EISSN: 2707-0425

East African Journal of Science, Technology and Innovation, Vol. 2 (1): December 2020.

Livestock disease surveillance through the use of Smart Phone Application in Isiolo County, Kenya

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Abstract

The specific goal of this study was to enhance disease surveillance through the community disease reporters (CDRs) on animal health incidents in Isiolo County of Kenya. The disease surveillance was conducted from 10th February 2017 to 22nd November 2018 covering 8 wards from all the three Sub-Counties of Isiolo County namely Isiolo, Garbatulla and Merti. The surveillance involved the use of web-based mobile phones application to upload and transmit disease cases, pictures and GPS locations to the Country Veterinary Department. Purposive and convenience sampling were used to select the households due to vastness and mobility of the pastoralists. A total of 194 households were selected for the study. The major findings were; 80% men and 20% women participated as household heads. A total of 283 reports were collected and uploaded by 18 CDRs from the 194 households. 17 CDRs (94.4%) were able to upload the data on the same day on which it was collected, 7 CDRs uploaded the data one day after it was collected, 8 CDRs (44.4%) uploaded the data within 2-6 days after collection with the same number of CDRs taking 15-31 days. For reported cases, cattle (67%), camels (72%), sheep (71%) and donkeys (90%) as well as poultry (33.3%) were attended to by the Veterinary Department. Overall, 60% (164/283) of all the livestock disease cases reported were followed or seen by the Veterinary Department. Of the diseases reported, Isiolo sub-county reported more cases in goats, cattle and poultry, while Garbatulla sub-county recorded the highest number of cases in camels and sheep. In all the three sub-counties, the most reported livestock disease cases were of goats. Based on the findings above, CDRs can detect and transmit real-time to near-real time livestock diseases information using web-based smartphone applications to help veterinary services to analyse and respond early to diseases, endemic or outbreaks, hence minimize morbidity and mortality losses.

Keywords: *Diseases; Isiolo; Kenya; Livestock; Smartphones; Surveillance*

Introduction

The livestock sector plays a major role in the rural economies in Kenya and the rural folk derive a range of financial benefits from livestock keeping, including the provision of credit, insurance, and as a means of sharing risk (IGAD, 2011). The credit benefits of livestock are derived from the ability of livestock owners to 'cash in' their animals for particular purposes at a time that they choose. This flexibility gives livestock owners access to money without the need to borrow, and confers an additional financial benefit beyond the sale, slaughter or transfer value of their livestock (IGAD, 2011)

Cite as: Ikiror *et al.,2020 Livestock disease surveillance through the use of Smart Phone Application in Isiolo County, Kenya. East African Journal of Science, Technology and Innovation 2(1)*

Received: 30/09/20
Accepted: 26/11/20
Published: 11/12/20

An estimated 50% of Kenya's livestock are kept in the arid and semiarid lands (Nyariki *et al.,* 2009). About 10-40 percent of the gross agricultural domestic product of Kenya and other African countries is derived from pastoral livestock production (African Union, 2010). In the arid and semi-arid areas, livestock production under pastoral livestock farming system is the main form of agriculture and source of livelihood as rain-fed agriculture is not sustainable (FAO, 2017). Pastoral livestock production remains the most sustainable land use option in the African Dryland compared to crop farming (Behnke & Kerven, 2013) and modern ranching (Angassa & Oba, 2007). A key challenge is the unreliable rainfall pattern, as during the dry season natural pasture is scarce and deficient in nutrient concentrations (Gwelo *et al.,* 2015). Different methods have been adopted to increase the livestock offtake in the pastoral systems as recently reported by Dabasso *et al.,* (2018).

In Kenya, the livestock subsector accounts for 30 per cent of the farm gate value of the agricultural commodities (IGAD, 2011). Kenya livestock population comprises of the following estimated livestock species; cattle (18m), sheep (18m), goats (28m), camels (3m) pigs (0.3m) and poultry (31m) (Kenya National Bureau of Statistics, 2019). Currently, about 60% of the total households keep livestock, with about 7 million of these households, keeping on average a fewer number of livestock (Kenya National Bureau of Statistics, 2019). The majority (75%) of livestock keepers are rural and among the less-well off in the population (FAO, 2017). As a response to the growing demand for animal-based foods, livestock keeping households as well as private commercial livestock enterprises, continue to expand their livestock assets and adopt productivity-enhancing practices. For some, livestock will represent a vehicle out of poverty (FAO, 2017).

Over 80 percent of the inhabitants of Isiolo rely on livestock for their livelihoods. Nomadic pastoralism is prominent in the county and defines the lifestyle of most of the county's inhabitants. The commonly found diseases that impact on trade are Contagious Caprine Pleuropneumonia (CCPP), Sheep and goat pox (S&GP and Peste Petit des Ruminates (PPR) in small stock, Lumpy Skin Disease (LSD), Foot and Mouth Disease (FMD), and Contagious Bovine Pleuropneumonia (CBPP) in cattle. In camels it is Pox and Trypanosomiasis. A number of other diseases are endemic throughout the year. Though a vaccination regime, surveillance and a real-time reporting system is available in some countries, a more structured and efficient approach is required for Isiolo County (Isiolo County Integrated Development Plan (CIDP) 2018-2022, (2017). Frequent outbreaks of infectious diseases hamper productivity in most cattle production systems in Kenya (Gitau *et al.,* 2001; Wesonga *et al.,*2010). These diseases also cause stunted growth and increased pre-weaning mortality rate in calves (Gitau *et al.,* 2001). Some past studies for example showed that the most prevalent cattle diseases in pastoral areas in Kenya include foot and mouth disease, Trypanosomosis, East Coast fever (ECF), contagious bovine pleuropneumonia and contagious caprine pleuropneumonia, lumpy skin disease, Blackquarter, and malignant catarrhal fever (MCF) (Njanja *et al.,* 2003; Wanyoike, 2013).

Disease surveillance enables various stakeholders to share health information for monitoring, controlling and preventing the occurrence and spread of reportable and notifiable infectious as well as some non-infectious diseases and conditions (Onono *et al.,* 2013). Given that notifiable diseases are highly contagious and rapidly spread thus causing serious illness or mortality, it is important that simple and easily adaptable technologies that support early detection and rapid transmission of disease events be developed to control livestock diseases and their associated outbreaks. The early detection will also allow resource planning, allocation and subsequent reduction of losses incurred due to livestock disease outbreak.

The objectives of this study were; 1) to establish a livestock disease reporting system using smart phone application through a web-based system to allow an electronic form to be designed and uploaded onto smart phones; and 2), to develop of a web-based interface to facilitate review and exporting of results in standard file formats e.g. excel sheets, graphs.

Materials and Methods

Description of Isiolo County and selection of the study area

Isiolo County is located right at the Centre of Kenya. It borders 8 counties namely; Marsabit to the North, Wajir to the East, Garissa to the south east, Tana River, Kitui, Meru to the south, Laikipia to the Southwest and Samburu to the West. Ewaso Nyiro River flows through the county and partly bounds it (Isiolo County Integrated Development Plan (CIDP) 2018-2022, (2017). It covers an area of approximately 25,700 km^2. It is located between Longitudes $36^o50'$ and $39^o50'$ east and latitude 0^o 05′ south and 2^0North (Isiolo County Integrated Development Plan (CIDP) 2018-2022, (2017). Isiolo town lies 285 kilometers north of Nairobi, the capital city of Kenya by road.

Isiolo County population is estimated at 268,002 (KNBS, 2019). The backbone of the County's economy is the livestock sub-sector. In the pastoral livelihood zone, 50 percent of the population is semi nomadic while the other 15 percent are fully and occasionally nomadic. In the agro pastoral livelihood zone, 45 percent of the population is fully settled while 30% are semi nomadic.

Most of the land in the Isiolo County is flat low lying plain and the local topography is arid or semi-arid. The plains rise gradually from an altitude of about 200m above sea level at Lorian swamp (Habaswein) 300m above sea level at Merti Plateau and 1100 M above the sea level at Isiolo town. The county lies in two ecological zones namely; semi-arid and arid. The county is hot and dry in most months of the year with two rainy seasons. The short rain season occurs between October and December with the peak in November while the long rain occurs between March and May with the peak in April. The topography of the landscape influences the amount of rainfall received. The higher ground areas near Mount Kenya and Nyambene Hills receive between 500-670mm of rainfall per year. The drier eastern and northern parts of the county receive less than 300mm. High temperatures are recorded in the county throughout the year, with variations in some places due to differences in altitude. The mean annual temperature in the county is 29 degrees centigrade.

Isiolo County was selected because it is one of the pastoral counties of Kenya, has all the livestock species raised in pastoral areas in Kenya, straddles between the pastoral and high potential dairy farming, is logistically near the capital city of Kenya and there was a funded livestock project during the time of the study.

Selection of sampling units

The target sampling frame for the disease surveillance was all the 58,072 households that formed the estimated Isiolo county human population of 268,002 persons. Out of this population, a sample size of 194 households was selected purposively and conveniently based on the occurrence of disease events and due to mobility of the pastoralists.

The study involved the use of both primary and secondary data collection. The secondary data were sourced through desk reviews mainly sourced from the internet and the past Isiolo County reports. The primary data, both qualitative and quantitative, were gathered directly from the households in the field. The primary data were collected using individual questionnaires and administered through household visits and face-to-face interviews and collected through the smart phones. The questions covered household demographics, livestock species, livestock diseases, and disease control and prevention measures.

Data Collection

The study was conducted from February 2017 to November 2018 covering 8 wards in Isiolo County. Prior to the field data collection, a three-day training of already existing and trained 18 veterinary paraprofessionals and Community Disease Reporters (CDRs) was held in February 2017 on the administration of the questionnaires and use of the mobile phone app. The training was conducted by the authors supported by the County Veterinarians. The CDRs comprised of four veterinary paraprofessionals (Animal Health Assistants (AHAs) and the existing 14 CDRs recruited from the local community, all collectively called "CDRs" for simplicity in the

rest of this paper. The CDRs had prior hands-on training and experience in collecting data and reporting livestock diseases to the Veterinary officers in the County using paper-based disease reporting format and had basic training, knowledge and skills on livestock diseases and data handling.

For this study, the CDRs were trained on the use of mobile phone in data collection and included the use a smartphone in: mobile data collection, login on the mobile data collection platform, filling in the questionnaire, taking good photographs, georeferencing the data collection sites and uploading the photos and the collected data. Following the training, each CDR was given specific log-in codes to enable them have access to the programmed questionnaire during the training session and during data collection. To ensure that the training was grasped properly, the trainees were taken through practical sessions to enhance the skills learned and were paired to carry out interviews among themselves, fill and transmit the responses to the Computer-Assisted Personal Interviews (CAPI) platform. A pre-test of the questionnaire was conducted at the end of the training among some households who were not to be selected for the main study one week before the study commenced. Each of the trainees carried out a pre-test on one pastoralist, took photos and uploaded the data on CAPI. The data collection commenced immediately after the training and the date of data collection and upload were recorded at the beginning of the study and the other subsequent days, though it was not mandatory to upload the same day. Data collected were transmitted to a central server located at the Veterinary Department at the County Headquarter.

The CDRs used the syndromic approach to report disease occurrence and these were verified/confirmed by the four project veterinarians through the photos of sick animals taken and uploaded on the smartphone applications or through visits that were facilitated by the project. It was intended that all reported cases were seen by the veterinarians in the field with exceptions of a few times when it was logistically difficult to accomplish.

Data handling and analysis

All the data collected were later entered in MS-Excel 2010 (Microsoft, Sacramento, California, USA), serialised, cleaned up, and checked for completeness before being subjected to the analysis. The cleaned-up data were then analysed using Ms-Excel (the Chart Wizard technique). The data were analysed using descriptive statistics and mainly by computing frequencies and proportions.

Results

Household Demographics

Distribution of respondents under the Disease Surveillance Exercise

A total of 194 households were interviewed during the study period. Table 1 shows the distribution of the 194 HH interviewed according to the three sub-counties of Isiolo County. Eighty percent (155/194) interviewees were men and the remaining 20% (39/194) were women. The detailed distribution and breakdown of participants by gender, Ward and sub-county is shown in Table 1.

Frequency of the Household visits

Figure 1 shows the frequency of visits made by the CDRs in the targeted households based on disease reports. The 18 CDRs made a cumulative 283 household visits to the 194 targeted households. A total of 160 households (82.5 %) were visited once, 22 households (11 %) were visited twice, 9 households (5 %) were visited three times. Two households and one household respectively (combined 1.5 %) were visited four and six times.

Table 1: Distribution of respondents by gender, Ward and Sub-County from Isiolo County between February 2017 and November 2018 (n=194)

County	Sub-County	Ward	Respondents (Livestock owners)	
			male	female
Isiolo	Isiolo	Burat	19	4
		Oldonyiro	39	6
		Ngaremara	13	4
	Garbatulla	Garbatulla	29	3
		Kinna	16	9
		Sericho	7	0
	Merti	Cherab	15	8
		Chari	17	5
TOTAL			**155(80%)**	**39(20%)**

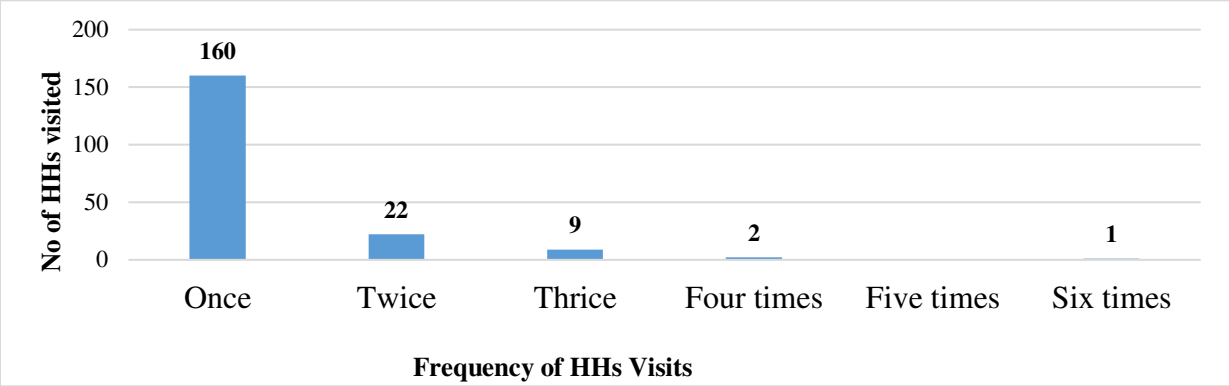

Figure 2: Frequency of household visits made by the CDRs to the targeted households (n=194)

Number of days taken by Community Disease Reporters to upload data

The number of days taken between date of data collection and date of data upload by each of the 18 CDRs during the disease surveillance exercise were counted and are presented in Figure 2 below. Data collected could be stored on the mobile phone by the CDR until uploaded to the central data server. On some occasions, 17 CDRs (94.4%) uploaded the data on the same day on which they were collected. Eight CDRs (44.4%) uploaded the data within 2-6 days with the same number of CDRs taking 15-31 days. In some cases, 7 CDRs (38.8%) respectively took 1 day, 7-14 days and 61-90 days to upload the data. Three (17%) CDRs took 91-140 days while 4 CDRs (22.2%) uploaded the data after 140 days.

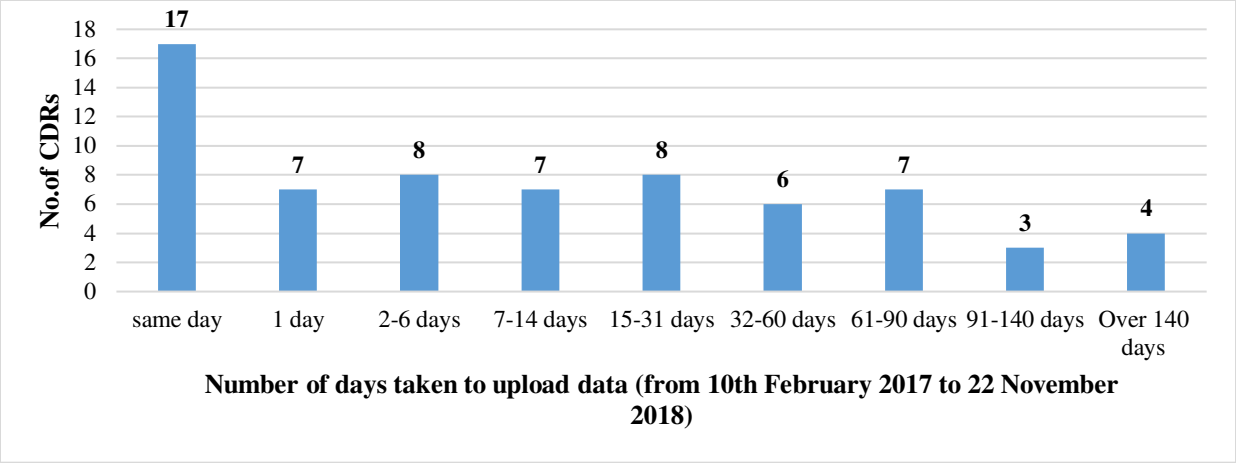

Figure 2: Number of days taken by Community Disease Reporters to upload data

Number of days taken by CDRs to upload the collected reports into the system

A total of 283 reports were collected by the 18 CDRs from 194 livestock owners and uploaded during the disease surveillance exercise. Figure 3 shows the number of days taken by the CDRs to upload data into the system. The delays to upload were due to lack of network in some areas or of battery power on the phones. A total of 145 reports (51%) were uploaded on the day of collection, 14 reports (5%) were uploaded one day after collection, 24 reports (8.5%) were uploaded 2-6 days after collection, and 22 (8%) reports were uploaded 7-14 days after collection. Respectively, 34, 13, 14 and 8 reports were uploaded 15-31 days (12%), 32-60 days (4.6 %), 61-90 (5%) and 91-140 days (3 %) after collection. Nine reports (3.2 %) were uploaded 140 days after collection.

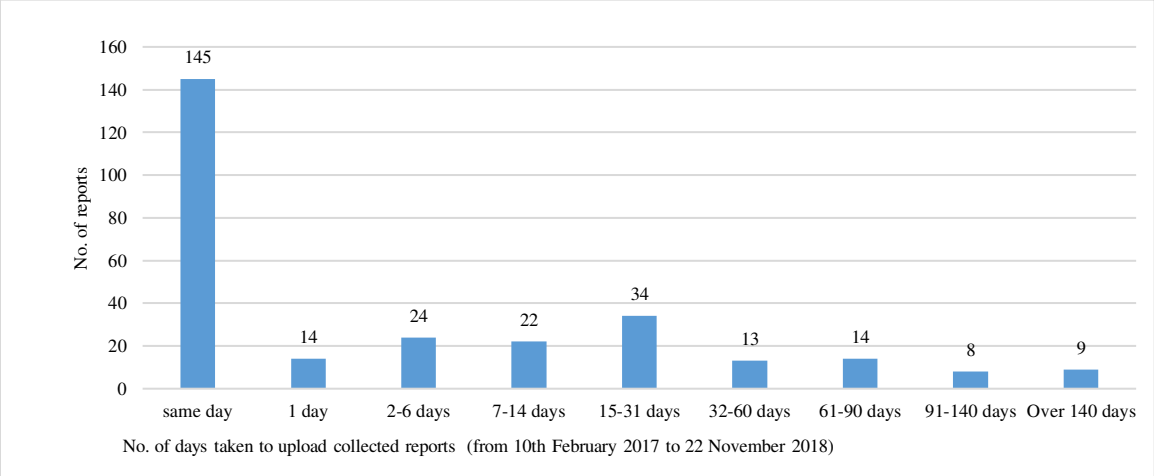

Figure 3: Number of days taken to upload the collected reports in Isiolo County between February 2017 and November 2018

Number of livestock disease cases reported and followed up per species

Table 2 shows the number of reports of livestock disease cases transmitted digitally by mobile phones according to species of livestock and the number that were later followed-up by the Veterinary Department of the Isiolo County Government. Overall, 58 % (164/283) of all the reported cases by the CDRs were followed by the

County Veterinary Department. The following percentages per livestock species were reported to have been attended by the Veterinary Department of the County; cattle (67%), camels (72%), goats (49%) sheep (71%), donkeys (90%) and poultry (33.3%).

Table 3: Number of [livestock disease cases reported and followed up per species in Isiolo County between February 2017 and November 2018

	Livestock species							
	Cattle	**Camels**	**Goats**	**Sheep**	**Donkeys**	**Poultry**	**Dogs**	**Total**
Number of cases reported	52	29	144	35	10	12	1	**283**
Number of cases followed up per species	35	21	70	25	9	4	0	**164**
Percentage cases reported that were followed by Veterinary Department	67	72	49	71	90	33	0	**58**

Incidents of diseases in the sub-counties

Out of the diseases reported, Isiolo sub-county generally reported higher cases in goats followed by Merti and Garbatulla sub-counties (Figure 4). Isiolo sub-county also recorded the highest cases in cattle and poultry than the other sub-counties while and Garbatulla sub-county recorded the highest cases in camels and sheep than the rest. In all the sub-counties, the most affected livestock which had the highest reported cases were the goats.

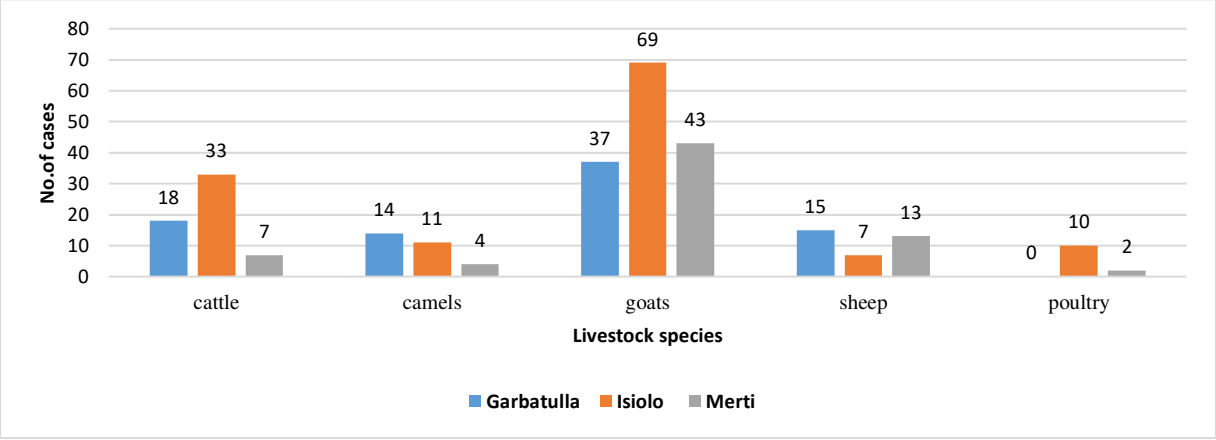

Figure 4: Number of disease reports made by livestock type per sub-county from Isiolo County between February 2017 and November 2018

Occurrence of diseases and mortality in the herds

In general, the total livestock species in the herds were marked with low disease occurrence and mortality (Figure 3). Of the 1650 disease cases, majority of the cases reported were in goats at 57.3% (946/1650), followed by cattle at 14.5% (240/1650), camels at 13.2% (218/1650), sheep at 8.4% (140/1650), poultry at 4.4% (72/1650), donkeys at 2% (33/1650), with the dogs being the least at 0.06% (2/1650).

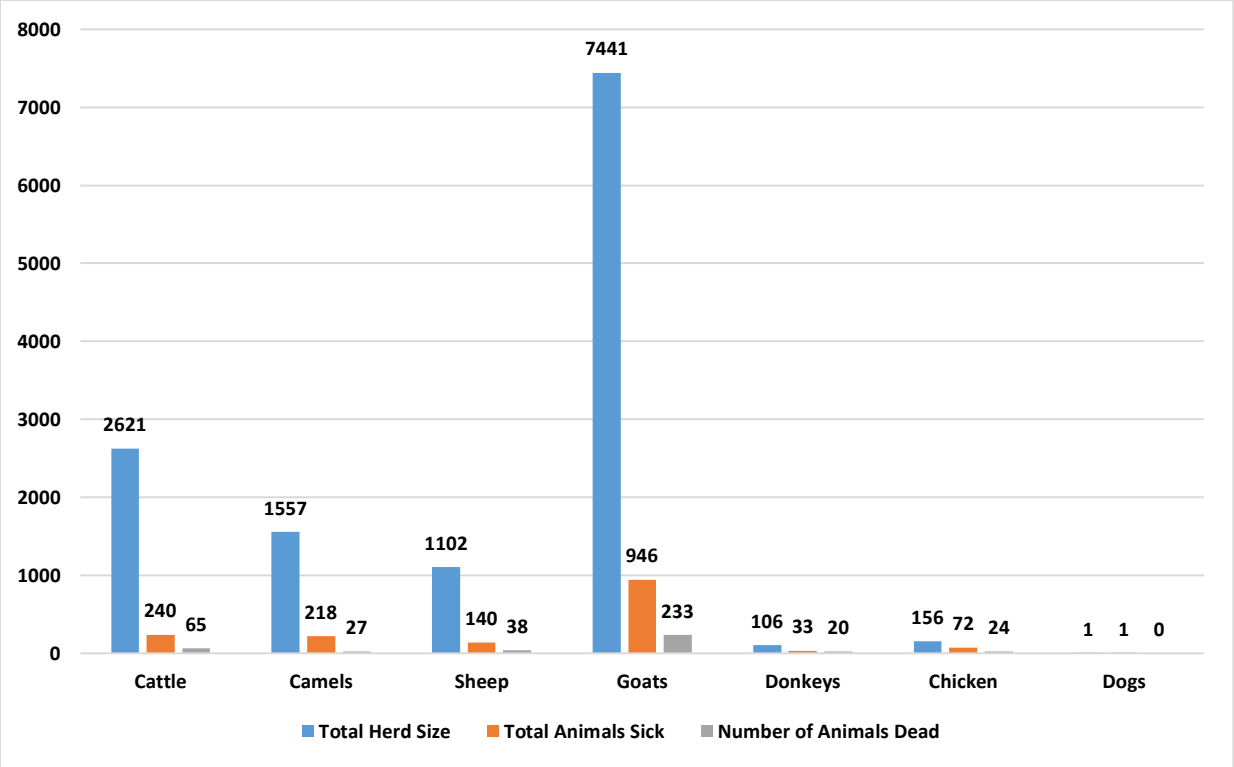

Figure 5: Occurrence of diseases and mortality in the herds from Isiolo County between February 2017 and November 2018

Frequency of disease cases by livestock species

Cattle

The respondents reported 18 different diseases in cattle from this study across the three sub-counties (Figure 6). The most common diseases mentioned, in descending order were; Anaplasmosis, Trypanosomosis, Black quarter, East Coast Fever (ECF) and Lumpy Skin Disease (LCD). Other less frequently reported cases included malnutrition, mange, helminthiasis, mastitis, pneumonia, pink eye, cow pox, Hypocalcaemia, eye infection, leech, allergic dermatitis and liver fluke infestation (fascioliasis).

Camels

Fourteen (14) camel diseases were reported across the three sub-counties (Figure 7). The most common diseases in camels were abscess, mange and pneumonia. The most frequently reported disease was abscess. The least occurring diseases were; hematoma, paralysis, helminthiasis, orf, wry rye neck, traumatic injury, babesiosis, Hemorrhagic Septicemia (HS), neonatal diarrhoea, urethral infection and ringworms. Abscess was reported as being transmitted through; direct contact with other infected herds at watering points and during migration, use of contaminated syringes, lack of isolation of infected herds, poor management of camel injuries as well as ectoparasites.

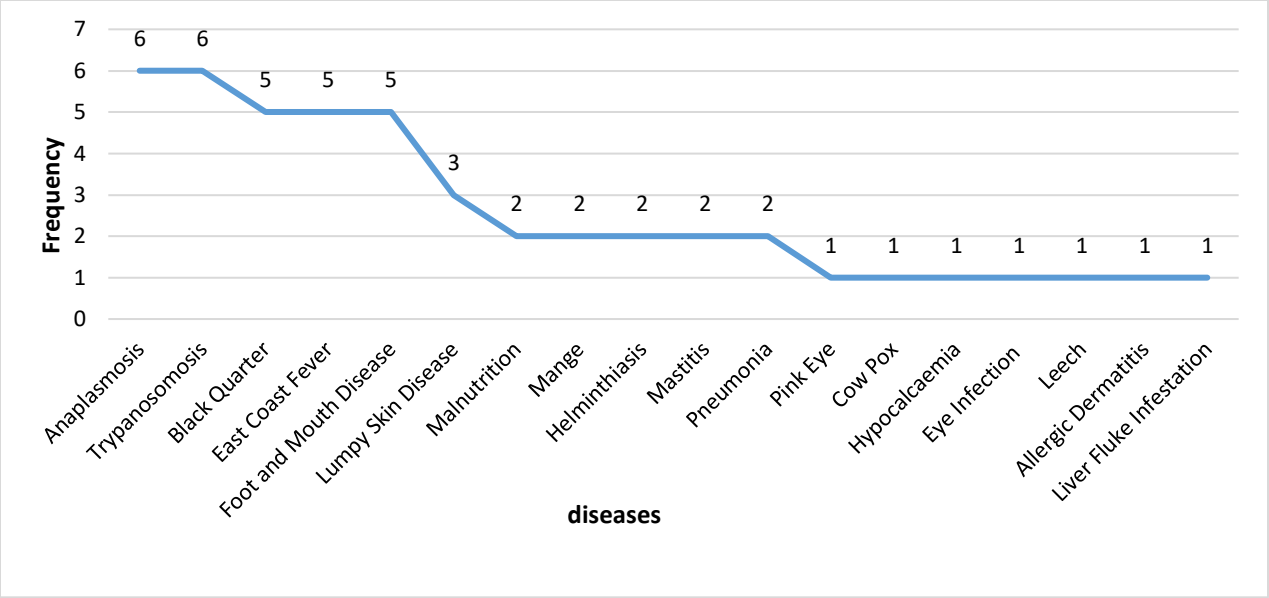

Figure 6: Cattle diseases reported from Isiolo County between February 2017 and November 2018

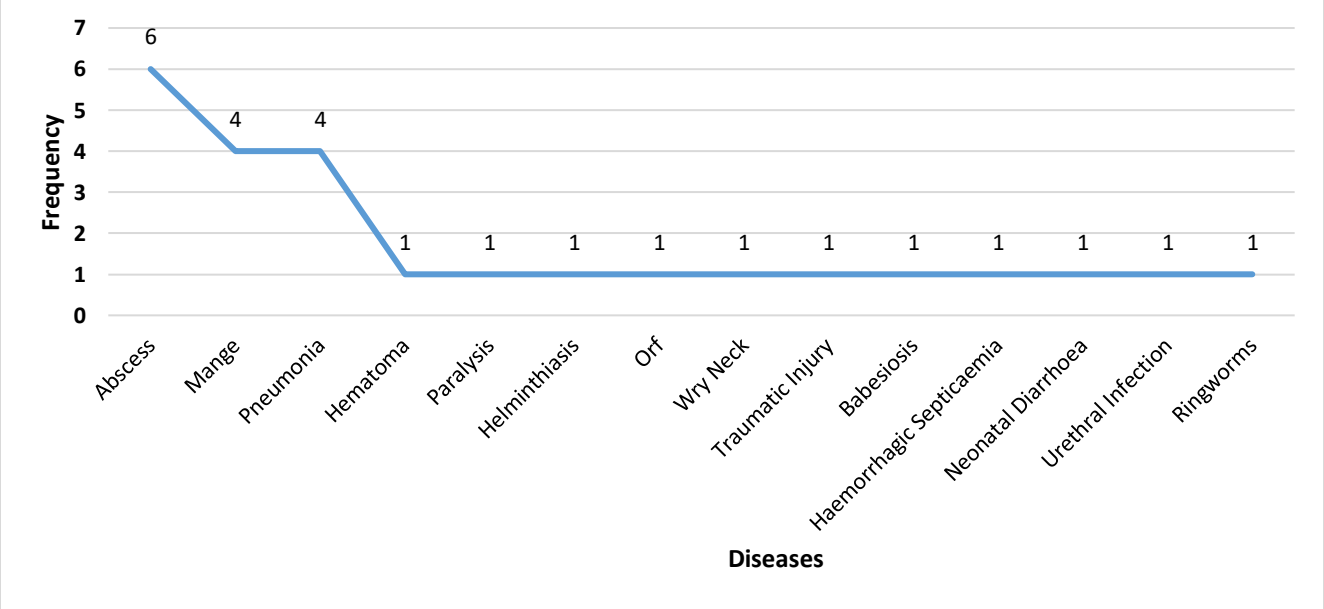

Figure 7: Camel diseases reported from Isiolo County between February 2017 and November 2018

Goats

Goats were reported with the highest number of diseases occurrences across the livestock species (Figure 8). The most commonly reported diseases were Contagious Caprine Pleuropneumonia (CCPP), Goat pox, Peste des Petit Ruminants (PPR), Pneumonia, Helminthiasis and Orf. The other moderately and less frequently reported diseases were Heartwater, Foot and Mouth Disease (FMD), Coenurosis, diarrhoea, lymphadenitis, allergic dermatitis, mastitis, foot rot, Anaplasmosis, Trichomoniasis, grain overload, Trypanosomiasis, Ascites, prolapse, Mycoplasmosis, infectious abortion, heavy worm

infestation, arthritis, food poisoning and insect bites. Contagious Caprine Pleuropneumonia, which was the most cited disease, was being reported by pastoralists to be transmitted through drinking contaminated water, exposure to infected flocks at watering and grazing areas and uncontrolled livestock movement.

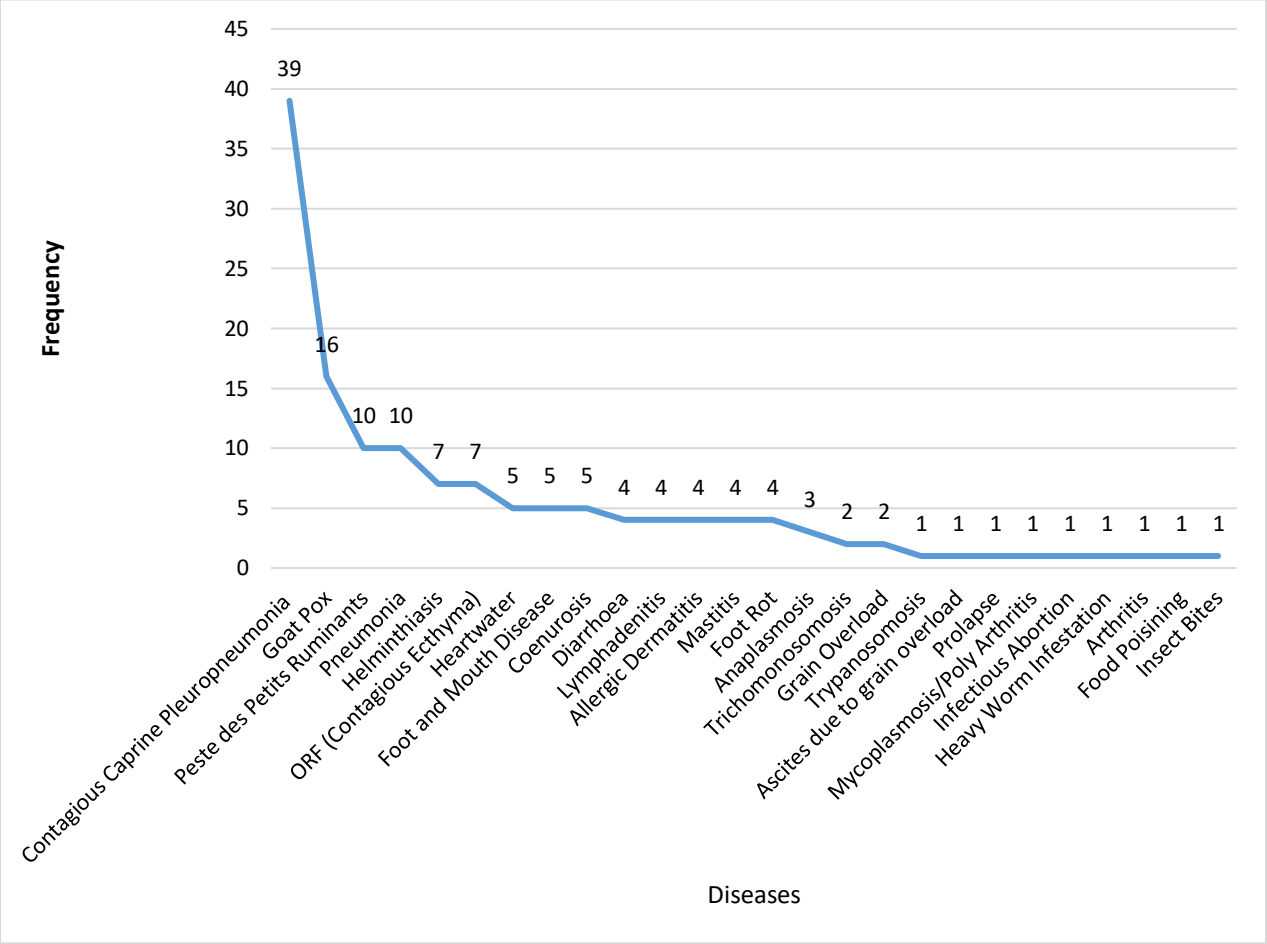

Figure 8: Goat diseases reported from Isiolo County between February 2017 and November 2018

Sheep

Thirteen diseases of sheep were reported across the three sub-counties (Figure 9). The most common reported diseases in sheep were pneumonia, helminthiasis and foot rot. The most frequently reported disease was pneumonia. Other less frequently reported diseases included; sheep pox, aspiration pneumonia, Peste des Petit Ruminants (PPR), Enterotoxaemia, ringworms, Trypanosomiasis, Abortion, pasture bloat and heart water. Pneumonia was reported as being transmitted through drinking contaminated water, exposure to infected herds at watering and grazing areas and insecurity where animals were kept together in the same area.

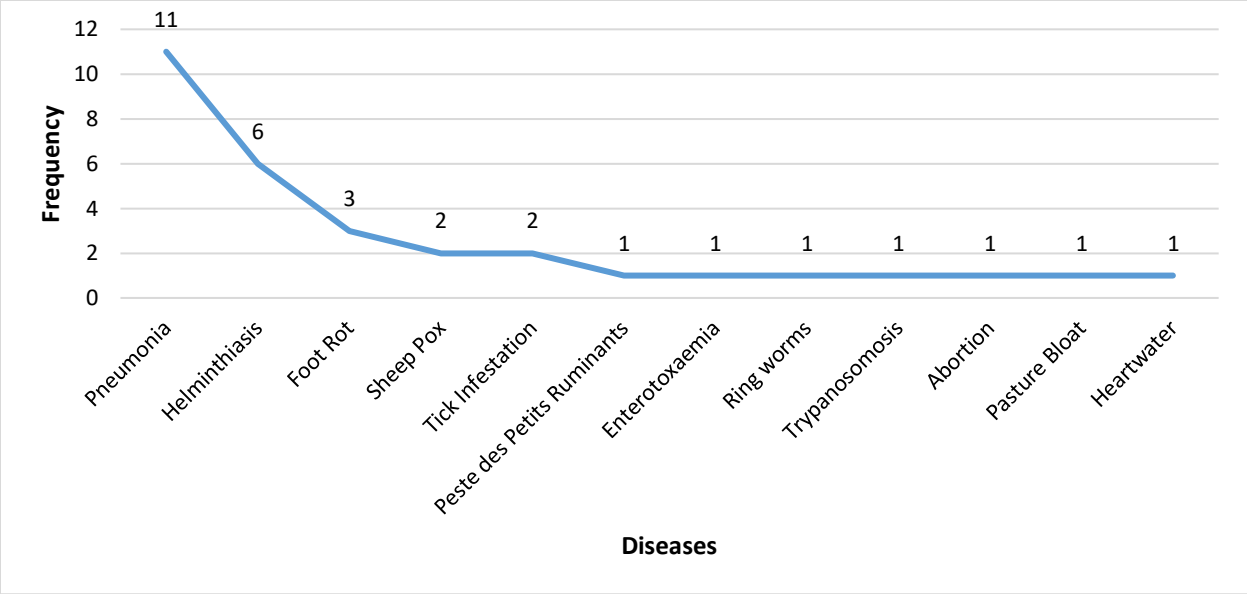

Figure 9: Sheep diseases reported from Isiolo County between February 2017 and November 2018

Donkeys

Seven (7) diseases were reported in donkeys across the sub-counties (Figure 10). The most common diseases reported were pasture bloat and septic wound. Other cases mentioned included mange, eyes infection, Trypanosomosis, helminthiasis and emaciation. Pasture bloat was reported as being transmitted through the overconsumption of *Mathenge* pods (*Prosopis juliflora*).

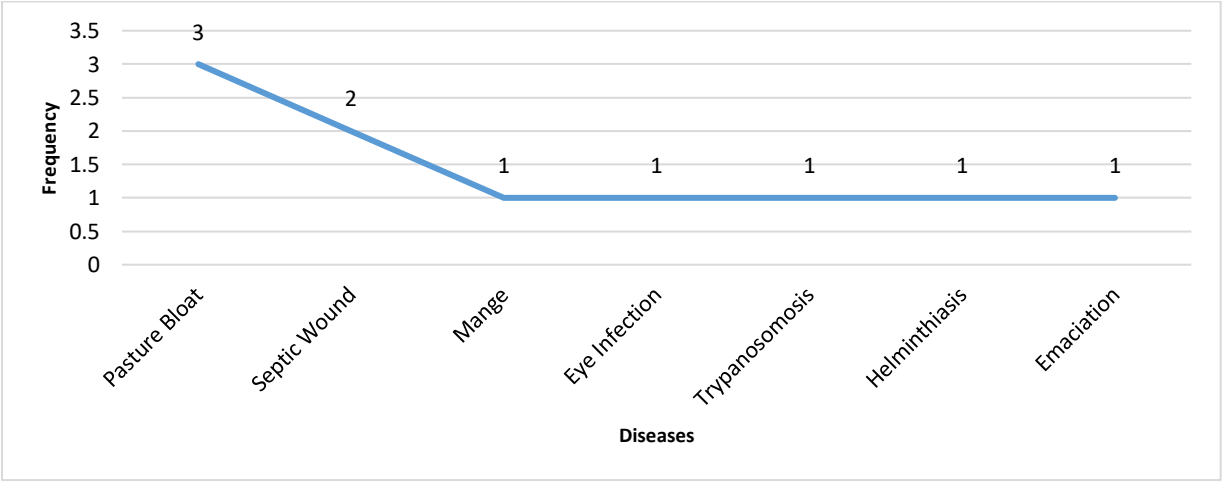

Figure 10: Donkey diseases reported from Isiolo County between February 2017 and November 2018

Poultry

Five diseases were reported in poultry across the sub-counties (Figure 11). The most common reported diseases were, Newcastle Disease (NCD) and fowl pox. Other less reported diseases were; tannin poisoning, tick infestation (poultry soft ticks) and mite infestation (scaly leg mites). Newcastle Disease was reported by pastoralists as being transmitted through the air, contact with infected poultry and introduction of new birds.

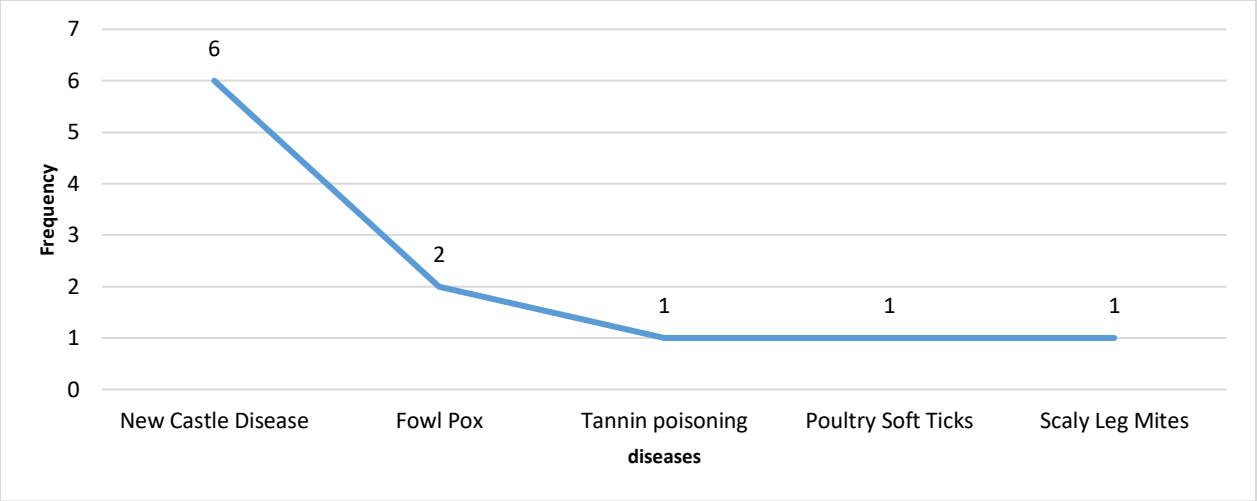

Figure 11: Poultry diseases reported from Isiolo County between February 2017 and November 2018

Discussion

This study reaffirmed the patriarchal-headed Kenyan society and household leadership as has been reported in other studies in pastoral and other agricultural farming communities in Kenya that over 80% of the households were led by men (KNBS, 2019). The two sub-counties of Isiolo and Garbatulla that also comprised the major urban centres also had a higher number of female-headed households. The later may have been associated with possible family lifestyle changes that are likely to occur in and around urban areas compared to the deeper rural set-up where there is a stronger cultural recognition of male-headed households. The above gender-based household leadership tends to have other implications on decision making in the family or household.

The study showed that the community disease reporters demonstrated competence and ability to operate mobile phone and digital platforms to record interview data, record disease events and upload the data to the centralized database. The latter was based on successful transmission of the same to the central server. The results further showed that the CDRs had entered and uploaded 72 % of disease data within the first 14 days from the date of data collection. This is a key milestone to ensure timely reporting of the disease information to the veterinary authorities. Since some of the households are remotely located, the rapid and efficient data collection would ensure real-time reporting of disease events and a faster response to intervention and thus reduce potential unnecessary spread of disease and mortality. Only 11% of the data collected took over 60 days to report and upload data. A major excuse was lack of source of power to the main grid and this can be solved easily by providing other reliable sources such as solar power. Another challenge was poor network connectivity in some instances. This is bound to decrease as the mobile network/internet connectivity continues to improve in Isiolo County and throughout Kenya

The results of the study showed that nearly 60% of the cases of large animals reported by the CDRs through the mobile phone platform were attended by the County Veterinary Service. A similar study carried out recently among smallholder dairy farmers in the neighbouring County of Meru showed that the use of mobile phones to interact with farmers can play a significant role on improving farm productivity and disease management (Makau *et al.,* 2018). The cases of donkeys reported the highest attendance of 90%. Given that the donkeys are the beast of burden in the pastoral areas and are used to support all forms of family transportation, any illness may elicit the need to

report and therefore urgent attendance by the owner so as to sustain smooth family survival. Only reported cases of poultry had a lower attendance of 33% probably because the pastoralists generally have less interest in poultry rearing and therefore may have reported few cases in poultry. The results indicated that the use of mobile technology for disease reporting coupled with better working interaction between County Veterinary Services and mobile phone-enabled CDRs can enhance the rate of livestock disease attendance. In the past, the higher occurrence of livestock morbidity and mortality has been blamed on inadequate extension services (Maingi and Njoroge, 2010; Wesonga *et al.,* 2010). In the latter case, regular preventive procedures such as vaccinations are not carried out but tend to be done after disease outbreaks when it is already late. If vaccinations are carried out early, it is likely to reduce the losses associated with disease morbidity and mortality to the pastoralists located in remote areas within the pastoral communities. Another important observation from the study was that Isiolo and Garbatulla sub-counties which also host the main urban centres reported higher cases of livestock diseases. The latter could be because farmers are near the veterinary service providers or since they host livestock markets, new animals are always brought to the market and hence likelihood of disease introduction. The other reason could be that the pastoralists in the remote areas could be using traditional methods of treatment and thus report less cases to the Veterinary Department.

The study showed that the main diseases reported in cattle were mainly both contagious and vector-borne such as Foot and Mouth Disease and Lumpy Skin Disease, and East Coast fever, Trypanosomosis and Anaplasmosis respectively. In sheep and goats, the main diseases were contagious such as contagious caprine pleuropneumonia, peste des petit ruminantes, orf and goatpox, and sheep pox respectively. In addition, pneumonia, helminthiasis and foot rot were reported to occur frequently in sheep. The contagious diseases are known to occur and spread easily in pastoral communities where there is unrestricted movement and interaction of animals as was the case in Isiolo County. A study by Onono et al. (2013) among the Maasai pastoral communities identified lack of veterinary extension services, and presence of diseases among other factors such as scarcity of water, frequent drought, and lack of markets for livestock and their products as the major constraints that impacted pastoralists' livelihood. There is also a tendency for these diseases to occur during the drier months when pastoralists move their animals for long distances in search of pastures and water therefore increasing contacts among different herds and flocks Onono *et al.,* (2013). Dust and close contacts at watering points enhance the rapid spread of these diseases. For camels, the main diseases reported were ectoparasites and injuries with the latter also reported in donkeys. Camels get injured by thorns in the head and neck regions due to their browsing way of feeding and these injuries develop into abscesses and other types of wounds. Some of these wounds/abscesses are also associated with chronic tick bites as the camels hardly receive any ectoparasite treatments such as acaricide (Lamuka *et al.,* 2017). The main conditions reported in donkeys were mainly wounds which were probably associated with poor harness and human beatings. For poultry, the two main contagious diseases were Newcastle and fowl pox. The latter were probably associated with movement of poultry from one homestead to another mainly associated with gifts and donations from one household to another in new introductions to improve the breeds.

A study by Onono *et al.,* (2013), in Kajiado County of Kenya showed that agro-pastoralists occasionally vaccinate their herds, despite high incidences of notifiable diseases. The difference in vaccination frequencies may not reflect variation in disease incidences across the study areas, but possibly relate to affordability of or access to vaccines. Homewood et al. (2006) investigated association between uptake of a veterinary intervention and the ability of livestock keepers of Mairowa area in Tanzania to pay for the intervention. They concluded that herd sizes and wealth status play a role in the use of livestock vaccines and that wealthy households tend to vaccinate a larger percentage of their herds than their poorer counterparts do. Another study recently showed that different methods have been adopted to increase the

livestock offtakes in the pastoral systems as recently reported by Dabasso *et al.,* (2018). The study showed that disease is one factor that could affect livestock offtake. Since the study showed that the link between CDRs and Veterinary Department was enhancing case reporting and eventual attendance, the pastoralists in Isiolo County should be encouraged to support this form of disease reporting system in order to reduce the negative impact of disease on their livestock.

Conclusion

Livestock in Isiolo County continue to experience both contagious/transboundary, and vector-borne diseases which form the major causes of morbidity and mortality. These diseases that include foot and mouth disease, Lumpy Skin Disease, East Coast fever, Trypanosomiasis, contagious caprine pleuropneumonia, peste des petit ruminantes, orf and goat and sheep pox, can be controlled and prevented easily if there exist a simple robust system of disease control.

The digitized form of disease recording and transmission used in this study facilitated a reduced turn-around time of intervention compared to the cumbersome paperwork in the veterinary offices and made it much easier to keep a database of outbreaks in digital formats. This was due to the fact that a CDR did not require to travel long distances to report a case but could report real-time via the mobile phone. The partnership with the Isiolo County Veterinary Department was in itself a positive milestone and guaranteed the full implementation and the potential sustainability of the disease surveillance in the County. The approach used also gave the communities leverage of ownership of the project as the CDRs were and are part of the community where the disease events occur.

It is recommended that to enhance the understanding of spatial and temporal distribution of the disease events and occurrence, a long-term longitudinal study should be designed and implemented to improve the quality of data collected. In addition to data quality and accuracy, such a study would also use other estimates and/or measures used in epidemiology and also understand clearly and accurately the risk factors associated with the occurrence of the disease. Any data entry inconsistencies that may have been noted or occurred in this study can be addressed and corrected and/or modified during the follow-up in a well-structured longitudinal study. Since some diseases were reported in their local names, there is need to create a dictionary of local disease names for the different ethnic groups to help with the data analysis and escalation process.

In order to counter the issues with CDRs busy schedules, there is need to increase the number of reporters to village level. It is vital to empower the CDRs to allocate time to the project alongside their regular work to ensure constant streaming of data. This can be organized together with the county office of the veterinary department. The Isiolo County Veterinary Department is aware of the active and efficient reporters and have been involving them in their activities in publicity, sensitization and mobilization.

Acknowledgements

We would like to thank Biovision Foundation for providing the funding that supported this study under the Project "Upscaling of integrated camel management for livelihoods and collaborative disease surveillance for animal health (in the climate-change affected ASAL region of Kenya)-UPICAM II", Biovision Project ID:BV AH-05/01.2016-12.2018. We also want to thank the staff of the Isiolo County Government, VSF-Suisse and Ipsos Kenya who supported and participated in this project. We also thank the community disease reporters and members of the households who participated and provided data regularly. Special thanks to Belinda Melizam for data analysis and to Francis Lekapana for technical assistance on IT.

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