Integrated community based human and animal syndromic surveillance in Adadle district of the Somali region of Ethiopia

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ABSTRACT

The economy of Ethiopia largely depends on agriculture and roughly 80% of the households have direct contact with domestic animals which make the community vulnerable to zoonotic diseases, especially in pastoral areas like the Somali Regional State (SRS) of Ethiopia. However, in addition to low reporting rates, especially in livestock, there is also lack of coordination between public health and animal health surveillance and there is no linkage between public health system and animal health system and mechanism or structure for sharing information on zoonotic diseases in SRS. In view of these challenges, a small scale study was conducted to evaluate the feasibility of mobile communication in the early detection of human and animal syndromes in remote pastoral areas including where there are no human and animal health facilities by engaging local communities in the diseases surveillance.

Method: A small scale study, testing a community based human and animal syndromic surveillance was conducted from August 2017 to February 2018 in 20 villages in four Kebeles of Adadle district in the SRS with an estimated 1390 households and 112,850 livestock. The selected community leaders were trained on disease surveillance and detection. The communication was done by direct calls. Two dollars per month were provided to the village leaders recruited for the surveillance.

Results: A total of 904 and 671 human and animal syndrome cases were reported in seven months of the study period. In addition to syndromes, suspected anthrax, sheep and goat pox (SGP), rabies, salmonellosis and mass abortion outbreaks were reported in animals. In humans, suspected cholera and chicken pox outbreaks were reported. Furthermore, tuberculosis and malaria cases were also confirmed in the study villages. In humans, gastrointestinal tract (GIT) disorder was the most common syndrome observed, which constituted (42.8%) of all syndromes, followed by respiratory disorder (37.8%) and febrile illness (15.5%). In livestock, cattle contributed (40.8%) of all cases of illness, while sheep, goats and camels contributed 24.1%, 18% and 17% of the cases respectively. Responses were organized for emergency treatment and vaccination campaigns against certain suspected disease outbreaks and emergencies such as SGP and cholera.

Conclusion: This study suggests that engaging and empowering the village local leaders in disease surveillance in pastoral setting areas, including where there are no human and animal health facilities, coupled with mobile technologies (non-smart phone), would improve early detection and response to human and animal health events including zoonotic emergencies, and consequently improve the reporting rate at district, regional and national level. However, the collaboration between sectors (human health and animals health) and the capacity to respond to zoonotic diseases and etiological identification are crucial elements for effective integrated human and animals disease surveillance and response.

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1. Introduction

1.1. Background

Over the past decades emerging diseases have increased. For instant, 75% of the emerging diseases are originated from animal; and approximately 61% of all human pathogens are zoonotic [29]. These emerging zoonotic diseases continue to threaten the economy of the countries where disease outbreaks have occurred and also impact other parts of the world [33]. Animal health surveillance is essential, as it provides early warning of emerging threats to human populations from naturally occurring infectious disease epidemics or bioterrorism, and thus integrated surveillance of disease events in humans and animals has been recommended to support effective global response to disease emergence [20]. Given the current risk of occurrence of new emerging diseases and the ineffectiveness of traditional disease surveillance systems to detect new emerging diseases in a timely manner, syndromic surveillance is a more relevant tool for early detection of unexpected health threats. The World bank estimates that the earlier a zoonosis is detected in the environment and animals, the lower are the cumulative cost for society [30]. Real time syndromic surveillance is a new system of detecting diseases outbreaks and bioterrorism which improves early detection of and response to emergencies and disease outbreaks. It has been used so far to detect and monitor diseases outbreaks such as influenza, Norwalk and West Nile virus, *Escherichia coli* 0157 and severe acute respiratory syndrome [14]. Syndromic surveillance might also enhance the collaboration among clinical providers, primary care providers, emergency services, information-systems professionals and public health agencies. Syndromic surveillance cannot replace traditional public health surveillance but can be used as a useful supplement [18].

Studies on mobile phone–based surveillance in Sri Lanka, Peru and India have shown the feasibility and use of mobile phones for health surveillance and monitoring to improve early detection and response of health threats and low reporting rates [7,21,24]. Furthermore, mobile technologies have been used effectively for syndrome surveillance and gathering of demographic information in pastoral areas [13].

In communities whose livelihoods are based on livestock production, the health of humans, livestock, and household economic welfare are interlinked, and the close contact between human and animals with consumption of raw milk and meat make the pastoralists more prone to zoonotic diseases such as anthrax, Q-fever, brucellosis and bovine tuberculosis [6,22]. Despite these high risks, health delivery systems in pastoral areas are very poor and not designed to fit the mobile style of the pastoral population [8]. Considering environmental changes, close contact between humans and animals and the role of the animal in the lives of pastoralists, it is essential to implement integrated approaches, such as '[17]', that combine human and animal health in order to improve the health of humans and animals simultaneously [32].

Emerging and re-emerging disease mostly erupt in remote local communities, suggesting that diseases are maintained in remote local areas. [1]. Most vulnerable communities live in remote areas that are hard to reach, and as a result they lack not only basic health services but also reliable communication, calling for innovative approaches for early detection and reporting of disease events in a near-real-time manner. Given the current increasing trend for uptake of mobile phones and ownership by the pastoral communities, participatory disease surveillance with innovative communication technologies that involve and empower local communities in disease detection and reporting could improve early detection of human and health events in a timely manner in rural and remote pastoral areas.

In the SRS of Ethiopia 85% of the population are pastoralists whose livelihoods are based on livestock production [4], and there is high risk of transmission of zoonotic diseases. Currently, there is generally weak linkage between the public health system and animal health system nor any mechanism or structure for sharing information on zoonotic diseases at regional level to mitigate the risk of zoonotic diseases transmission.

Due to limited health facilities in pastoral areas of Ethiopia both human and animal health services are poor, which may lead to under-reporting of diseases. In such situations, it is imperative to engage communities in the detection and reporting of both human and animal syndrome in order to improve surveillance and response in pastoral areas. Therefore, the aim of this study were to assess the role of the community leaders in the detection and reporting of both human and animal syndromes, identify challenges that could be faced, and to recommend community based syndromic human and animal diseases surveillance in SRS pastoral areas.

2. Material and methods

2.1. Study population

The study was conducted in Adadle district of the Somali Region (SRS) of Ethiopia. Adadle is located in the lowlands of the Wabe Shabale River sub basin of the Somali Regional State of Ethiopia (latitudes: 5°38′10″ to 6°24′14″ N; longitude: 42°43′9″ to 43° 54′29″ E) (Fig. 2. The district covers 719,755 ha in the hub of rangelands. Animal husbandry is the main livelihood of villagers and mobile pastoralists. In the twenty village of this small scale study villages. There were 1390 households with 9730 humans and an average household size of seven people per household. The livestock population in the study area is 112,850 of which 34,750, 20,850, 34,350, 22,900 are camels, cattle, goat and sheep respectively. The study includes all households and their animals of the twenty villages of all age groups and both sexes. (See Fig. 1.)

2.2. Study design

This study was conducted from August 2017 until February 2018 in the Adadle district of the SRS. As a small scale pilot study, four kebeles, where there is mobile network were purposively selected. The study was a community based human and animal syndrome surveillance where trained village leaders reported human and animal syndromes. District human and regional health bureaus, district and regional livestock bureaus and Jigjiga One Health Initiative (JOHI) staff were involved in investigation and responses to diseases outbreaks and emergencies. A schematic overview of the integrated human and animal syndromic surveillance and response system (IHADSR) is shown in Fig. 2.

Before the start of the study, participatory stakeholder meetings were held with the communities, community leaders, human and animal health staffs, and human and animal health offices of the district to reach a common consensus about the importance of including the village leaders in the early detection and response of human and animal diseases. Separate meetings were also held with the human and animal health staff and district health and livestock offices in order to discuss their role in the response of disease outbreaks and emergencies. From each village one village leader was selected and trained on disease surveillance and reporting. The village leaders reported any identified syndrome based on their indigenous knowledge of diseases that occurred in humans or animals to the call center at Jigjiga University and district health facilities. The reporting was by direct call communication between the village leaders and the call center at Jigjiga.

Depending on the nature of cases, patients or livestock owners were instructed to go to nearby clinics and animal health posts to get medical care, but when severe or contagious cases were suspected the information received from the village leaders were shared with the district livestock and health offices, and when necessary to both SRS regional bureaus to organize immediate action in order to control and prevent further spread of disease.

The reported syndromes included fever (fever report were based on local name of fever "kandho" or "humad"), diarrhea (defined as the passage of three or more loose or liquid stools per day), pneumonia/cough, stillbirth or abortion, urinary tract disorders and nervous
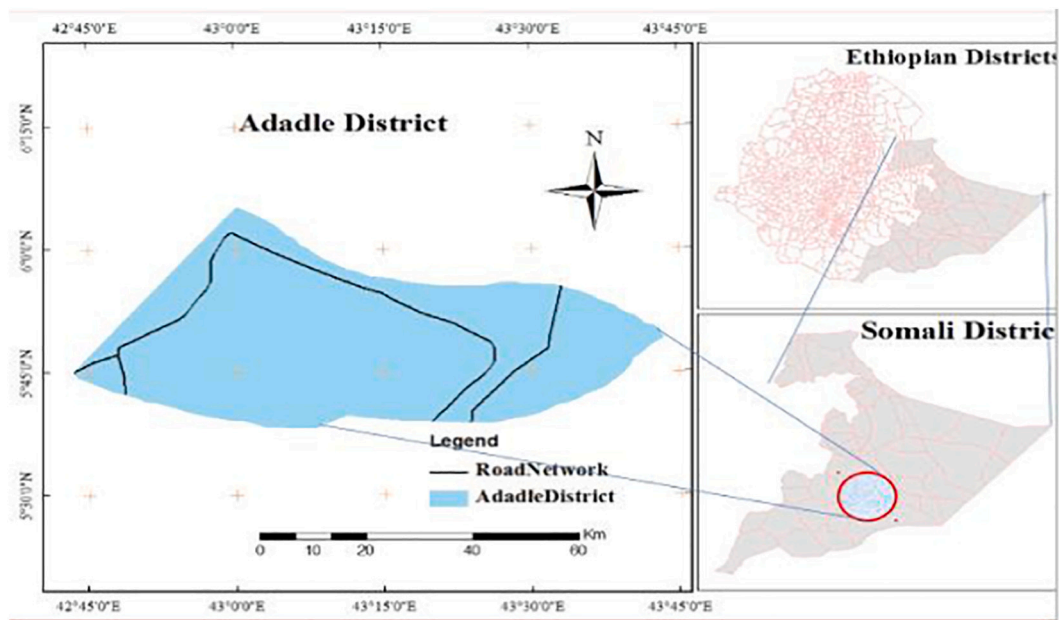
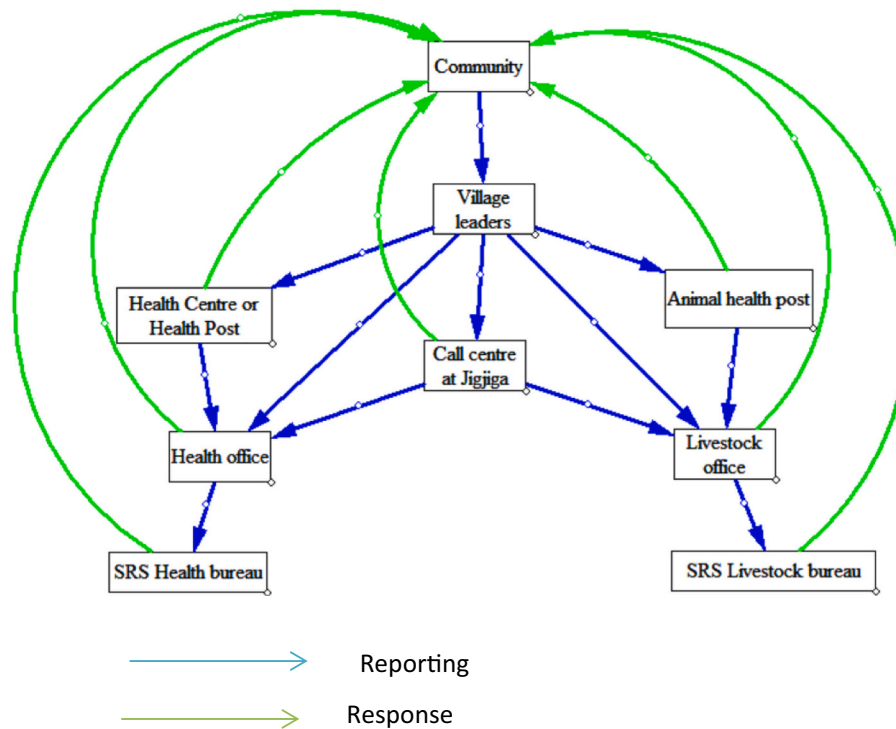**Fig. 1.** Map of Ethiopia and Adadle district.

Fig. 2. Schematic diagram showing human and animal syndromic surveillance and response flow.

disorders in humans, while in animals the reported syndromes were respiratory disorders, digestive disorders, reproductive disorders, nervous disorders, skin disorders and musculoskeletal disorders. A summary of syndromes and the key signs associated with each syndrome is provided in (Table 1). Mobile credits were provided to the village leader participants during the study period after every call in a way that did not provide an incentive for unnecessary calling. Up to 50 Ethiopian Birr (1.53 US$ www1.oanda.com/currency/converter/ accessed March 19, 2020) credit per month was provided for all participants depending on

the air time used on calling.

To encourage the community participation in the reporting system and to improve the health delivery services in the study area, human health posts or centers and animal health posts were supported with human and veterinary drugs that were not available in their stores.

2.3. Data collection and analysis

A data collection format which contains both animal and human

Table 1
Syndromes and associated clinical signs.

Syndrome	Clinical signs (livestock)	Clinical signs (humans)
Gastrointestinal disorders	Diarrhea, bloating, inappetence, abdominal pain	Diarrhea with blood and without blood, vomit, bloat, abdominal pain and in appetence, arthralgia
Respiratory disorders	Coughing, nasal discharge, difficulty breathing and rabid breathing	Coughing, nasal discharge, difficulty in breathing, rabid breathing sneezing and sometimes fever
Reproductive disorders	Abortion, stillbirth and vaginal discharge and retained placenta	Abortion
Nervous disorders	Circling, in coordinated movement, recumbence, hyperactivity and behavioral change	Mental impairment, muscle weakness, persistent headache
Musculoskeletal disorders	Lameness, recumbence (livestock)	
Udder disorders	Swollen udder, change in the color of milk, drop in milk yield painful udder up on palpation, lesion on the udder	
Skin disorders	Itching, hair loss and skin scabs	
Febrile illness		Rise in temperature (kandho or Humad), headache, muscle and joint pain, chills, nausea and vomiting
Urinary tract disorders		Pain upon urination, lower abdominal pain and frequent urination

health information and response was developed. The format included type of syndrome, sex, age, date and time of onset of signs and symptoms observed, and intervention.

The data was double entered into EPI Data version 3.10 followed by validation of the entered data. Analysis was carried out in Stata version 14. Descriptive statistics were applied to measure the frequency of the syndromes in humans and in different species of animals. A village illness index for humans and for animals was computed by determining the total number of cases of illnesses in humans, and in animals per village. The human illness index was treated as the main outcome variable. To estimate the correlation, Poisson regression models were applied.

2.4. Ethical review statement

The study protocol was reviewed and approved by the Ethics Committee of Northwestern and Central Switzerland (EKNZ BASEC Req-2017-00394) and the Ethics committee of the Jigjiga University (RERC/031/2017). The participants were informed about the purpose of the study. For any identified reported disease, each individual was advised to seek health care at the nearby health centers or posts. Emergencies like complicated births or accidents were handled and managed together with district health centers or hospital through the existing health services.

3. Results

3.1. Human and animal syndromes reported

A total of 904 human cases were reported from an estimated total population of 9730 (159 syndromes per 1000 people per year), and a total of 671 livestock cases were reported from a total population of 112,805 animals (10 syndromes per 1000 animals per year). In addition to syndromes, suspected anthrax and rabies, sheep and goat pox, salmonellosis and mass abortion outbreaks were reported in animals. In

humans, cholera, chicken pox outbreaks and rabies case were reported. Tuberculosis and malaria cases were also confirmed in the study villages.

3.1.1. Human disease syndromes

From August 2016 to February 2018, a total of 904 human illness cases were reported. The most frequent syndrome reported was gastrointestinal syndrome, which constituted 42.8%, followed by respiratory syndrome 37.8%, febrile illness 15.5% and others 3.9%.The frequency of syndromes was higher in females compared to males, 56.8% and 43.3% respectively.

Frequency of syndromes in different months was assessed. The highest frequency of syndromes were recorded in September 27.4%, followed by October 20%, and least syndromes were recorded in December 7.6% (Fig. 3, indicating most the syndromes were observed during the dry months and decreased as the stress of the drought decreased (Fig. 3).

To test the hypothesis that there is no correlation between human illness and animal illness cases at village level, we computed the summary of total number of reported illnesses in humans and in animals for each village over the seven month period of observation. To assess the association, Poisson regression models were applied. The outcome variable for this analysis was total number of human illnesses per village, which was regressed against total number of illnesses in animal as an explanatory variable. The analysis suggested that for every ten cases of animal illness in a given village, the human illness cases increased by 14% in the same village (95% CI: 10.1–16.8%) (Table 2).

3.1.1.1. TB incidence and delayed diagnosis.
Out of 342 pneumonia cases (37.8% of the all cases reported), 11 cases tested positive for tuberculosis in Gode Hospital. The incidence rate of TB in the study area in seven months was 16/100,000 with an annual incidence rate of TB estimated to be 28/100,000 (95% CI: 15–50/100,000).To measure the time lag from the onset of clinical signs to intervention, tuberculosis was followed from the date of onset of clinical signs to the date of intervention or diagnosis. The mean and median delay of diagnosis were found to be 44 and 40 days respectively. The longest diagnosis delay was 70 days and the shortest delay was 29 days (Table 3).

3.1.2. Animal syndromes

Data were collected on seven syndromes in cattle, sheep, goats and camels. Between August 2016 and February 2017, a total of 671 cases of livestock illnesses were recorded. Cattle contributed 40.8% of all cases of illness, while sheep, goats and camels contributed 24.1%, 18.0% and 17% of the cases respectively.

Of the syndrome cases reported among each livestock species, gastrointestinal tract syndrome cases were the most frequent syndrome, with the exception of camels, comprising 57%, 52.1%, and 46% of total cases
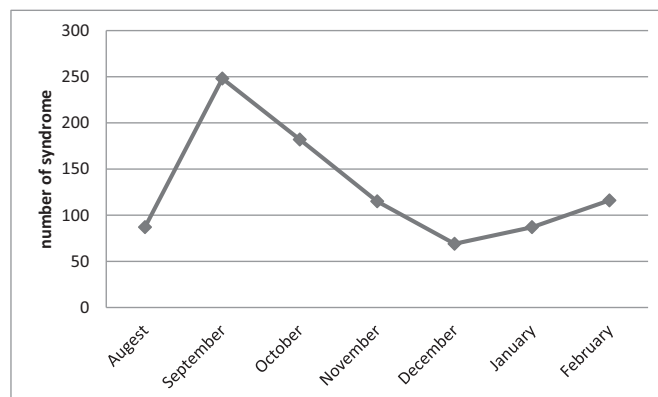
Fig. 3. Graph of human syndromes by month.

Table 2
Human and animal syndrome correlation at village level.

Total no. of syndromes in humans	Coefficient	SD	P-Value	95% CI
Total No. of syndromes in animals	0.13	0.0019	0.000	0.0101_0.0107
Constant	3.35	0.076	0.000	3.20_3.50

in sheep, goats and cattle, respectively. For these three species, respiratory syndromes were the second most commonly observed, comprising 31.5%, 30.7% and 24.8% of total syndromes in sheep, cattle and goats, respectively. In camel, respiratory disorder was the most common syndrome recorded (58%) (Fig. 4, Fig. 5).

3.2. Disease outbreak investigation

In the disease surveillance system, disease outbreak investigation and response is very critical. Over the seven months of integrated surveillance, suspected outbreak cases of sheep and goat pox (Fig. 6), rabies, anthrax, salmonellosis, mass abortion and camel pox (Fig. 7) were occurred (Fig. 6. Anthrax (Fig. 5) and salmonellosis were confirmed based on the laboratory result, clinical sign and epidemiology of the diseases. Rabies were reported in cattle, camel, sheep and goat. All case were caused by jackal. Some of the affected animals shown the clinical signs of the rabies such as excitement, attack any object, salivation, aimless movement, incoordination movement and finally death. But because of the safety issues, lack of rabies diagnostic laboratory in the study area and other technical barriers, samples were not collected to confirm the outbreak. Samples collected from aborted sheep and goat were found negative for brucellosis and RVF. The status of disease outbreaks are summarized in the following (Table 4).
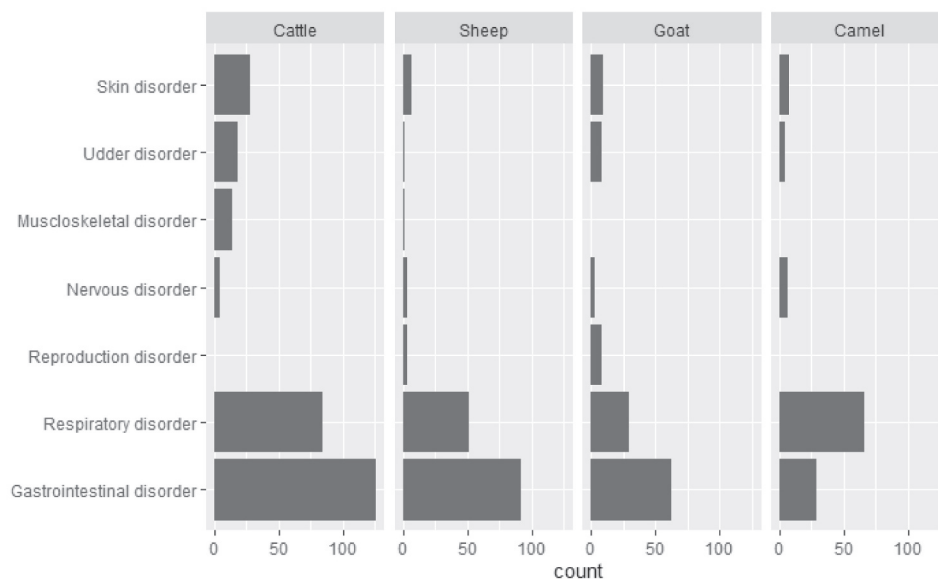
3.3. Integration of human and animal health sectors in surveillance, monitoring and response to zoonotic diseases

The collaboration of both sectors is very critical when there is an outbreak of zoonotic disease. There is need for joint planning of surveillance and response to such emergencies in order to combat the threat and burden of zoonotic disease for public health and animal health. With regard to collaboration of both livestock and health bureaus during the outbreak of anthrax and rabies, JOHI took the lead to initiate cooperation between human and animal health sectors in surveillance, monitoring and response to the zoonotic disease outbreaks. Unfortunately, the two sectors were not connected to the level required in terms of preparing joint plans, mobilizing resources and staff, and creating community awareness to mitigate risk of the diseases in both humans and animals. The main challenge recognized is that there is no structure linking the two sectors in surveillance, monitoring and response to zoonotic diseases. Following investigation of zoonotic diseases in the study area, a platform was created to bring human and animal health sectors and other NGOs that are working in the region together to discuss the importance of collaboration between the human and health sectors and NGOs in surveillance and response to zoonotic diseases. A consensus was reached to create communication between human and animal health officials on zoonotic diseases surveillance and response.

3.4. Assessment of system implementation

3.4.1. Technical considerations

The system is very simple, so that the village leaders could report when they detect any identified syndromes in humans and animals through a direct call in their local language. The system did not use applications. The major technical barrier was how to decide which cases of syndromes and when to report. For this reason training and continued support on disease surveillance and the importance for village leaders might be required.

Table 3
Delay of diagnosis of tuberculosis.

Disease	No. of observations	Median	Mean	Standard deviation	Minimum	Maximum
Tuberculosis	11	40	43.9	14.5	29	73

Fig. 4. Distribution of syndrome by species of animal.
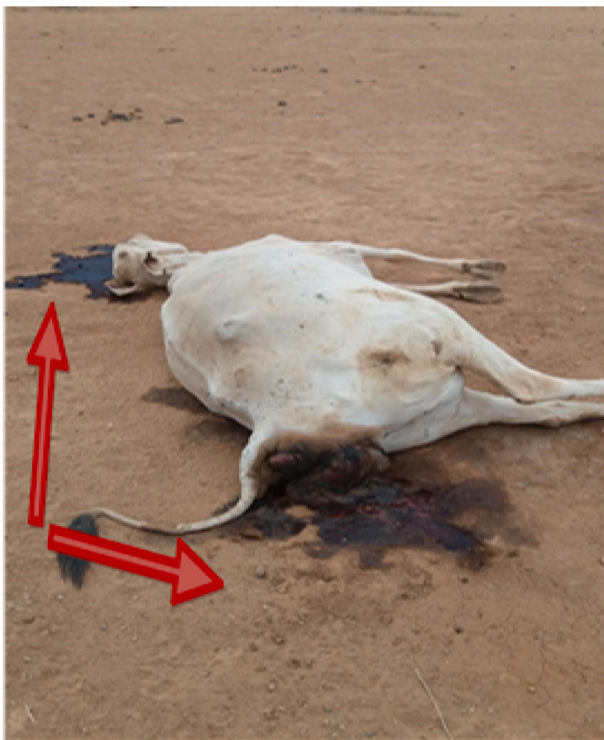
Fig. 5. Cow with unclothed blood from the natural, suggestive of anthrax.

Fig. 6. Goat with nodular lesion along the entire skin (right), typical sign of Sheep and goat pox.

Fig. 7. Young camel with nodular lesion around the body, typical sign of camel pox.

Table 4
List of investigated diseases and their status.

Disease reported	Species of animal affected	Status		Remark
		Suspected	Confirmed	
RFV brucellosis	Sheep and goat	✓		Negative for RVF and brucellosis
Sheep and goat pox	Sheep and goat	✓		
Camel pox	camel	✓		
Salmonellosis	Sheep and goat		✓	Salmonella
Anthrax	cattle		✓	*Bacillus anthracis*
Rabies	Cattle, camel, sheep and goat	✓		

3.4.3. Political considerations

Political support was the most important factor in the successful implementation and operation of the (IHADSR). Ethiopia is an African country with high burden of zoonotic diseases which has a large livestock population [11], but the government of Ethiopia realized the high risk of transmission of zoonotic diseases between animals and humans and the importance of implementing a surveillance system that combines both human and animal diseases or syndromes. This research is complementary to the national surveillance strategy, but the problem could be how the village leaders can link to the existing surveillance system. These challenges might be solved through a series of discussions between concerned bodies.

3.5. Challenges to integrated human and animal syndrome surveillance

During the course of study, the following list of key challenges was identified

3.4.2. Financial considerations

The system is cheap and easy to use. The main costs of the system were associated with air time and solar charger cost. The solar charger is not very expensive ($200), and the cost of solar chargers could be reduced after the electricity expansion reached the rural areas. Another challenge was unavailability of mobile credit in the villages which sometimes caused the village leaders to use provided air time for other purposes and resulted in additional costs.

- Lack of etiological identification and feedback to the community about the cause of disease outbreaks, which in turn, affects the reporting rate
- Failure or delay to respond to some outbreaks, especially in livestock
- Network irregularity and mobile phone running out of charge during working hours that led to delay in reporting on some occasions
- Difficult to trace sick humans and animals and their locations since the communities are mobile pastoralist.
- Failure to capture the whole syndrome which occurred because the pastoral community was broadly dispersed over a wide area and it was difficult to reach all of them

4. Discussion

Data collection using mobile communication has been used in several resource limited countries to improve early detection of human and animal diseases. Most of them used smart applications or SMS and the participants involved in the reporting were human and animal health professionals [7,15,21]. However, in this study, direct phone calls, using dumb phones which most of the remote pastoral communities owned, adapted for illiteracy which is common among the pastoralists, were used, enabling village leaders to report syndromes in their local language using their indigenous knowledge on human and livestock diseases or syndromes. The local village leaders, who are in close contact with pastoralists who are broadly dispersed over a wide range of area where there is no human and animal health facilities or do not have access to health services, participated. The community human and animal based surveillance helped to detect early disease outbreak emergencies such as anthrax, sheep and goat pox, salmonellosis in livestock, and cholera and chicken pox in humans. The combination of participatory community-based approaches with mobile technology has the potential to support not only early detections of disease events happening at the community level [9], but also near real-time responses. Communication and collaboration between animal and public health sectors in the region are weak and only used on an *ad hoc* basis. There are no formal linkages, structures or policies to enhance the collaboration between the two sectors or with other sectors[27]. However, the pilot study, on integrated human and disease surveillance created an opportunity to bring different disciplines and sectors together to have mutual understanding and collaboration on prevention of zoonotic diseases. This might motivate the region to improve the coordination between human and animal health sectors, among government and non-governmental organizations in surveillance, monitoring and response to zoonotic diseases in order to decrease zoonotic diseases posing threats to economies, societies and health.

The most common syndrome reported in humans were gastrointestinal tract (42.8%), followed by respiratory tract disorder (37.8%). This finding is different than that of Thumbi *et al* [25] which reported 54% respiratory disorders followed by 40% febrile illnessed and 5% gastrointestinal disorders. The difference may be due to differences in lifestyle, epidemiology of diseases or health care systems between the two study areas. Similarly in livestock, the common syndrome observed in all studied species of animal was gastrointestinal disorder (46.2%), followed by respiratory disorder (34.4%), with the exception of camels where the most common syndrome was respiratory disorder, in agreement with the findings of Thumbi *et al* [25].

The highest number of syndromes in humans was recorded during September (37.7%) and October (16.99%), the last months of the dry season, which then started to decline in November when the rains began, with a slight increase in February, at the start of dry period. The possible reason for these syndrome dynamics may be that in the dry months, livestock production goes down, and livestock disease incidence is high, but the income of households decreases. All of these factors coupled with the extreme climate may affect the nutritional status and immunity of the pastoralists against diseases, making them very prone to disease. Other studies also reported increased syndrome and malnutrition during the dry period in pastoral areas [2,5].

Simultaneous collection of longitudinal data on human syndromes and animal syndromes in the same villages over time allowed us to correlate human health and animal health at the village level. Although our analysis is at village level not at household level which could better estimate the association, we found strong association between cumulative number of human syndromes and cumulative number of animal syndromes at village level (Table 3). To test the hypotheses that zoonotic diseases contributed to human illness or that there was sharing of pathogens between human and animals, the etiology of the syndromes in both human and animals should be identified and characterized.

It is also important to note that animal illness as an explanatory variable of human illness would not indicate the directional causality of animal health to human health, but instead should interpreted as indication of evidence of a complex relationship between human and animal health, even at the village level.

Over the seven month of study period, 15–50/100,000 annual incidence rate of TB was recorded. This finding is much less than the previous finding of 175–250/100,000 in the region [26]. This difference could be due to the sensitivity of surveillance, study design or improvement in TB control program in the region in recent years.

Recording and follow up of chronic coughing allowed us to assess delay in TB diagnosis in eleven confirmed cases of tuberculosis. We found 40 and 43 delay days to diagnosis median and mean respectively, with minimum 29 days and maximum 73 days. This finding is comparatively lower than previously reported median delay diagnosis which was 60 and 130 days mean and median delay diagnosis, respectively in Ethiopian Somali region [10]. Nonetheless, this finding is higher than in other parts of country, Amhara (median 30 days) [31] and Awasa (median 4.3 weeks) region of Ethiopia [3]. The reason for less delay to diagnosis in this study may due improvement in the health delivery system, TB control programs in the pastoral area of Ethiopia, Somali region, study design or sensitivity of the surveillance system. On the other hand, the improvements may not be to the level of the highland or sedentary parts of the country that is why the TB delay diagnosis is still higher in pastoral areas compared to sedentary setting areas of Ethiopia.

5. Conclusion

The village leaders in pastoral area including where there is no human and animal health facilities able to detect and report human and animal syndrome as early as possible before any other surveillance bodies receive reports. Indeed, availability of mobile network and ownership of pastoralists of mobile phone facilitate the use of mobile communication technologies in pastoral area to improve early detection of human and animal health emergences. Therefore, engaging and empowering local pastoral community leader's couple with mobile technologies could provide near real time human and animal health information that enhance timely responses to tackle threats to human and animal health posed by zoonotic diseases, especially in remote pastoral area. However, to make the IHADS effective and encourage participation of the community in the early detection of diseases emergencies, the surveillance must assisted with etiology confirmation, early joint response to diseases outbreaks, fully functionalizing of animal health and human health clinics and improve diagnostic capacities of the laboratories.

Author contribution statement

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