at all	5	2 Pastoralists, 1 Pastoralists' FGD, 1 Chief, 1 MCA			

Frequency is the number of respondents that mentioned a given item.

they believe have the expertise to manage any disease condition. It could be deduced that the community wanted all disease reports made to ultimately reach the GAHWs. The high influence of animal owners in reporting agreed with findings from Hayes et al. (2021) in Australia who found that producers had a high influence and interest in surveillance activities.

Animal owners/pastoralists also had high perceived power when it came to disease response, a finding that agrees with Makundi et al. (2012) in Tanzania who found that animal owners/pastoralists irrespective of age were skilled diagnosticians that managed treatment and control of diseases. Various methods were used by pastoralists in managing diseases. These included; use of alternative veterinary practices, amongst many other researchers, similar findings were observed by (Chinsembu et al., 2014; Chitura et al., 2018; Kebede et al., 2018) in Namibia, South Africa and Ethiopia respectively. Pastoralists also treat their animals using modern synthetic drugs. They were observed keeping various animal drugs and equipment for their administration, like syringes, a finding extensively documented by other authors including but not limited to, Makau et al. (2022) and Roderick et al. (2000) in Kenya, (Alhaji and Isola, 2018; Greter et al., 2017; Mangesho et al., 2021; Mikecz et al., 2020), in Nigeria, Chad, Tanzania and Uganda respectively.

Another important node at community level were the CDRs, who are a category of Community Based Animal Health Workers (CBAHWs). The community highlighted that they relied and trusted them to get reports quickly to the GAHWs, while GAHWs also highlighted their reliance on CDRs to constantly inform them on the disease situation on the ground. They also had roles in disease response and as such they had a high total degree centrality based on network statistics. Similar findings on the importance of CBAHWs were noted in Ethiopia by Admassu et al. (2005) where significant reductions in livestock disease impact were registered due to their utilization. Similar findings were also documented in South Sudan, Ethiopia and Kenya by Leyland et al. (2014) where CABHWs ranked high on attributes of accessibility, availability and acceptability. It's worth noting that in the above two studies, CBAHWs were also active in managing disease conditions while from our results CDRs focused mainly on disease reporting, as much as a few of them reported engaging in direct management of diseases.

Non – state actors including NGOs and iNGOs were perceived to have high power in disease response with their central role as supporting the county government with resources in responding to diseases. This finding agrees with George et al. (2021) in Tanzania who identified a USAID project, *Lishe endelevu* in several districts, having the highest resource based influence in animal health activities. These findings are also

similar to Abebe, (2016) in the pastoral Karamoja region of North Eastern Uganda, who noted that animal health service delivery in the region heavily relied on NGO support. However, this may not be the case in developed countries, Hayes et al. (2021) did not identify any NGOs or iNGOs in stakeholder mapping in animal health surveillance in Australia. These findings have mostly been documented in developing countries and could point to the role of Non – state actors filling an institutional/resource vacuum/deficit of the national governments through collaborations (Oruko & Ngung'u, 2009). However, despite their challenges in disease response, its noteworthy that the community expressed high credibility attached to the GAHWs based on their perceived power in response.

Use of mobile phones in disease reporting was a frequently mentioned method and this agrees with a study by Thumbi et al. (2019) in Western Kenya which showed that livestock illness events were 15 times more likely to be reported through the phone system compared to routine household visits and that disease syndromes with severe presentations were more likely to be reported through the phone system. This rapidly evolving use of mobile phones in disease surveillance is probably due to benefits offered due to their use, including real time exchange of information, improved completeness and accuracy of reports and they are simple and easily adoptable technologies, among others (Carrillo et al., 2021).

A major disease response challenge highlighted by the study is the low number of Animal Health Workers and under resourcing of the few available ones. A similar challenge was highlighted in Baringo County in Kenya (Shivairo, 2013; Omondi et al., 2016) in Narok, Kenya. This limitation was also conceded by the National Government in its draft national livestock policy (Ministry of Agriculture Livestock Fisheries and Cooperatives, 2019), which acknowledges that the technical-staff to farmer ratio is 1:1000 for pastoral systems, the highest compared to other production systems. It further highlights that most of the Arid and Semi-Arid Lands mainly depend on their respective County governments for extension services but lack consistent dissemination of the same and this adversely impacts production (Ministry of Agriculture Livestock Fisheries and Cooperatives, 2021). To address this challenge, pastoralists find themselves offering treatment to their animals by themselves, a practice that largely contravenes the Kenyan Veterinary Surgeons and Para-professionals Act Cap 366 (Government of Kenya, 2012) that mandates treatment by only veterinary surgeons and paraprofessionals that are registered and licensed according to the Act.

The study should be viewed in light of some limitations. The first one being that the National Director of Veterinary Services, Radio representatives and the County Department of Health Services were not interviewed therefore it's possible that their roles were not fully captured in this manuscript. It would be of use to triangulate the themes identified in this study by working with a wider range of stakeholders, across a wider pastoral geographical range.

Conclusion and recommendations

This study showed that livestock disease surveillance in pastoral areas comprises of various stakeholders, each with unique roles. These stakeholders interact to exchange information and services in regards to disease reporting and response, utilizing various methods in the process. Therefore, the efficiency of existent pastoral surveillance systems and those under development can be improved by engaging all stakeholders and utilization of their unique roles. A lot of information and service exchange happens through and by community level stakeholders. The national government and its development partners can consider innovative and formal collaborative approaches where these stakeholders for example, the animal owners, traditional healers, CDRs and agrovets/ private animal health workers are equipped with skills, knowledge and resources in management of livestock disease conditions and outbreaks. There is a growing presence and use of phones and media like radio in sharing disease outbreak information among a wide range of stakeholders. This widespread evolution in ICT and media sources is an opportunity that can be harnessed for the benefit of livestock disease surveillance. Challenges in livestock disease response, mainly low numbers and under resourcing of Animal Health Workers were highlighted. We recommend that the national government and development partners direct efforts towards addressing these inadequacies to improve livestock disease response. Due to constraints in extension services, pastoralists manage livestock diseases themselves through treatment with synthetic drugs, this finding necessitates law and policymakers to have a discourse around revision of the existent legal framework as pertains to provisions relating to veterinary practice. We further recommend that an official system of communication between the County Public Health Officials and the County Department of Veterinary Services be established, this is an important arm of livestock disease surveillance.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by the Faculty of Veterinary Medicine, Biosafety, Animal Use and Ethics Committee. The studies were conducted in accordance with

the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

Conceptualization: JO, RA, OW, and DS. Data curation: DS. Formal analysis: DS, RA, JO, and DM. Funding acquisition: JO, OW, and RA. Investigation: DS, RA, and HA. Methodology: DS, RA, JO, OW, and DM. Project administration: JO and OW. Software: DS, DM, and HA. Supervision: JO, RA, OW, and DM. Writing–original draft: DS. Writing–review and editing: all authors. All authors reviewed the results and approved the final version of the manuscript.

Funding

The author(s) declare that financial support was received for the research, authorship, and/or publication of this article. The study is an outcome of the project "Increasing efficiency in rangeland-based livestock value chains through machine learning and digital technologies (InfoRange)" funded by the German Federal Ministry of Education and Research (BMBF) within the "Research for Sustainability" (FONA) strategy (FKZ 01LL2201A).

Acknowledgments

We acknowledge the pastoral communities for their time and cooperation. We also acknowledge the locally recruited research assistants Mathew Leamo, Juma Saigor, and Peter Orguba for their hard work in translation during data collection.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontierspartnerships.org/articles/10.3389/past.2024.13468/full#supplementary-material

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