Improving cattle disease reporting and surveillance in Ethiopia using smartphone-based application

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Abstract

This study explores the use of a smartphone-based application to increase the accuracy and completeness of cattle disease reporting and surveillance in three regions of Ethiopia. We compared the performance of a smartphone-based application with traditional (paper-based) cattle diagnosis and reporting, in terms of demographics and disease information, level of detail and delay in time to transmit information to higher levels. A total of 547 and 678 clinical cattle cases were diagnosed in veterinary clinics visited by two groups of final-year veterinary students using the *VetAfrica-Ethiopia* (VAE) smartphone app and manual approach respectively. The group using the VAE application diagnosed over 90% cases as diseases of a specific name, while in reports from the manual system almost 50% of cases were diagnosed as non-specific diseases or 'syndromes'. Furthermore, the mean duration of time required for smartphone data to be received by zonal- and federal- level veterinary services through a Cloud-based server were estimated to be two days (95% CI: 1.6–2.3), five days (95% CI: 3.8–5.4), and 13 days (95% CI: 12–14.9) in the Central, Eastern and Southern regions. The traditional reporting system adopted a batch reporting approach and only around two thirds of all cases reach the federal veterinary service by the end of a month. Despite the fact that such smartphone technology-assisted reporting and surveillance involves considerable start-up challenges and may be affected by intermittent mobile internet network coverage, they offer significant benefits in terms of improving data integrity, timeliness and reduced costs in the long run.

Keywords: *Smartphone application, surveillance, diagnosis, disease monitoring, data integrity*

Introduction

In Ethiopia, livestock agriculture contributes around 20% of the total gross domestic product, 45% of the agricultural gross domestic product and directly contributes to the livelihoods of around two-thirds of Ethiopian families (1). On the other hand, the high burden of livestock disease (2) combined with limited infrastructure, pose significant challenges for animal productivity (3). Protecting animal and human health requires that adequate reporting be put in place to allow appropriate actions to be taken to control any potential risks quickly and effectively (4). Disease monitoring and surveillance systems have thus become a major component of veterinary activity (5). Such systems are used to assess existing levels of disease, the effectiveness of control programmes, and, subsequent to disease eradication, to document the continued absence of disease from a given region or zone (5).

Timely and good quality disease surveillance data at regional and national levels are therefore needed to support and inform continuous improvements in animal health and to detect outbreaks of disease, including emerging and zoonotic diseases (6). Real-time disease reporting and surveillance as opposed to interval-based ''batch' reporting are essential in minimising the impact of livestock diseases, as early notice shortens the time between detection and providing measures for control (7). However, current disease reporting/ surveillance by most African countries veterinary services, such as in the Ethiopian national veterinary service department, is performed using paper-based reporting often on a monthly basis which is known to be slow in reaching central/national databases through zonal and regional offices. Application and use of smartphone technology has been demonstrated to have great potential in public health care practice and community-based reporting. Similarly, such tools and services are hypothesised to sustainably and substantially improve animal health recording and surveillance in developing countries (8).

In this study, the performance of a previously developed smartphone based application (9) to assist in disease diagnosis of Ethiopia cattle, was compared with a manual disease diagnosis/ reporting system the explore potential advantages in terms of improving disease reporting and surveillance.

Materials and methods

Study site and participants

This study was conducted in 11 public veterinary clinics in three regions of Ethiopia: the Central (three clinics), Eastern (four clinics) and Southern (four clinics) regions. Twelve final-year veterinary medicine students from the College of Veterinary Medicine and Agriculture of Addis Ababa University were selected and allocated to a specific veterinary clinic based on the colleges' assignment to final year clinical practice in different regions. Six students (i.e. two in Central, two in Eastern, and two in Southern Ethiopia) were given smartphones with the *VetAfrica-Ethiopia* (VAE) application installed while six students were assigned similarly to comparable public veterinary clinics but were not given smartphones and asked to use manual diagnosis and paper-

based reporting methods (at one of the clinics in Central Ethiopia, two students were assigned to work independently in the same clinic, Bishoftu, with and without the VAE smartphone application). The students given smartphones received some basic training on how to use the app in clinical case management and to carry out rudimentary trouble-shooting as necessary.

Clinical presentation of disease and proportional morbidity
The list of cattle diseases diagnosed and their relative frequencies from the total number of cases presented at the veterinary clinics during the study period, as diagnosed by the student practitioners using *VetAfrica-Ethiopia* as well as those using 'manual' methods, were computed. Accordingly, the top ranking diseases and their estimated proportional morbidity were reported.

Comparison on features of VetAfrica-Ethiopia application
The level of completeness of demographic and patient information was compared between the groups. The time required for case information to be reported to higher administrative levels was also compared between the two approaches. Further, the number of clinical signs reported per case was also compared.

Results
Breakdown and quality of cases reported
The student practitioners who used the VetAfrica-smartphone application and those who used the manual system reported on a total of 547 and 678 cattle cases respectively; based on visits to veterinary clinics in the three regions. The proportion of cases from Cross and Exotic cattle breeds varied significantly (p<0.01) across the three regions, irrespective of which reporting approach was considered. When looking at proportions based on gender, there appeared to be no significant difference (p=0.07) in the case of the VAE group, while those using the manual system reported almost three times more male than female cattle (p<0.01) in the Southern region. In the manual system, the age category of cattle reported was often inconsistently formatted; we therefore aggregated anything that was not an adult, and reported these as "young".

Profile of diseases diagnosed and their proportional morbidity
The common causes of morbidity as diagnosed by both groups included: PGE (Parasitic Gastro Enteritis), FMD (Foot and Mouth Disease), Blackleg, Pasteurollosis and LSD (Lumpy Skin Disease). However, there were also a large number of non-specific diagnoses reported by those using the manual approach, which would likely impact the relative importance of a number of apparently under-reported diseases in that group.

The students who used the VAE app diagnosed a total of around 76 diseases (including the 14 specifically listed as outcomes in the app), and provided specific disease outcomes for over 97% of all cases. On the other hand, the group using the manual approach diagnosed just over 50 different diseases and 'syndromes'. However, almost 50% of these cases were recorded as having a non-specific disease outcome.

Comparison regarding levels of completeness
In the group which used the VAE application; all of the information captured during diagnosis, including each animal's sex, age and breed, a detailed list of clinical signs and the putative disease, were all reported to higher administrative levels. However, in the case of those using the manual system, only the total number of cases (aggregated over each month by animal species) were reported, leading to the loss of additional, potentially valuable, information captured during diagnosis.

Delay in time of reporting
The average duration of time required for case reports to be received at all administrative levels based on reports from the VAE-smartphone assisted groups were two days (95% CI: 1.6–2.3), five days (95% CI: 3.8–5.4), and 13 days (95% CI: 12–14.9) in the Central, Eastern and Southern regions. Cases reported from the Southern region were significantly (P<0.01) slower (max of 35 days) when compared to the Central and Eastern regions. Although disease reports leave diagnosing clinics at the end of each month when using the manual system, it was not possible to compare the number of days required to reach higher administrative levels as the receiving offices do not register the exact dates on which reports arrive (they simply check whether they have arrived within that month). However, reports from VAE-app users indicated that the further the distance from the 'centre', the longer duration the report took to arrive at administrative levels through the Cloud-based server. This is likely because areas far from the centre have less consistent and reliable access to the Internet or mobile data networks.

In the paper-based manual reporting, the chain of command states that each veterinary clinic has to report the aggregated number of cases by species to the district Agricultural office, and that the district Agricultural office then sums the number of cases by species from different veterinary clinics in the district and reports to the zonal Agricultural offices, after which the zonal office aggregates the number of cases by species and reports to the regional and federal veterinary offices. Although the reporting system from the paper-based system sounds inconsistent, we estimated that between 52%–97% of the veterinary clinics report to districts, 88%–100% of districts report to zones, and 44%–89% report on from the zonal level. There appeared to be inconsistent reporting performance across regions. For instance, of 10 veterinary clinics in the Bishoftu district supposed to nine report each over nine months (June 2015 – March 2016), only 62 (68.9%) were reported. Similarly of the nine reports expected to be reported to zonal agricultural office over the nine months all have reported eight times except one district which has reported all. On the other hand, the zonal agricultural offices sent to federal veterinary services an average of 6 reports (range: 4–8 reports). It was also shown that the south region is the worst (mean: 5) in terms of number of report over the study period of nine months. This is probably due to the

fact that this region is physically distant from the federal veterinary office based in the capital city, Addis Ababa.

Range and standardisation of clinical signs
The average number of clinical signs that were noted to be present per case, recorded by the group using the VAE application, was 5.1 (95% CI: 4.9–5.3); just over twice the mean of 2.5 (95% CI: 2.4–2.6) clinical signs reported by those using the traditional paper-based approach. The potential recording of disparate clinical signs which actually relate to the same cause is mitigated by the user interface in the case of the VAE application, while in the manually diagnosed and reported cases a wide range of slightly differing terms tended to be used to describe similar or indeed identical clinical signs.

Discussion

In this study we exploited the potential for improved cattle disease reporting, and thus surveillance, through the use of a smartphone application. It was not possible to make a direct comparison of every feature as comparable information was not available for all facets of the paper-based reporting approach. The demographic data collected using the smartphone app was shown to be consistent with data collected previously in similar regions (9). We can thus hypothesise that the lower proportions of cross and exotic bred animals reported in the manual approach were inaccurate due to incomplete reporting. Furthermore, the formats used in recording an animal's sex and age were haphazard, inconsistent and non-uniform. This led to uninformed aggregation which may result in incorrect conclusions regarding basic demography.

The most important cattle diseases in terms of economics and trade had been identified based on the list of diseases targeted for control by Ethiopian veterinary services (10). These were seen to be present with relatively high prevalence in both the VAE-assisted and manual reporting systems. However, the manual system reported 59% of cases as having no specific disease name, noting only a non-specific sign or syndrome. These non-specific outcomes create uncertainty and may mask the extent of some economically important diseases. On the other hand, these non-specific signs and syndromes may provide important inputs in the context of syndromic surveillance.

We also compared the smartphone- and paper- based approaches in terms of completeness, time required for the report to reach higher administrative levels, and the comprehensiveness of clinical signs. A guideline for Evaluating Public Health Surveillance Systems (11) identifies completeness and timeliness to be key measures of surveillance data quality. We found that the manual reporting system omitted valuable demographic information and details on clinical signs when reported to higher administrative levels. These data are expensive to collect but if present can be used at higher administrative levels for further analysis such as syndromic categorisation based on clinical signs. Between 3–48% of the cases from clinics were not reported to district agricultural offices. While of those reported to the district agricultural office, between 12% and 55% were never reported to the zonal or federal veterinary service levels. This has implications in terms of a lack of consistency in reporting from different clinical sites and areas of the country. In the case of VAE-assisted reporting, every case was reported in real-time to all levels simultaneously via a *Cloud*-based server. However, significantly longer delays in update to the Internet were evident when reports were submitted from rural areas. This indicates that the notion of instantaneous reporting from any animal health worker in possession of a phone, regardless of location, may be over-stated.

We have demonstrated the potential use of smartphone applications for animal disease reporting and surveillance. Timely reporting to relevant offices helps with preparedness for outbreaks and emerging diseases. In contrast, a manual data collection process, using paper-based questionnaires tends to be time consuming and prone to error (8). Mobile apps provide clear benefits when compared to manual paper-based data collection and reporting in terms of gathering consistent, complete demographic and epidemiological information, as well as delivering information in a more timely manner; offer opportunities for improvements in disease reporting and surveillance within developing countries; enable early and relatively easily detection of emerging diseases.

To our knowledge this is the first attempt to evaluate such an approach in a resource-limited setting. It seems likely that this approach has great potential in other constrained sectors of veterinary service provision. Despite the fact that smartphone assisted reporting and surveillance presents considerable start-up challenges in terms of financial resources and intermittent mobile network access, they offer significant benefits in terms of improving data integrity, timeliness and reduced costs in the long run.

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