JIMMA UNIVERSTY

COLLEGE OF AGRICULTURE AND VETERINARY MEDICINE

SCHOOL OF VETERINARY MEDICINE

EVALUATION OF “EDDIE MOBILE APPLICATION”AS A TOOL OF DIAGNOSIS AND SURVEILLANCE OF TRYPANOSOMOSIS AND BABESIOSIS OF CATTLE AT NEKEMTE, BAKO AND SHAMBU VETERINARY CLINICS, WESTERN OROMIA, ETHIOPIA

MSc THESIS

BY

NEMOMSA ANBESE JIRU

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JIMMA, ETHIOPIA

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MSc Thesis

A Thesis Submitted to the school of veterinary medicine, Jimma University, Postgraduate Studies of Veterinary Medicine in partial fulfillment of Master of Science (MSc) in Veterinary Epidemiology.

By

Nemomsa Anbese Jiru

<u>Advisors</u>: Prof. Tadele Tolossa (DVM, MSc, PhD)
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I have incorporated the suggestion and modifications given during the internal thesis defense and got the approval of my advisors. Hence, I hereby kindly request the department to allow me to submit my thesis for external defense.

Nemomsa Anbese Jiru ________________ ____/_____/____

Name of the student Signature Date

We, the thesis advisers have verified that the student has incorporated the suggestions and modifications given during internal thesis is ready to be submitted. Hence, we recommended the thesis to be submitted for external defense.

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Decision/suggestion of Department Graduate Council (DGC)

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STATEMENT OF THE AUTHOR

First, I declare that this dissertation is my authentic and real work and that all sources material used for this thesis has been properly acknowledged. This thesis has been duly submitted in partial fulfillment of the requirements for an advanced (MSc) degree at Jimma University, College of Agriculture and Veterinary Medicine and is deposited at the University/College library to be made available to borrowers under rules of the library. I sincerely declare that this thesis is not submitted to any other Institution anywhere for the award of any academic degree, Diploma or certificate and allow access to users.

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BIOGRAPHICAL SKETCH

Dr. Nemomsa Anbese Jiru was born in1988 G.C. from his father Anbese Jiru and his mother Konise Senti, in Jardega Jarte Woreda, Horro Guduru Wollega Zone, Oromia regional state, Ethiopia. He attended his primary education at Alibo elementary school up to grade eight and secondary education at Alibo senior secondary and preparatory school, Jardega Jarte district. After successful completion of his education from preparatory school, he joined Wollega University School of veterinary medicine in 2009G.C and graduated with the award of Doctor of Veterinary Medicine (DVM) degree in June 2014. After his graduation, he was employed at Wollega University and served as animal health researcher up to 2017 and obtained an opportunity to undertake his routine training in September 2017/2018, by joining Jimma University, College of Agriculture and Veterinary Medicine, School of Veterinary Medicine to pursue his Msc in Veterinary Epidemology. He is authored and co-authored 7(seven) scientific publications. Dr. Nemomsa has married and a father of two sons.

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LIST OF ABBREVIATIONS

AAU	Addis Ababa University
ADSARS	Animal Disease Surveillance and Response System
CI	Confidence Interval
CLOHS	Community Level one Health Security
CSA	Central Statistics Agency
EDDIE	Ethiopian Differential Diagnosis Information Environment
E-Health	Electronic Health
EMA	Event Mobile Application
FAO	Food and Agricultural Organization
FMD	Foot and Mouth Disease
GPS	Global Positioning System
HIV	Human Immune Virus
IDSAS	Infectious Disease Surveillance and Analysis System
IOS	I phone Operating System
mHealth	Mobile Health
NAHDIC	National Animal Health Diagnostic and Investigation Center
NGO	Non Governmental Organization
OIE	Organization for Animal Health
RDT	Rapid Diagnostic Test
SMS	Short Message Service

ABSTRACT

A descriptive case study was used in this study by Purposive sampling of cattle coming to veterinary clinics. Accuracy of EDDIE app compared conventional (paper-based) of cattle disease diagnosis and reporting in terms of demographics and disease information. A total of 811 clinical cases were diagnosed in three veterinary clinics visited using both *EDDIE* app and paper/manual approach using the same animals. This case explores the use of a Smartphone-based application to increase the accuracy of cattle disease (trypanosomosis and babesiosis) reporting and surveillance in three veterinary clinics (Nekemte, Bako and Shambu) veterinary clinics. Out of the total animals examined by both EEDDIE app and paper based diagnosis, 778(96%) and 33(4%) were matched and unmatched respectively. The accuracy of EDDIE app was approved by confirmatory diagnosis using laboratory test of 10% from the total matched cases. Accordingly, from 778 matched cases 78(10%) cases were laboratory tested and 21(26.92%) cases were positive for the two heamoprotozoan parasites. This laboratory confirmation indicates EDDIE app was as accurate as paper for diagnosis and surveillance of two cattle disease (trypanosomosis and babesiosis) in the study area. It may therefore provide proportional morbidity in the study area; breed, sex, age and geographic location effects were consistent with current epidemiological understanding. The EDDIE app tool leading to a significantly increase in the number of clinical signs recorded than paper based, suggesting this as a key beneficial consequence of its use. It may also inform approximate proportional morbidity and represent a useful epidemiological tool in poorly resourced areas.

Keywords: *EDDIE app, cattle disease, diagnosis, Smartphone, surveillance, Ethiopia*

1. INTRODUCTION

Ethiopia is believed to have the largest livestock population in Africa, which is a significant contributor to economic and social development in the country (Demelash and Moges 2006). In Ethiopia, livestock accounts for 15-17% of total GDP and 35-49% of agriculture GDP (CSA, 2017). 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 (FAO, 2011).

Livestock diseases affect productivity of animals through decreased yield and work output, in addition to direct mortality. On the other hand, the high burden of livestock disease (Behnke, 2010) combined with limited infrastructure, pose significant challenges for animal productivity (Solomon, 2003).

The occurrence of existing and emerging animal diseases continues to increase, and is combined with the added threat of the relative ease with which biological agents can be agonized and intentionally introduced into human and animal populations. Therefore, there has never been a more critical time at which to leverage information technologies in order to enhance data collection and analysis for the early detection and surveillance of, and response to, natural and intentional disease events.

Protecting animal and human health requires that feasible disease diagnosis and adequate reporting be put in place to allow appropriate actions to be taken to control any potential risks quickly and effectively (MOA, 2010). Disease monitoring and surveillance systems have thus become a major component of veterinary activity. 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 (Tadesse and sultan, 2014).

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 (Bayissa *et al.*, 2011). Real-time disease reporting and surveillance as opposed to interval-based ‘’batch’ reporting are essential in minimizing the impact of livestock diseases, as early notice shortens the time between detection and providing measures for control (Jemberu *et al.,* 2014).

Application and use of Smartphone technology has been demonstrated to have great potential in public healthcare practice and community-based reporting. Similarly, such tools and services are hypothesized to improve animal health recording and Surveillance sustainably and substantially in developing countries (Asresie *et al.,* 2015).

Surveillance systems and animal disease monitoring more generally are a major component of health-care systems (Robertson *et al*., 2010). Such systems are critical to any assessment of disease occurrence, effectiveness of control programs and, in the context of disease eradication programs, population or region, in addition to the detection of emerging diseases (Doherr and Audige, 2011). Presence of robust animal disease surveillance systems also benefits human health as around 75% of the emerging infectious diseases that affect humans have their origin in animal populations (Taylor *et al.,* 2011).

The ability to collect data is the key to the success of many organizations operating in the developing world. Given the weaknesses of current tools and the surge in mobile phone growth, there is an opportunity for mobile and cloud technologies to enable timely and efficient data collection and thus change how healthcare is delivered to millions of people (Anokwa *et al*., 2009).

The application and use of Smartphone technology has been more generally explored in the field of public health care (Michael *et al.,* 2013) and community-based reporting within low resource settings. Such tools and services have been proposed as a means to substantially improve animal health recording, reporting, and surveillance in developing countries (Robertson *et al.,* 2010), but few detailed field-based trials have been reported in the literature (Freifeld *et al.,* 2010).

Babesiosis and trypanosomosis are two economically important vector-borne diseases of tropical and subtropical parts of the world including Ethiopia (Sumba *et al.,* 1998). Bovine trypanosomosis and babesiosis were the most important arthropod borne disease of cattle worldwide they causes significant morbidity and mortality and the first and second most common blood-borne parasitic diseases respectively (Hamsho *et al.*, 2015). Babesiosis is one of the most important diseases in Ethiopia because it occurs sometimes in acute forms with serious recognized clinical manifestations yet lowering the productive performance of the affected animals (Wodajnew *et al*., 2015).

Of Oromia region as well as the country the huge livestock resource is highly challenged by one of economically devastating vector borne disease and its vectors most of the trypanosomosis and tsetse fly. From the year 2000-2019 almost 25 published papers on prevalence of bovine trypanosomosis were identified in Oromia (Gamechu *et al.*, 2015). Hence, the purpose of the present study was to evaluate the accuracy of EDDIE app diagnosis and surveillance of bovine babesiosis and trypanosomiosis infections, for knowing the proportion of these infections in study area.

This paper shares researcher experience which contributed to the design and testing of a Smartphone application-supported "*EDDIE* " system that has potential to improve animal health and productivity, not only in the study area but also in Ethiopia and beyond. In Ethiopia, both the government and civil society not frequently use Smartphone for data gathering.

In Ethiopia, various surveys have been carried out by observational studies on distribution, abundance and prevalence of heamoprotozoan parasites (trypanosomosis and babesiosis) on cattle in different regions of the country by various investigators (Tolossa, 2010). However, there was no detailed study on the heamoprotozoan parasites (trypanosomiasis and babesiosis) in cattle "EDDIE app" in our country; particularly Western Oromia Regional State (Nekemte, Bako and Shambu). Therefore, this study is designed with the following objectives:

- To evaluate the accuracy of the EDDIE app in diagnosis of Babesiosis and Trypanosomosis affecting cattle compared with the paper/manual based disease reporting system currently used in Ethiopia
- To assess the proportion of bovine Babesiosis and Trypanosomosis by EDDIE app versus paper based diagnosis
- To evaluate the accuracy of EDDIE app as compared to laboratory confirmatory diagnosis 10% from total cases

2. LITERATURE REVIEW

2.1. Application of Smartphone application in health care

Mobile health apps are becoming both more popular and technologically sophisticated. It is one of the most important parts of Information Technology and the use of information technology has become persistent in the management of organizations in all sectors of mobile economy, and it is difficult to imagine any organizations to be competitive without using computer applications (Stefan and Tobia, 2010).

Mobile devices used to support mobile health technologies, or mHealth technologies, include handheld devices such as mobile phones, Smartphone, and tablets that allow data to be collected at the location and time (or soon thereafter) at which animals are examined. These technologies help to address the many challenges associated with current data collection and surveillance systems (i.e. data timeliness and quality, the lack of data standards and the ability to geolocate) that limit the speed of detection and the response to a disease event (Vasudevan *et al.,* 2016).

Mobile phone health technologies provide data collectors with the ability to quickly reach large numbers of people at a low cost. In addition, such technologies, by their portable nature, can be utilized in rural areas of developed and developing countries where livestock are commonly located. Furthermore, they enable all members of an animal health enterprise (e.g. livestock owners, community animal health workers and technicians, veterinarians, etc.) to be active participants in bidirectional information exchange. Participants provide data, and receive information and feedback from animal health experts (e.g. diagnostic laboratories) and authorities (e.g. government animal health officials) (Robertson *et al.,* 2010).

Information provided to veterinarians and livestock owners on animal health trends and events in their area can then be used to make production and animal-health decisions. The opportunity to leverage mobile and internet connectivity for animal-health data collection, surveillance and disease detection continues to increase. The types of information technology platforms being used for data collection utilize both the voice and short message service (SMS) capabilities of mobile devices, and the mobile application (‘app’) and geolocation capabilities of smart phones and tablets (Karimuribo *et al.*, 2016).

The widespread use of mobile devices has offered a novel approach to address many health-related challenges. The emerging mobile health (mHealth) technologies rely on mobile communication devices such as cell phones and tablets to realize remote medical diagnosis and monitoring. In many regions of the world, medical equipment is either unavailable or insufficiently portable for wide and fast deployment. The penetration of mobile devices in many low- and middle-income countries has surpassed many other infrastructures such as paved roads, electricity, and advanced healthcare resources. Such increasing accessibility of mobile devices can provide opportunities to transform the way health services and information are delivered, collected and managed (Steinhubl and Muse, 2015).

Smartphone’s have been increasingly adapted in various health care applications in recent years. According to the applications, the use of Smartphone based healthcare practice can be divided into two categories: out-of-clinic use and in-clinic use. Out-of-clinic Smartphone use covers most of the software applications (apps) and the corresponding devices for the daily monitoring of the health and wellness. Smart phones can also be used to promote a healthy life style and help people get access to useful medical information when they need it. Built in sensors inside the mobile devices or external wearable sensors measure people’s health-related activities such as heartbeat and breathing during walking, running, or sleeping (Batista and Gaglani, 2013).

Unlike older generations of at-home monitoring equipment that require manual record keeping, these applications usually have a high-level of automation in terms of the recording and processing of the measured data, and usually the information is stored in a personalized profile that can be securely transmitted to a cloud center to perform processional medical analysis. Such applications usually present the data in an appealing graphic fashion to users and provide simple suggestions or conclusions. On the other hand, the in-clinic applications of smart phones involve the diagnostics of specific types of diseases and are supposed to help make clinical decisions. Many of the tests that are usually exclusively performed in centralized laboratories with high-end instrumentation and skilled personnel can be simplified and realized with the smartphones (Mtema *et al.*, 2010).

2.2. Use of Mobile Phones in Health

Mobile devices can play a role in improving the coverage and timeliness of data collected through surveillance systems (Alexander *et al.,* 2013). Mobile phones have greatly reduced communication costs, thereby allowing individuals and companies to send and obtain information quickly and cheaply on a variety of economic, social and political topics. An emerging body of research shows that the reduction in communication costs associated with mobile phones has tangible economic benefits, including improved agricultural and labor market efficiency and producer and consumer welfare in specific circumstances and countries. As prices of both handsets and airtime continue to fall, the mobile phone will complete its transformation from an elite status symbol to a necessity in all income levels (Aker and Mbiti, 2010).

For animal disease surveillance; a mobile phone based infectious disease surveillance system was developed and implemented in Sri Lanka, involving field veterinarians reporting animal health information. This demonstrated the possibility for early warnings of emerging infectious diseases and changing disease patterns, as it led to the establishment of baseline patterns of presumptive diagnoses and syndromes in cattle, water buffaloes and chickens. Development of human resource and increased communication between local stakeholders were instrumental for successful implementation. Mobile-phone-based surveillance in animal population is acceptable and feasible in resource-limited settings, and that the use of existing infrastructures and social networks help to reduce barriers to reporting and improve sustainability (Colin *et al.,* 2010).

In Africa, the use of digital pens to monitor transboundary diseases has been utilized in Malawi, Namibia and Zambia for data gathering on potential outbreaks from remote field locations, to allow timely decisions in case quarantine needs to be imposed. The high mobile penetration rate and subscription numbers indicate that mobile technology can be useful in the livestock sector, even in rural and poor areas. The type of data collection tool used depends on the type of surveillance being conducted (active or passive), as well as on the role of the people submitting reports. Traditional methods include retrospective and passive surveillance of notifiable diseases, conducted on standard paper forms, which are submitted, consolidated and resubmitted at various levels until the information reaches the OIE (Fred, 2010).

Paper-based data collection methods have been used for a long time; paper-based collection methods are not always standardized, are time-consuming and are especially error-sensitive. In addition, with a system such as the traditional one for notifiable disease reports, data may take months to reach a level at which they can be analyzed for trends and outbreaks. The consistency and quality of data collection in a format that facilitates analysis is critical to effective surveillance and the main drawbacks of the classical data collection are numerous: inaccuracies in data collection, errors in translation of paper forms to computer databases, duplication of efforts, delay in detection of cases, lack of feedback mechanisms and linkages between levels, delayed response times to events, etc. Widespread access to the internet has enabled animal disease surveillance systems to improve in terms of speed of submission. However, on the ground and in the field the primary data are still likely to be collected on a paper form, allowing the errors listed above to continue (Robertson *et al.,* 2010*).*

A rapidly growing alternative to paper-based forms is the use of mobile phones and cellular networks to submit information to a database directly from the field. Such tools offer the advantages of immediate digitization, transmission, and aggregation of data, potentially improving speed, cost-effectiveness and accuracy of surveillance (Schuster and Brito, 2011). They have been especially useful in developing countries where access to traditional electricity infrastructure, computers and the internet is limited, but mobile phone access is rapidly growing (World Bank., 2008).

Mobile phone-based surveillance tools may be based solely on the traditional uses of cell phones, including voice calling and text messaging (SMS), or rely on mobile Internet (3G) for data submission. Software designed for low-end mobile phones with submission of data via SMS have proven to be extremely useful for human and animal health surveillance in a variety of situations, such as disease reporting after earthquakes (Yang *et al.*, 2009) or reporting of emerging infectious diseases (Qekwana *et al*., 2010).

Many mobile phone-based surveillance systems also allowed system supervisors to monitor the data collection, work performance and workload of each health worker in real time and on an individual level. Necessary data corrections, feedback and additional training needs could be identified promptly and communicated immediately and may result in an additional quality improvement (Shirima *et al.* 2007). Smartphone applications (apps) and algorithms present another use of smart phones as a standalone tool in the diagnosis of parasitic diseases, such as the interpretation of the rapid diagnostic test (RDT) results for malaria (Scherr *et al.*, 2017).

2.3. Smartphone Application Based Data Collection

With the development of Smartphone, their increasing capabilities, and wide distribution across the globe, the use of apps for electronic data collection is rapidly increasing (Walker, 2013). Permission users can enter data into an electronic questionnaire/survey that is accessible via a mobile device. Mobile apps can collect and transmit large amounts of a wide variety of data, including text, geolocation information, barcodes, photographs and videos. The ability to transmit photographs and videos allows for remote clinical assessment, diagnosis and treatment (i.e. telemedicine) (Stevens & Pfeiffer, 2015).

Mobile apps also enhance data quality and completeness as they allow for drop-down menus and single- or multi-select data fields that limit errors from free text entry, pop-up text boxes and images that can provide instructional help, and data entry verifications and validations. Through the data, and the app's verification and validation capability, an app developer can require a subset of, or all, data fields to be completed before a report can be submitted. In addition, the app can provide restrictions that allow for only biologically plausible data fields to be entered (Holmstrom *et al.*, 2013).

Apps can store data on a mobile device until the user next establishes a network connection. It is at this point that the data can be manually or automatically transmitted and submitted. This allows for data collection in remote areas to occur with the knowledge that, once a network connection is established, the data will be automatically submitted and added to the database for analysis (Thompson *et al.*, 2016).

Another advantage of Smartphone is their ability to collect locational data using the device's global positioning system (GPS) (Stevens & Pfeiffer, 2015). The spatial attributes of data enhance the quality of data analysis that can be provided to end users, and this analysis's subsequent use in the early identification and detection of disease outbreaks, or in the verification of the absence of disease, in a geographical location. Novel ways of using Smartphone' GPS for spatial data collection are also being seen. A recent example of this was the use of de-identified mobile-phone voice-call records as a valid data source for estimating near real-time population movement patterns after a natural disaster (Wilson *et al.*, 2016).

Additional capabilities continue to be developed that enhance the quality of data collection via mobile apps. For example, (Jandee *et al.*, 2014) developed a customized language voice survey within a mobile app. This development allows for questions to be read aloud in the local dialect, and demonstrates the enhanced quality of the data collected. Both online software platforms and custom-developed mobile apps are being used increasingly in animal health for near real-time data collection. Several online software platforms are available that allow users to develop their own questionnaires which are then accessible via mobile apps on iPhone and Android devices for data collection (Open Data Kit, 2017). For example, EpiCollect has been used in Kenya by farmers and veterinarians to report animal disease outbreaks and track vaccination and treatment campaigns, as well as in West Africa for tick surveillance (FAO, 2013).

EMA has been successfully piloted in Uganda since in 2013 with plans to expand its use across the country for tracking animal diseases, as well as additional pilot projects planned in other countries (FAO, 2015). Regardless of the platform, mobile apps have been well received when applied in animal health to remote data collection and have been shown to improve the timeliness of this collection as compared with paper-based questionnaires (Karimuribo *et al.*, 2016). While the current process for mobile app development is device-specific (i.e. Android and iPhone apps are developed separately), newer methods for cross-platform mobile app development are emerging that allow one data collection form to be developed and deployed to Android and iPhone operating system (iOS) mobile phones/tablets simultaneously, eliminating the need to develop forms separately and thus decreasing the time from development to deployment (Smutny, 2012).

Another advantage of mobile apps is the enhanced capability to provide near real-time feedback to end users using visual and analytical tools, such as spatial trends and anomaly detection algorithms

(Madder *et al.,* 2012). This feedback can be viewed by end users on their mobile devices, as well as through Web-based applications such as eHealth technologies. For example, EpiCollect has the option for users to integrate their collected data with online spatial visualization and analytical tools through a website (spatial epidemiology.net) (Aanensen *et al.*, 2009).

These technologies can control the type and granularity of the feedback, such as sharing the data in anonymous format and in aggregate form at a higher resolution than the level at which the data were collected. Like SMS, mobile apps on Smartphone can communicate in the form of alerts from a central authority, such as from government animal health authorities, to all or a subset of users. Additionally, mobile apps can further support bidirectional information flow through the use of within-app messaging between users in the field, and animal health experts and/or authorities (Thompson *et al.*, 2016).

These capabilities overcome the challenges of current surveillance systems characterized by hierarchical data flows resulting in slow data collection, analysis and sharing of information (Vasudevan *et al.,* 2016). Furthermore, they allow animal health status information to be instantaneously available to the frontline animal health workforce in the field, thus increasing the likelihood of the early detection of disease as well as enhancing overall point of-care animal health decision-making from treatment to interventions by veterinarians and animal health workers (Braun *et al.*, 2013).

With the increasing availability of mHealth technologies, the decision regarding the most appropriate platform(s) for data collection should be guided by the objectives and data to be collected, as well as factors such as accessibility and cost. Appropriate training is essential to ensure that users are familiar with the mobile technology and its use in data collection. SMS and mobile app technology platforms are still in the infancy of their implementation and sustainability within animal disease surveillance and outbreak response systems globally. Still, the use of mobile technologies will only continue to increase and it would be prudent to take advantage of their use for electronic data collection, as well as to identify novel ways in which they can be used in animal health (Thompson *et al.*, 2016).

Smartphone are considered as the new generation of mobile devices. A mobile app has been developed that helps African farmers and vets quickly and accurately diagnose problems in livestock. If the livestock are ill then it will efficiently direct the user to find the appropriate remedy or help alert qualified support. Statistics and knowledge improve herd management. The mobile solution has been developed by a Scottish based company, Cojengo Ltd. As it works and helps diagnosis conditions in the farms of East Africa so it also accumulates data, growing in value, with an ability to store and share the data gathered on disease surveillance and monitoring (Huntley *et al.,* 2009).

Since then Cojengo has been developing further services for vets and farmers. It has extended the product range to include an online data analysis tool to help adapt the diagnostic engine for new markets. The company has announced a new Vet Africa Suite, which it claims is the continent's first integrated product range to aid diagnosis, collect data from the field faster, make sense of it and target resources more effectively. The independent field trials of the Vet Africa app and its development were conducted during 2015 in Ethiopia. It set out to evaluate the effectiveness of the app, demonstrating its reliability and effectiveness as a mobile health tool designed to work in Africa. The app also acts as a passive surveillance device, as all of the data collected is uploaded to the Cloud and can then be used in a number of ways; for example, as part of a syndromic surveillance exercise a good use of open data for farmers and rural vets (World Bank, 2018).

Smartphone apps have a number of qualities that make them potentially useful platforms for behavioral health treatment delivery. Widespread availability as well as their low cost, independence of time and geography, and the anonymity they afford make them a promising tool for allowing individuals to actively engage in and self-manage their condition. Smartphone technology may also be utilized as an additional tool in clinical treatment settings, with potential benefits such as determining appropriate level of care, assisting with tracking of treatment progress, facilitating secure patient–provider communication, decreasing patient burden associated with paper based homework assignments, and supporting relapse prevention by improving patient follow up (Luxton *et al.,* 2011) .

Paper-based data collection is convenient for many researchers and data collectors. It has several potential advantages over the automated method; data extraction is not limited to a Specific place and it is seemingly easier to produce, modify, manipulate, and implement. In addition, they can provide along-lasting record of all modifications and an instant evaluation of forms can be completed by different review authors. Moreover, data loss using the paper-based method is potentially less likely than with automated data collection (King *et al.*, 2013). Studies from developing countries have found, however, that using paper-based methods result in a higher frequency of in complete records, a greater potential for human errors, and more time is needed to organize the data (Njuguna *et al.*, 2012). In addition, it can involve labour-intensive data entry and may limit timely analysis (Weber *et al.*, 2005).

As information communication technologies grow and soft ware such as the` Android' systems platform and many open-source applications have been developed, researchers in the health sector have begun using Smartphone as a tool in patient data collection, disease surveillance, clinical research, and national surveys (Garg *et al.*, 2013). However, paper-based questionnaires continue to be the main data collection tool in many countries, especially in sub-Saharan Africa (King *et al.*, 2013).

Using Smartphone technology-based tools for data collection has many advantages and can provide a broader range of options. It is economically and environmentally friendly, and it can provide faster reporting with more accuracy (Pakhare *et al.*, 2014). It is also more efficient. Data collection and entry can be combined in to one step (Garg *et al.*, 2013) forms can be easily developed to provide built-in checking and reliability rules, and has additional features such as a Global Positioning System (GPS). In addition, time stamps, alarms, automatic completions, and reminders can help in work-rate monitoring and data validation (Le Jeannic *et al.*, 2014).

In contrast, data security and connectivity can be a concern, and data collectors need to be familiar and comfortable with using an automated tool (King *et al.*, 2014). Accidental loss of data, battery life, loss or theft of the device, security of the device, and network connectivity in rural areas are also major concerns (Tomlinson *et al.*, 2009).

Information technologies are rapidly advancing the way in which animal health data and information can be collected and analyzed in order to support disease surveillance and response. These technologies have the capability to collect and analyze large volumes of data in near real time, which can allow for rapid detection and response to natural and intentional disease events as they occur. With the threat of bioterrorism and high-consequence disease outbreaks being part of the current global health landscape, real-time data collection and analysis is even more critical (Beckham & Holmstrom, 2015).

The utilization of these technologies could provide critical information in near real time in developed and developing countries, even when robust veterinary health infrastructures do not exist (Karimuribo *et al.,* 2016). In 2015, a survey conducted on behalf of the World Organization for Animal Health (OIE) aimed to assess the availability and current and potential uses of information technologies across different animal health settings within OIE Member Countries' Veterinary Services (Beckham & Holmstrom, 2015).

The animal health settings that were assessed were: data management, disease outbreak reporting, active and passive surveillance, and emergency response. A key finding of the survey indicated that, while information technologies are widely available to Member Countries, they are used only at low levels, and sometimes not at all (Karimuribo *et al.,* 2016).

2.4. Opportunities for Strengthening Disease Surveillance

Community-based disease surveillance strategies have the potential to benefit from improved data quality and access, given the current increased trend in the penetration of smart phones and ownership, as well as universal internet access by rural communities. The use of paper-based system to record and submit health events data in resource-poor countries contributes enormously to delayed response. It is also common practice in African cultures that the health care pathway does not start off at official health facilities but rather at home or traditional healers. Thus, most health events within communities are not captured in the official health surveillance system (Karimuribo *et al.,* 2016).

The quest for an early warning system calls for community members to be directly involved in the surveillance and detection of health events (i.e. participatory epidemiology). Innovative solutions are therefore needed to bridge the gap of capturing health events at community level that should inform the relevant authorities to provide appropriate responses in a timely manner. A disease surveillance approach that not only is grounded in One Health principles but is also participatory, supporting sharing of health information among stakeholders is likely to enhance early detection of human and animal diseases at the community level by empowering communities to take ownership and control over local decisions and to have a stake in maintaining the surveillance structures and practices (Cojengo, 2014).

The widening use of mobile phones in sub-Saharan Africa, where the penetration rate has reached 67%, offers the opportunity to develop innovative participatory surveillance strategies that rely on the design and deployment of digital and mobile technology solutions. Its overall goal is to promote Community Level One Health Security (CLOHS), thus complementing international disease surveillance strategies with participatory engagement of local communities and enhancing early disease detection and response at community, national, regional, and global levels (Guardian, 2015).

2.5. Surveillance Using Novel Information Technologies & Data Sources

Recent rapid developments in technological capacities for data collection and communication have had implications for the way in which health surveillance is conducted, and in many cases the use of electronic data collection and reporting systems has already improved detection of pathogens compared with older, manual methods (Bravata *et al.,* 2004; Soto *et al.*, 2008). Because of this, there is a hope that the use of novel technologies such as internet-based data extraction algorithms and mobile phones will enable global disease surveillance and facilitate great improvements in surveillance capacities within the developing world particularly.

In many cases, the communications technologies discussed in this section are not in themselves surveillance systems and it is important to recognize that as with any other data collection tool, their considerable potential can only be realized if incorporated into well designed systems.

However, the global adoption of new communication technologies, first the internet and more recently mobile phone connectivity, have undoubtedly provided opportunities and enabled a new class of participatory systems for global disease surveillance and monitoring (Freifeld *et al.,* 2010).

2.5.1. Internet-Based Surveillance Systems

In recent years, there has been a proliferation of new online data resources such as blogs, news outlets and discussion sites and of new data collection methodologies such as data-mining (a process of extracting patterns from large quantities of data) and crowd sourcing (a technique that involves engaging large numbers of people to perform a task) that can be used to access and utilize these data. The potential value of these non-traditional data sources and analytical tools for disease surveillance has in turn prompted a new generation of online disease surveillance systems (IOM, 2007).

Many of these systems are designed to achieve early detection of emerging disease threats and for this purpose specifically, non-traditional data sources and proxy measures such as school and work absenteeism, calls to telephone care nurses, search engine query data and over the counter pharmacy sales have all been proposed as potential indicators of adverse health events that should be included in surveillance systems to provide an event signal earlier than more traditional surveillance data sources such as hospital admissions and mortuary reports (Bravata *et al.,* 2004; Ginsberg *et al.,* 2009).

The use of automated electronic systems means that data on disease outbreaks can be processed and made available for access in near real-time at very low cost (Soto *et al.,* 2008; Brownstein *et al.,* 2009) and as a consequence, web-based systems are credited with being the first to detect a number of significant recent infectious disease events. Options for cross-validation and moderation of submissions are being explored (Brownstein *et al.,* 2009; Freifeld *et al.,* 2010), as it is argued that even when using data from sources that are perhaps biased or awed in some way, the aggregation of several sources of data can be used to decrease the potential for false alarms, whilst maintaining the sensitivity and timeliness that is key for early warning (IOM, 2007).

Internet-based surveillance systems that continuously scour the web for health/ disease related terms or reports have demonstrated utility for the early detection of health anomalies and potential disease outbreaks and their capabilities and value are likely to increase as these tools are refined over time (Ginsberg *et al.,* 2009). However, such systems are inherently limited in developing countries, and particularly in rural areas where infrastructure is very poor, surveillance is weakest and livelihoods are most closely associated with animals. It is therefore important that investment in `internet-based' systems does not compromise investment at the ground level, which cannot be replaced by a technological fix.

Mobile phones and other electronic data collection/entry tools represent a considerable improvement over traditional paper and pen recording methods in that they reduce the number of error-prone translation steps between the initial collection of data and its use, enhancing both speed and accuracy (Soto *et al.,* 2008; Yu *et al.,* 2009; Mtema *et al.,* 2010). These attributes make mobile phone based technologies particularly well suited to address deficiencies in disease surveillance capacities in the developing world, which have been chronically hindered by poor infrastructure and which currently represent the weak-spot in global surveillance capacities (GAO, 2001).

One of the greatest strengths of surveillance systems that utilize mobile phones is this capacity for two-way transfer of information. Feedback to incentivize and enhance responses can range from automated responses that acknowledges receipt of a report, to reminders of follow-up clinic appointments and the provision of up-to-date data on drug stocks or the nearest source of vaccine (IOM, 2007; Soto *et al.,* 2008; Mtema *et al.,* 2010).

It was suggested that SMSs improved the relationship between the patient and the healthcare worker in an area where healthcare access is typically very poor. Good relationships between patients, animal owners, healthcare and animal health workers (both within and between sectors) are necessary to improve the collection and quality of surveillance data. The potential value of two-way communication can operate on multiple levels, by for example providing a direct means of empowering stat to action a response (e.g. alerting the responsible person within the relevant sector), providing an outlet for communication with peers or colleagues and facilitating supervision. These attributes that are aided by mobile technologies have all been shown to improve health worker performance in low-income countries and are likely to be equally applicable to animal health workers (Rowe *et al.,* 2005). There are now a large and rapidly growing number of mobile systems being piloted for public health. Several of the more developed mobile-based participatory systems for public health are described (Freifeld *et al.*, 2010).

In terms of animal disease surveillance though, the potential of mobile phone based systems has yet to be fully explored or exploited. The Infectious Disease Surveillance and Analysis System (IDSAS) project in Sri Lanka represents one of the first examples of the application of this kind of approach to animal disease surveillance. The IDSAS project was designed to obtain timely animal health data from field veterinarians and involved mobile phone based submission of clinical data obtained by veterinarians during their normal daily work activities. A major output from this project, was the demonstration that mobile phone based surveillance of animal populations is both feasible and acceptable in lower-resource settings. Several schemes are now also under-development in sub-Saharan Africa, such as the animal disease surveillance and response system (ADSARS) that is being rolled out in Kenya and the rabies surveillance system operating across sectors in Southern Tanzania (Robertson *et al.,* 2010).

While there is a lack of cost-effectiveness studies for surveillance systems in general, quantifying the costs for the deployment of new technologies would be particularly valuable for determining whether such technologies are an ordable in developing countries. The major expenses associated with establishing and running mobile-based surveillance systems are associated with the hardware required and a potential drawback with many of the mobile phone surveillance applications that are currently in development is that they rely on expensive Smartphone which are not widely available in resource-poor settings (Freifeld *et al.,* 2010).

The sending a detailed report/collected data from smart mobile phone over the GSM network costs are potentially lower than paper-based reporting and would also allow more efficient monitoring of users. In the long-term, the capital costs of hardware are also likely to be compensated by reductions in the requirement for data entry time. However, the investment required for training users and the acceptability of mobile phones when deployed on a large-scale has yet to be seen, but preliminary studies indicate that time is needed to garner support for the implementation of alternative surveillance methods (Yu *et al.*, 2009).

As the rapid growth in mobile phone applications for surveillance continues, care should be taken to ensure that integrated and efficient systems are established to meet the needs of stakeholders rather than generating a variety of parallel reporting systems each with their own focus and possibly different hardware and software requirements. Mobile phone networks are unique amongst communication systems in their global coverage and accessibility. By enabling access to existing networks of people, mobile phones will perhaps provide the tool to address the key question of how to overcome the limitations of paper-based systems and get data from the ground into the system, particularly for those regions of the developing world that have been so badly served by existing surveillance systems. If used in combination with other novel approaches such as syndromic and sentinel surveillance, the use of mobile phone technologies offers the potential to generate comprehensive data on both animal and human health patterns in a timely and cost-effective way, and ultimately to address the considerable gaps in global surveillance coverage that currently exist, for the developing world particularly (Soto *et al.*, 2008; Robertson *et al.*, 2010).

3. MATERIALS AND METHODS

3.1. Study Areas

This study was conducted from September 2018 to August 2019 at three (3) public veterinary clinics in western parts of Oromia region (Nekemte, Bako and Shambu). Nekemte is found in East Wollega Zone, Oromia regional state. It is located at 331 km west of Addis Ababa at a latitude and longitude of 95°5' N and 360°33'E, respectively with an elevation of 2,088 meters above sea level (m.a.s.l). The minimum and maximum annual rain fall and daily temperature ranges are between 1450 to 2150 mm and 15 to 27C°, respectively (CSA, 2012).

Bako district is located in West Shoa Zone of Oromia Regional state at about 250 km west of Addis Ababa. It is characterized by topography ranging from 1600 to 2870 meters above sea level and its annual rainfall varies between 800-1200 mm per year, of which more than 80% falls in the months of May to September. It has temperature ranging from 11^0C to 24^0C. It has a total area about 638 $km^2$and the population density of about 217 per square kilometer (CSA, 2011).

Shambu is found in Horro Guduru Wollega Zone and located at 09º29´N and 37º26´E, at an altitude of approximately 2296 meter above sea level with a uni-modal rainfall ranging between 1200mm-1800mm (Olana, 2006). The rainy season occurs from April to mid-October where maximum rain is received in months of June, July and August. Maximum temperature of 23-27^0C are reached from January to March, and minimum temperature of 7-15 ^{0}C is normal from October to November (CSA, 2013).

The study areas were selected due to having high population of cattle, high reports of the cattle disease challenge and having different agro-ecological location. The clinics were selected based on their type of clinic for laboratory access to confirm 10% from the total matched cases and internet access to submit the collected data to higher administrative levels.

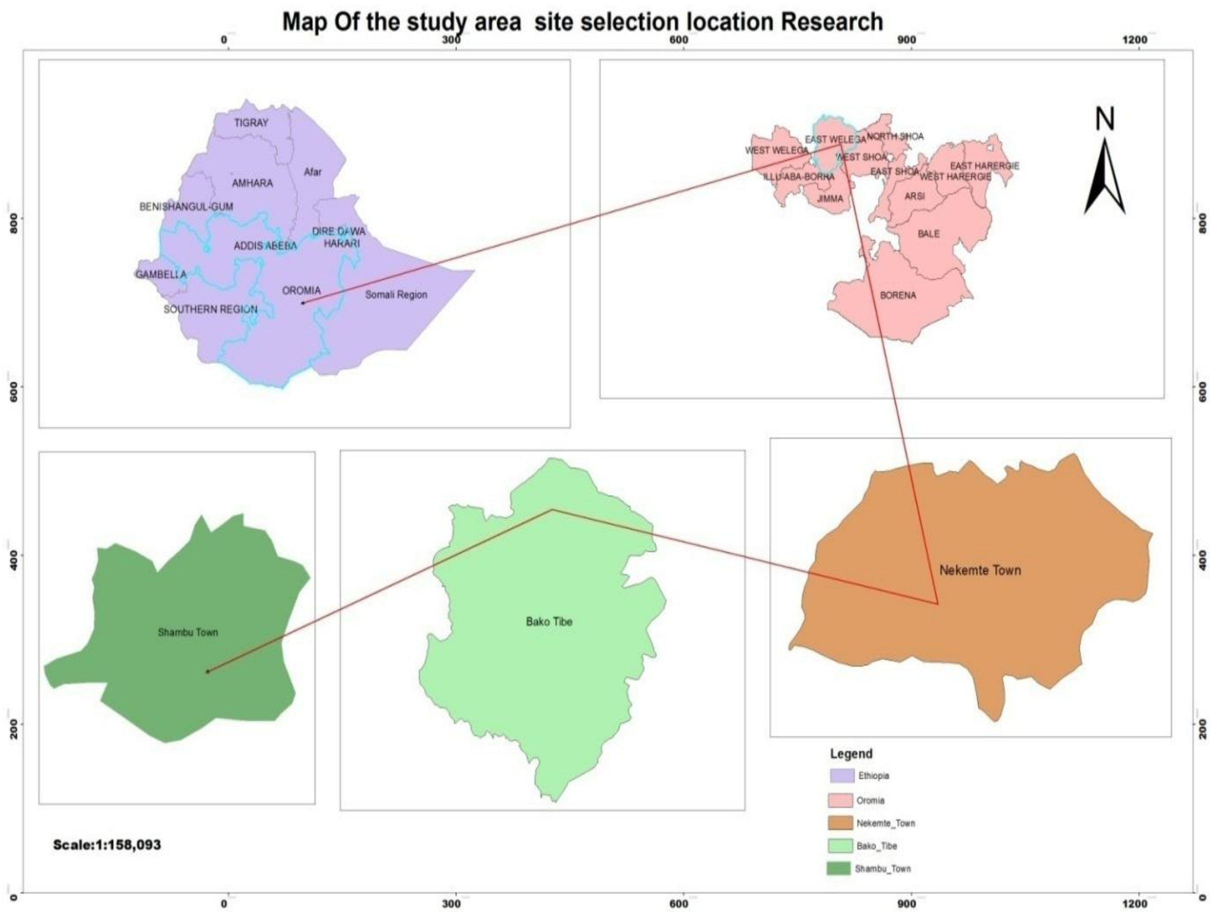

Figure 1: Maps of Study Area

3.2. Study Design and Study Population

A descriptive case study was used in this study. A descriptive study is limited to a description of the occurrence of a disease in a population and is often the first step in an epidemiological investigation. Purposive sampling technique was used on bovines coming to the clinics. Bovine species with different age, breed and sex group were included in this study. This case study was undertaken at animal health facilities center to report important encountered clinical diseases and disorders pertinent to Babesiosis and Trypanosomosis in bovine during the study period.

3.3. Case Handling Protocols

Clinical case handling protocol (Jackson and Cockcroft, 2002) was used in this case study as indicated in Annex part (Annex 1).

3.3.1. History Taking/Anamnesis

Disease problems in veterinary medicine are invariably presented to the clinician through the medium of the owner's complaint, which is a request for professional assistance. Owner is the best link between clinician and patient animals, so appropriate anamnesis are very important in disease diagnosis. For completeness and accuracy of history taking, the following check lists were considered (Patient data, Immediate/present history, past history, Management and Environment history) and history of each case was carefully taken which gave a guideline for examination of the animals.

3.3.2. Physical and General Examination

Physical condition, behavior, posture, gait, roughness of the hair coat, enlargement of peripheral lymph nodes, anaemia, weight loss, pyrexia, abortion, reduced milk yield, loss of appetite, cessation of rumination, labored breathing, emaciation, progressive hemolytic anemia, various degrees of jaundice (Icterus) from paleness in mild case to sever yellow discoloration of conjunctival and vaginal mucous membranes in more progressive cases; haemoglobinuria, accelerated heart and respiratory rates. The temperature, pulse, and respiratory rate from each of sick animals were recorded. Clinical examination of cattle of different ages was conducted on the basis of diseases history, owner complaint, symptoms, to diagnose diseases and disorders.

3.3.3. Clinical Presentation of cases and Proportional Morbidity by Disease

An assessment of the way in which case presentation was recorded in the traditional paper-based approach was made and compared with the case recording facilitated by EDDIE app. In particular, the number and form of clinical signs recorded under these alternative approaches was summarized and compared. Bovine trypanosomosis, babesiosis and other cases presenting at the veterinary clinics during the study period, as diagnosed by the researcher using EDDIE and the paper-based approach, were reviewed and enumerated. Accordingly the diseases and their estimated proportional morbidity (i.e. the relative frequency of trypanosomosis, and babesiosis diseases from the total cases visiting the clinics during the study period) were reported.

3.3.4. EDDIE Smartphone Diagnosis and Laboratory Investigation

In addition to EDDIE application as a diagnostic tool; 811 clinical examinations was used in this research and 10% from total matched cases laboratory techniques were also performed to confirm the individual cases. In this research, EDDIE application was developed as a smart phone diagnostic tool. Different data with species of animals, clinical signs, and disease were recorded on EDDIE. At the end clinician's/veterinarian's tentative disease diagnosis was compared with the Smartphone based mobile App result as a diagnostic tool. The appropriate samples was collected from tentatively diagnosed cases (by clinician) from the study sites and transported to laboratory room. From this result the uses of the smart phone-based mobile app in disease diagnosis was evaluated and compared with the laboratory finding. The way in which EDDIE works was mentioned under annex 2.

The cattle diseases selected were: Babesiosis and Trypanosomosis. Cattle disease (Babesiosis and Trypanosomosis) was diagnosed and their relative frequencies from the total number of cases was presented at the veterinary clinics during the study period, as diagnosed by the researcher using *EDDIE* as well as those using 'manual' methods, was computed. The level of completeness of demographic and patient information was compared between the groups.

3.4. Comparison of Features recorded by EDDIE to the Paper/Traditional approach

The level of completeness associated with demographic and patient information was compared between the group using the EDDIE app and the paper/manual case recording and reporting. In addition, the number of clinical signs observed per case was compared. In the case of EDDIE, the data are available to all authorized users as soon as the details of a case have been uploaded to the Cloud server. Details of the information captured by those using the Smartphone app and those using the paper-based approach are given in Table 1.

Table 1: Comparison on details of information captured and reported for cattle by EDDIE app users versus paper/ manual system users.

	EDDIE app	Paper/Manual approach
Details captured while diagnosing (local level)	For each animal:	For each animal:
	Sex Age Breed Detailed list of clinical signs Specific disease	Sex Age Breed Limited list of clinical signs Disease or syndrome
Details included while reporting (to higher administrative levels)	For each animal All of the above noted data were available to all administrative Levels in real time[a]	By animal species group: Number of cases (aggregated over previous month) for disease/syndrome[b]

[a] Real- time/instant reporting depended on available Internet connection.

[b] Reported as batch updates at the end of each month.

3.6. Data Analysis

The collected data were entered into Microsoft Excel database and descriptive statistics were used to explore the proportion of cases diagnosed across demographic and disease specific scenarios. Chi-square tests were used to ascertain differences in profile of sex, age, and breed by study area for both the EDDIE and paper/manually based reported cases. Statistical analysis was performed by Cohen's kappa using SPSS software. Kappa (w) software was used to test the agreement between the categorical variables. P-values of less than 0.05 were used to report the significance of the results. Kappa (k) is one of the most commonly used statistics to test interrater reliability. It is a standardized value and thus is interpreted the same across multiple studies. It can range from -1 to +1, where 0 represents the amount of agreement that can be expected from random chance, and 1 represents perfect agreement between the raters.

Table 2: Kappa (w) range and level of agreement (Source: Isara *et al.*, 2013)

Kappa range	Level of agreement
0.00	No agreement
0.01-0.20	Slight agreement
0.21-0.40	Fair agreement
0.41-0.60	Moderate agreement
0.61-0.80	Substantial agreement
0.81-0.99	Almost perfect agreement
1.00	Perfect agreement

In clinical research, agreement between observers is often analyzed when evaluating various methods. Agreement between observers (inter-rater agreement) can be measured in different ways, and some methods may be regarded as more accurate than other. Depending on which method one uses, one can obtain quite different values (Bland *et al.*, 1986).

4. RESULTS

4.1. Characteristics of cases reported by researcher

The total of 811 cattle cases were reported that visited the veterinary clinics from the three study area during the September 2018 to August 2019 studies period and was diagnosed through the EDDIE app and paper/manual based reporting approaches. Relatively higher numbers of animals were examined in Shambu veterinary clinics and lower numbers of animals were examined in the Bako veterinary clinics by EDDIE app and paper based. This difference was due to cattle population that visited the veterinary clinics in the study area during study period (Table 3).

Table 3: Comparison of all cases recorded during the study (N = 811) by site and in terms of proportions across key variables within each study area

Characteristics		Study Area/Site			
		Nekemte	**Bako**	**Shambu**	**Overall**
		No (%)	**No (%)**	**No (%)**	**No (%)**
Total cases		**292**	**110**	**409**	**811**
Sex:	Male	96(32.8)	43(39)	162(39.6)	301(37.1)
	Female	196(67.2)	67(61)	247(60.4)	510(62.9)
Breed:	Local	255(87.3)	98(89.1)	395(96.6)	748(92.2)
	Cross and Exotic	37(12.7)	12(10.9)	14(3.4)	63(7.8)
Age:	0-6months	46(15.7)	22(20)	59(14.4)	127(15.65)
	7-12months	44(15.1)	20(18.2)	67(16.4)	131(16.15)
	13-24months	54(18.5)	18(16.4)	31(7.6)	103(12.7)
	2-4years	62(21.2)	24(21.8)	76(18.6)	162(20)
	>4years	86 (29.5)	26(23.6)	176(43)	288(35.5)

The above table indicates breakdown of all cases reported by EDDIE app and manual/paper based surveillance and reporting approach according to a number of key variables (breed, sex and age). More female animals examined from the shambu veterinary clinic and Nekemte veterinary clinic, and the majority of cattle belonged to the greater than four years age category. In all study area, over 92% of the cattle presenting were local (zebu) breeds, with limited numbers of cross and exotic-bred animals (8%).

4.2. Proportional Morbidity

The proportional morbidity based on the diagnoses reported by the EDDIE and paper is given in Table 3. Causes of morbidity in both diagnoses methods were trypanosomiosis and babesiosis. From the two diseases that trypanosomiosis, was the most commonly reported disease by the *EDDIE* app and paper followed by Babesiosis. The proportional morbidity of each of the two diseases with their variables was explained by the EDDIE app and paper based of reports is illustrated (table 4).

4.3. Comparison of Babesiosis and Trypanosomosis Diagnoses made by EDDIE app and Paper/Manual

The relative frequency of both diseases diagnoses suggested by EDDIE app and paper/manual based on clinical signs reported during each of the two reporting approaches of the study. Across the two reporting approaches, the EDDIE app suggested diagnoses in proportions were higher little difference with that of the paper/manual approaches.

Table 4: Characteristics of bovine babesiosis and trypanosomosis diagnosis and surveillance data collected using EDDIE app and paper based

Characteristic	**Total (%)**	**Total Cases (N=811)**		**Matched**	**Unmatched**	**kappa(w)**
		EDDIE (%)	**Clinical (%)**	**(N=778)**	**(N=33)**	
Site:						
Nekemte	292(36)	292(100)	292(100)	286(98)	6(2)	
Bako	110(13.6)	110(100)	110(100)	98(89)	12(11)	0.72
Shambu	409(50.4)	409(100)	409(100)	394 (96.3)	15(3.7)	
Sex:						
Male	301(37.1)	301(100)	301(100)	285(94.7)	16(5.3)	0.87
Female	510(62.9)	510(100)	510(100)	493(96.7)	17(3.3)	
Breed:						
Local	748(92.2)	748(100)	748(100)	723(96.6)	25(3.4)	
Cross and Exotic	63(7.8)	63(100)	63(100)	55(97.7)	8(34.8)	0.89
Age:						
0-6months	127(15.65)	127(100)	127(100)	121(95.3)	6(4.7)	
7-12months	131(16.15)	131(100)	131(100)	128(97.7)	3(2.3)	
13-24months	103(12.7)	103(100)	103(100)	94(91.3)	9(8.7)	0.25
2-4years	162 (20)	162(100)	162(100)	158(97.5)	4(2.5)	
>4years	288 (35.5)	288(100)	288(100)	277(96.2)	11(3.8)	

The two heamoprotozoan parasites out of the total animals examined were (36%), (13.6%) and (50.4%) from Nekemte, Bako and Shambu districts respectively, by both EDDIE app and manual/paper. From these both reports the proportion of both diseases in Nekemte (98%, 2%), Bako (89%, 11%) and Shambu (96.3%, 3.7%) were matched and unmatched respectively. Kappa indicates that substantial level of agreement (w=0.72) between the both reporting approaches of diagnosis and surveillance.

Based on sex groups, the matched and unmatched proportion of both diseases were in male (95.3%, 4.7%) and female (96.7%, 3.3%) respectively and the level of agreement (w=0.87) between the diagnostic methods were almost perfect.

This study revealed that the proportion of both diseases in local breeds (96.5%, 3.5%), cross breeds (90.2%, 9.8%) and in Exotic breeds (75%, 25%) were matched and unmatched in both reporting approaches recorded respectively. Kappa shows that almost perfect agreement between EDDIE and paper based the reporting approaches.

Comparison was also made on the proportion of both disease on the groups of age category that the difference in proportion among the three age groups. In both diseases the EDDIE app and manual/paper surveillance and reporting approaches were relatively highest in >4years (35.5%) old than other age groups. Kappa shows that fair agreement between the two methods of diagnosis and surveillance methods.

Table five (5) indicates that both the EDDIE app and paper/manual based diagnoses and surveillance of trypanosomosis proportions with the variables. In study area, the proportion of matched and unmatched of trypanosomosis which diagnosed through both the EDDIE app and paper/manual were in Nekemte (96.5%, 3.5%), Bako (89%, 11%) and Shambu (96%, 4%) and kappa shows moderate level (w=0.53) of agreement between the two reporting approaches.

The matched and unmatched comparison proportion of trypanosomosis diseases in EDDIE app and paper/manual were in local (95.4%, 4.6%), cross (93.75%, 6.25%) and Exotic breeds (80%, 20%) reporting approaches respectively and kappa indicates that substantial level of agreement (w=0.74) between EDDIE app and paper based diagnosis and surveillance of trypanosomiosis.

Based on sex, bovine trypanosomosis diagnosed by both EDDIE app and manual/paper based and matched and unmatched proportion in male (94%, 6%) and in female (95.8%, 4.2%) were reported respectively and kappa indicates that there is fair level of agreement between the two reporting approaches (w=0.31).

In age groups the proportion of matched and unmatched of EDDIE app and paper based reporting approaches were in 0-6 months (95.1%, 4.9%), 7-12months (93.4%, 6.6%), 13-24months (94%, 6%), 2-4years (93%, 7%) and >4years (97.6%, 2.4%). Kappa indicates that almost perfect level of agreement between EDDIE and paper reporting approaches.

Table 5: Trypanosomosis cases recorded using EDDIE app and those using clinical reporting in terms of proportions across key variables

Characteristic		Total(%)	Total Cases(N=578)		Matched	Unmatched	Kappa(w)
			EDDIE(%)	Clinical(%)	(N=550)%	(N=28)%	
Site:							
	Nekemte	202(34.95)	202(100)	202 (100)	195(96.5)	7(3.5)	
	Bako	82(14.2)	82(100)	82(100)	73(89)	9(11)	0.53
	Shambu	294(50.85)	294(100)	294(100)	282 (96)	12(4)	
Sex:							
	Male	198(34.25)	198(100)	198(100)	186(94)	12(6)	0.31
	Female	380(65.75)	380(100)	380(100)	364(95.8)	16(4.2)	
Breed:							
	Local	541(93.6)	541(100)	541(100)	516(95.4)	25(4.6)	
	Cross	32(5.5)	32(100)	32(100)	30(93.75)	2(6.25)	0.74
	Exotic	5(0.9)	5(100)	5(100)	4(80)	1(20)	
Age:							
	0-6months	82(14.3)	82(100)	82(100)	78(95.1)	4(4.9)	
	7-12months	91(15.7)	91(100)	91(100)	85(93.4)	6(6.6)	
	13-24months	84(14.5)	84(100)	84(100)	79(94)	5(6)	0.83
	2-4years	113(19.5)	113(100)	113(100)	105(93)	8(7)	
	>4years	208 (36)	208(100)	208(100)	203(97.6)	5(2.4)	

From both EDDIE app and manual/paper reporting approaches of bovine babesiosis in matched and unmatched were in Nekemte (97.7%, 2.3%), Bako (96.4%, 3.6%) and Shambu (98%, 2%) in study area and the level of agreement between the two reporting approaches were substantial (k=0.64) (table 6).

Comparison of bovine babesiosis proportion in EDDIE app and manual/paper diagnosis and surveillance the matched and unmatched were in local (98.5%, 1.5%), cross (94.7%, 5.3%) and exotic (85.7%, 14.3%) breed respectively. The kappa indicates (w=0.63) substantial level of agreement between the both reporting approaches.

In both reporting approaches, bovine babesiosis was compared based on sex and the matched and unmatched between the EDDIE and paper were in male (98%, 2%) and female (97.7%, 2.3%) respectively. Between the two diagnostic methods of bovine babesiosis based on sex there were (k=0.48) moderate level of agreement.

Based on age groups, bovine babesiosis by two reporting approaches was compared and the proportion of matched and unmatched were in 0-6months (100%, 0%), 7-12months (100%, 0%), 13-24months (89.5%, 10.5%), 2-4years (97.9%, 2.1%) and > 4years (97.5%, 2.5%). The level of agreement between the two diagnostic methods was (k=0.89) almost perfect (table 6).

Table 6: Babesiosis cases recorded using EDDIE app and those using paper/manual reporting in terms of proportions across key variables.

Characteristic	**Total (%)**	**Total Cases (N=233)**		**Matched**	**Unmatched**	**Kappa(w)**
		EDDIE(%)	**Paper(%)**	**(N=228)%**	**(N=5)%**	
Site:						
Nekemte	90(38.6)	90(100)	90(100)	88(97.7)	2(2.3)	
Bako	28(12)	28(100)	28(100)	27(96.4)	1(3.6)	0.64
Shambu	115(49.4)	115(100)	115(100)	113 (98)	2(2)	
Sex:						
Male	103(44.2)	103(100)	103(100)	101(98)	2(2)	0.48
Female	130(55.8)	130(100)	130(100)	127(97.7)	3(2.3)	
Breed:						
Local	207(88.8)	207(100)	207(100)	204(98.5)	3(1.5)	
Cross and exotic	26(11.2)	26(100)	26(100)	24(98.4)	2(19.6)	0.63
Age:						
0-6months	45(19.2)	45(100)	45(100)	45(100)	0(0)	
7-12months	40(17.15)	40(100)	40(100)	40(100)	0(0)	
13-24months	19(8.15)	19(100)	19(100)	17(89.5)	2(10.5)	0.89
2-4years	49(21)	49(100)	49(100)	48(97.9)	1(2.1)	
>4years	80 (34.35)	80(100)	80(100)	78(97.5)	2(2.5)	

4.4. Laboratory Confirmation of Bovine Trypanosomosis after Diagnosed by EDDIE app and paper/manual based

To evaluate the accuracy of EDDIE app, laboratory confirmatory diagnosis was done using 10% from the total of matched cases to identify the causative agents of the diseases. Accordingly, in the three study area the proportion of trypanosomosis which confirmed by laboratory test and the results were in Nekemte (36.8%), Bako (37.5%) and Shambu (17.8%) from matched cases based reporting approaches. The above laboratory confirmation indicates EDDIE app was accurate for diagnosis and surveillance of bovine trypanosomosis.

Based on the breed group, the proportion of trypanosomosis diseases which diagnosed by EDDIE app and paper, the proportion of laboratory confirmed and laboratory result were in local (29.4%), cross and exotic (0%).

However, bovine trypanosomosis was diagnosed by EDDIE app and paper, the proportion of laboratory confirmed and results were in male (31.5%) and female (25%). Laboratory result indicates EDDIE app was accurate than paper based trypanosomosis diagnosis and surveillance.

The proportion of bovine trypanosomosis with the age categories which diagnosed by EDDIE app and paper and the proportion of laboratory results were in 0-6 months (37.5%), 7-12months (44.4%), 13-24months (37.5%), 2-4years (10%) and >4 years (20%). The above laboratory confirmed proportion shows in study area, breed, sex and age groups were almost accurate with EDDIE app for the diagnosis of the trypanosomosis (Table 7).

Table 7: Lab. confirmation of bovine trypanosomosis which diagnosed by EDDIE and paper (matched)

Characteristic		Trypanosomosis				
		Matched (EDDIE and Paper) (N=550)	**No. of test animals by lab. (N=55)**	**No. of positive animals (N=15)**	**X^2(P-Value)**	**Kappa(w)**
Site:	Nekemte	195(96.5%)	19(9.7%)	7(36.8%)		
	Bako	73(89%)	8(10.95%)	3(37.5%)	9.876(0.04)	0.63
	Shambu	282(96%)	28(9.92%)	5(17.8%)		
Sex:	Male	186(94%)	19(10.2%)	6(31.5%)	1.58(0.09)	0.28
	Female	364(95.8%)	36(9.9%)	9(25%)		
Breed:	Local	516(95.4%)	51(9.88%)	15(29.4%)	19.757(0.001)	0.84
	Cross and exotic	34(98.75%)	4(12.5%)	0(0%)		
Age:	0-6months	78(95.1%)	8(10.3%)	3(37.5%)		
	7-12months	85(93.4%)	9(10.6%)	4(44.4%)	7.211(0.05)	0.67
	13-24months	79(94%)	8(10.1%)	3(37.5%)		
	2-4years	105(93%)	10(9.5%)	1(10%)		
	>4years	203(97.6%)	20(9.8%)	4(20%)		

4.5. Laboratory Confirmation of Bovine Babesiosis after Diagnosed by EDDIE app and paper/manual

Bovine babesiosis was diagnosed by EDDIE app and paper based reporting approaches. To evaluate the accuracy of EDDIE app in babesiosis diagnosis, 10% from the total matched cases of babesiosis were confirmed by laboratory test. Accordingly, in the three study area the proportion of laboratory result were in Nekemte (33.34%), Bako (0%) and Shambu (27.28%) (Table 8). Based on the above number of laboratory confirmation, EDDIE app was accurate for diagnosis and surveillance of bovine babesiosis.

Based on the breed group, the proportion of babesiosis diseases which diagnosed by EDDIE app and paper and the laboratory results proportion in local (30%), cross and exotic (0%) were examined.

With age categories, the proportion of laboratory results from matched EDDIE app and paper cases were in 0-6 months (20%), 7-12 months (25%), 13-24 months (0%), 2-4 years (20%,) and >4 years (42.85%) reported. The above laboratory confirmed proportion indicates in study area, breed, sex and age groups were accurate with EDDIE app for the diagnosis of the babesiosis diseases (Table 8).

Table 8: Laboratory confirmation of bovine babesiosis which diagnosed by EDDIE and paper (matched)

Characteristic	Babesiosis				
	Matched (EDDIE and clinical) (N=228) (%)	No. of tested Animals by lab. (N=23) (%)	No. of positive Animals (N=6) (%)	X^2(P-Value)	Kappa(w)
Site: Nekemte	88(97.7)	9(10.2)	3(33.34)		
Bako	27(96.4)	3(11.1)	0(0)	2.450(0.07)	0.42
Shambu	113(98)	11(9.7)	3(27.28)		
Sex: Male	101(98)	10(9.9)	2(20)		
Female	127(97.7)	13(10.23)	4(30.77)	6.292(0.04)	0.51
Breed: Local	204(98.5)	20(9.8)	6(30)		
Cross and exotic	24(97)	3(11.2)	0(0)	13.39(0.01)	0.43
Age: 0-6months	45(100)	5(11.1)	1(20)		
7-12months	40(100)	4(10)	1(25)		
13-24months	17(89.5)	2(11.76)	0(0)	1.241(0.21)	0.13
2-4years	48(97.9)	5(10.4)	1(20)		
>4years	78(97.5)	7(8.9)	3(42.85)		

4.6. Clinical Signs Recorded by Two Reporting Approaches

There were a total of 2957 clinical signs recorded (1864 in EDDIE app and 1093 in Manual/Paper) for the 811 cases investigated by two reporting approaches of the study. The most commonly occurring sign was Staring/Rough coat, seen in over (67.2%, 52.8%), Anemia/pall (63.7%, 46.8%) of cases in EDDIE app and Manual/Paper respectively (table 9). Weight Loss/Emaciation, Lymph node enlargement, and Anorexia/Loss of appetite were observed in almost half of all cases while, Weakness, and Pyrexia/Fever were also present in around 40% of cases. Diarrhea and dyspnoea/difficult breathing was seen in around a 25% of cases, with constipation being seen in just15% of cases. The remaining signs were observed relatively infrequently (i.e. in around 5% or fewer cases)

Table 9: Proportion of times that a given clinical sign was noted for cattle cases (Trypanosomosis and Babesiosis) captured by each of the disease reporting approaches

Clinical signs	**EDDIE app (%)**	**Paper/Clinical based (%)**
Staring/Rough coat	67.2	52.8
Anemia/pallor	63.7	46.8
Weight Loss/Emaciation	52.2	39.1
Lymph node enlargement	52.1	36.4
Anorexia/Loss of appetite	50.1	32.4
Weakness	41.3	27.9
Pyrexia/Fever	40.5	23.2
Diarrhea	25.1	19.4
Dyspnoea/difficult breathing	23.3	11.4
Constipation	16.8	10.1
Icterus /yellowish mucus membrane	5.2	2.1
Ataxia/Incoordination of movement	3.2	1.6
Other	-	9.4
Total signs recorded	1864	1093
Total number of cases	811	811
Signs per case	2.3	1.3

(Table 9) lists signs in order of the proportional change in their observation frequency between EDDIE app and Manual/Paper reporting approaches. The average number of clinical signs recorded as being present for any given case by the group using the EDDIE app was 2.3 (95% CI: 1.8–2.9); significantly higher than the mean of 1.3 (95% CI: 1.0–1.7) clinical signs recorded in the paper-based system. However, for the sake of making more realistic comparisons with data from the paper-based approach restrict the current analyses to only those signs that were indicated to be present for a given case. The list of clinical signs provided for cases captured using the two recording approaches is shown in Table 9. The signs are ordered according to those which occurred most frequently when signs were recorded by the group using the EDDIE app. Before comparing the proportion of cases for which given signs occurred in it is important to note the “Other” at the foot of the table. This indicates that in 9.4% of the cases records.

Some of the next most common signs were also reported by both approaches, including: Staring/Rough coat, Anemia/pall, Weight Loss/Emaciation, Lymphnode enlargement, Anorexia/Loss of appetite, Weakness, and Pyrexia/Fever (although their prevalence was higher in the case of EDDIE app due to the much higher number of absolute signs reporting using that approach). Certain signs, such as diarrhea, dyspnoea/difficult breathing, Constipation, Icterus/yellowish mucus membranes and ataxia/incoordination of movements, occurred an order of magnitude less frequently in the paper-based system; given that each of these signs appeared in at least one in all cases reported in EDDIE app it seems likely that they are being systematically and grossly underreported in the paper-based records.

5. DISCUSSION

Data allowing for evaluation and comparison of two surveillance systems employed in different geographical area, and used in reporting similar disease events in the same animal species, and with the data corroborated through response visits conducted by veterinarians. The data show that the EDDIE app mobile phone-based system has a higher probability of reporting valid disease events compared with the paper based disease surveillance visits, paradoxically demonstrating that an EDDIE app mobile phone-aided passive surveillance system can outperform an active surveillance system. Active surveillance systems such as routine visits to study households require more time and resources than a passive surveillance system where animal owners have to decide whether to report disease events occurring at their farm. When it comes to the health of their livestock, people quickly notice unusual signs and tend to report these to health authorities, provided a working system is in operation (Halliday *et al.,* 2012). Novel approaches are also being developed to combine singles that may exist in multiple data sources associated with syndrome surveillance (Struchen *et al.,* 2017).

Thus, for example, the researcher can posit that the lower proportion of cross and exotic bred animals reported by both EDDIE app and manual recording system across the three study area; this may be due to few number of cross and exotic bred animals exist in the population. An often reported benefit of reporting using mobile phone is the more accurate geo-referencing of case data (Aanensen *et al.,* 2009). In particular case, this was less relevant as the reports were being made from clinics whose locations were fixed and known; however, if EDDIE app were being used as part of a visit to cattle in their field setting, then the geo-referenced coordinates of each case could add significant value, particularly in the case of a disease outbreak where locational clustering can be a key indicator for early detection.

A major challenge of traditional reporting systems centers on the need to compile reports from various sources and provide these to central offices at regular intervals and to different administrative levels (Walker, 2013). The compiling process is potentially challenged by unintentional alterations of results due to errors in data submission or transcription (Madder *et al.*, 2012).

In addition, Robertson *et al.,* (2010) reported that such mobile phone-based surveillance system reduce the number of data entry errors and facilitate automated data analysis. The increased opportunities offered by "big data" in terms of data integration and semi-automatic analyses have been reported for both human and veterinary health data recording systems (Vander Waal *et al.,* 2017). Those cattle diseases that have the highest importance from an economic or trade perspective were included in the EDDIE app, based on the diseases targeted for control by the veterinary services of Ethiopia (Drewe *et al.,* 2016).

The accuracy of EDDIE app was approved by confirmatory diagnosis using laboratory test 10% from the total matched cases and accordingly, from 778 matched cases 78(10%) cases were laboratory tested and only 21(26.92%) cases were positive for the two heamoprotozoan parasites (bovine trypanosomosis and babesiosis).

Ideally, the accuracy of the data collected by such applications should be supported by field evaluation as to disease outcomes for all cases. In this study, it was not possible to conduct all field evaluation using laboratory confirmation due to logistic constraints including cold chain to keep the samples to destined locations, shortage of laboratory consumables, processing costs, etc. These constraints appear to be shared by many studies of surveillance systems (Vrbova, 2010).

A recent survey exploring the potential for mobile phone use to deliver animal health information in Uganda found that while almost all livestock keepers owned a feature phone, only around 10% owned a Smartphone (Karimuribo *et al.,* 2016). Their use in supporting public health systems in developing countries to address a lack of quality data and instant transmission of health data from lower levels has been documented (Braun *et al.,* 2013). Unlike such surveillance systems that depend on healthcare or veterinary workers to report disease events (including those using EDDIE app mobile phones to improve reporting), this study has demonstrated a EDDIE app mobile phone-based surveillance system directly dependent on researchers/veterinary professionals to report disease events. These findings that owning mobile phone is not a determinant of using the EDDIE app phone-based surveillance system are insightful, indicating a good interplay between widespread phone ownership and likelihood of accessing phones to report disease events. This is important as it removes the possible reporting bias that would be associated with mobile phone ownership.

These findings on greater propensity of using the EDDIE app phone-based system for reporting illnesses (especially those presenting with severe clinical signs) and not death events has broader implications for the surveillance for infectious diseases in cattle. The effectiveness of surveillance systems is linked to response actions or incentives for reporting. In this study, all reported cases likely served as an effective incentive for community reporting of disease events observed in their animals. Reporting illness cases provided animal owners with opportunities for receiving immediate help for their sick animals without incurring veterinary treatment expenses. Although reporting death cases may lead to knowledge of what killed the animals and what might be done to prevent similar deaths in the future, this was not seen as sufficient incentive for real-time reporting of death events in this study. The EDDIE app phone-based surveillance system in this study was dependent on internet access and costs associated with data transmission.

The composition of the case data sets remained broadly similar between the two reporting approaches interms of a number of variables, namely animal age group, sex and breeds. This breakdown is broadly reflective of the cattle for which they were receiving requests to carry out diagnosis.

In this study the total number of clinical signs observed in EDDIE app compared with paper based was 2.3 and 1.3 respectively. Clinical signs events were 1.0 times more likely to be reported through the EDDIE app mobile phone-based surveillance system when compared with the paper based visits. The observed significant differences in the reporting methods according to the type of disease sign observed. In paper based the individual signs contributing most to this increase were Staring/Rough coat, anaemia/pallor, Weight Loss/Emaciation, weakness, Anorexia/Loss of appetite, and which all but higher in number in EDDIE app to be seen in over half of all cases. However, while the overall number of signs reported increased in EDDIE app, this increase was limited to signs listed on the EDDIE app; some other signs reported during paper based but not on the EDDIE app, such as haemoglobinuria, lacrymation, dullness etc were no longer reported after its introduction. The interpretation of this may be that while the EDDIE app encourages clinical examination and recording of signs observed, this effect is limited to those signs listed on it.

In the present work, EDDIE app was shown to identify some signs more frequently than paper based. It can be envisaged that the EDDIE app might be helpful to animal health workers in diagnosing endemic disease in their cattle, and the results obtained here support earlier work in confirming they are able to identify at least some clinical signs.

Given that the researcher diagnoses were available for both the EDDIE app and paper based of the study, the initially used these to characterize the disease status of the animals examined as a measure of proportional morbidity in the population under the clinical care of the researcher. The two diseases covered by the EDDIE app and paper based of the putative diagnoses made by the researcher for cases that attended throughout the study period, and hence the EDDIE app diagnoses may also provide an approximate measure of proportional morbidity in the study area (Nekemte, Bako and Shambu) of western Oromia.

The conditions most commonly diagnosed by researcher in both reporting approaches were two vector-borne diseases (trypanosomosis and babesiosis). While trypanosomosis remained the most common diagnosis through both reporting approaches, representing more than half of two diagnosed diseases, but babesiosis was diagnosed significantly less commonly in both reporting approaches.

Specifically, there appeared to be predisposition towards diagnosis of both trypanosomosis and babesiosis in exotic cattle, as compared with cross breed, whereas local (zebu) breed appeared to have greater likelihood of diagnosis of both diseases than other breeds, observations consistent with known breed susceptibilities (Magona *et al.*, 2004). Similarly, some district level effects were observed, for example; from laboratory tests (positive animals) lower proportional morbidity of trypanosomosis in Nekemte (3.6%) and Shambu (1.8%) District, consistent with its higher elevation on the slopes of mid highlands, and that highest prevalence of trypanosomosis in was found in Bako district (4.1%) as the area lies at mid lowland compared to other study area. The results reported here are based on data collected over two specific periods in a single year across the areas under consideration.

Age effects on proportional morbidity were possibly of greater interest. In this area of Western Oromia, there appears to be clear evidence that diagnosis of babesiosis is primarily associated with young animals while the opposite appears to be the case with trypanosomosis (significantly fewer cases in the two age classes of animals under one year and significantly more in those cattle of two years or older). However, it is arguably the age distributions for cases diagnosed with tick-borne diseases that are most interesting. For both disease (trypanosomosis and babesiosis) there is evidence that the presence of disease in young animals (less than 6 months old) was significantly lower than would be expected based purely on proportions of cattle in each age group, consistent with the concept of inverse age immunity for these diseases (Eisler *et al.,* 2003).

Previous attempts at evaluating paper based systems for animal disease diagnosis have used selected test cases (Eisler MC *et al.,* 2007), whereas the present study was based on naturally occurring disease. Hence, one challenge in evaluating the performance of the EDDIE app was having an independent assessment as to which disease or diseases were truly present in each of the cases. Fortunately provisions of definitive diagnostic capability through laboratory confirmation at least 10% from the total matched cases had been done in this study. In the presence of such a laboratory confirmation to evaluate whether the application achieved the 'correct' diagnosis the assumption that the researcher made the correct diagnosis and but simply assessed how often the suggested diagnosis of the EDDIE app.

A further complication is that both paper based and the EDDIE app may suggest multiple diagnoses. Indeed, the concordance values reported here must be interpreted taking into consideration that neither the paper' nor the EDDIE app diagnoses returned perfect scores when compared with each other. In trypanosomosis diagnoses the breakdown of cases from key variables, the kappa statics in breed group shows substantial agreement between EDDIE app (k=0.74) with paper diagnoses, between age groups (k=0.83) almost perfect agreement between sex group (k=0.53) moderate level of agreement (Table 5). For bovine babesiosis diagnosis and surveillance, babesia cases with variables age group showed that kappa statics gave almost perfect level between EDDIE app (k=0.89) with paper diagnoses, and the concordance of other variables showed moderate and substantial level (Table 6**)**. This indicates that EDDIE app was almost as accurate as paper base for diagnosis of bovine trypanosomosis and babesiosis.

Concordance is the proportion of agreement corrected for chance taking into consideration both ‘positive’ and ‘negative’ agreements, i.e. where both paper and the EDDIE app agree that the diagnosis either is or is not a particular condition. Hence while concordance is a better measure of whether there was agreement between the two diagnostic tests of the study, it gives only limited indication of where disagreements lie.

6. CONCLUSION AND RECOMMENDATIONS

In this study researcher evaluated the performance of the EDDIE application based on the level of match between paper based diagnoses and the EDDIE app's predictions. Information technologies are rapidly advancing the way in which animal health data and information can be collected and analyzed in order to support early detection and response to natural and intentional biological introductions. Such mobile apps provide clear benefits not only in comparison to paper based data collection and reporting but also in terms of gathering more consistent and complete demographic and epidemiological information. The main findings of this study indicated that an acceptable overall level of matching could be achieved and that the major determinants of such matching were the disease being diagnosed, the diagnostic ability of the paper based and the level of certainty the EDDIE app assigned to the most likely diagnosis. Generally in this study; the important points included were application of clinical case handling protocols, comparison of EDDIE app diagnosis, paper based diagnosis and Confirmation of 10% from the matched cases with laboratory to determine the accuracy of EDDIE app. As it has been seen in the current research EDDIE app offer opportunities for improvements in disease diagnosis and reporting. Diagnoses of bovine trypanosomosis and babesiosis suggested by the EDDIE app were broadly consistent with those made by paper. Based on the above conclusion the following recommendations are forwarded:

- ✓ It is advisable if awareness creation undertaken on the usage of EDDIE app for animal health workers for more accurate diagnosis, Surveillance and data reporting purpose.
- ✓ The EDDIE app should include all species of animal like; poultry and small animals in the future perspective.
- ✓ The laboratory should be fully accessed and other diagnostic tool should be installed in the study area for further confirmation of the cases.
- ✓ Further research, involving more definitive case outcomes, adequate number of samples is required to fully access improvements in disease diagnosis and the provision of the most appropriate treatment advice through EDDIE app.

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8. ANNEXIES

Annex 1: Clinical case handling protocol

Owner's complaint
Signalment of the patient
History of the patient(s)
Observation of the environment
Observation of the animal at a distance
Detailed Examination of the animal
Further investigations (laboratory diagnosis)

Sources: (Jackson and Cockcroft, 2002)

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ADDIS ABABA UNIVERSITY
College of Veterinary Medicine
and Agriculture
Bishoftu/Debre Zeit

Animal Research Ethical Review Committee

Ethical clearance certificate

Certificate Ref. No: VM/ERC/32/07/09/2017

Name of Applicant: Tariku Jibat **(DVM, MSc, PhD fellow)**

Address: College of Veterinary Medicine and Agriculture, Addis Ababa University

Title of the project: Improving livestock disease diagnosis, treatment and surveillance in Ethiopia through development and evaluation of smart-phone based application

Date of application:	**24/07//2017**
Nature of the project:	**Mildly invasive**
Target animal species:	**all livestock species**
Number of animals involved:	**depends on case availability**
Study area:	**Ethiopia**

Minutes No. and date of review: **VM/ERC/07/09/017, 15/08/2017**

The above indicated research project is acceptable from ethical perspective, relevance, originality and technical competence points of view. Hence the project is allowed to be executed provided that:

1. All procedures and conditions stipulated in the proposal are respected and any deviation or changes be reported to the committee
2. The project activities be open for occasional supervision by the committee whenever this is deemed necessary

Dr Getachew Terefe
Chairman

Signature

Dr. Dinka Ayana
Dean
College of Veterinary Medicine
and Agriculture

The Federal Democratic Republic of Ethiopia
Addis Ababa University College of Veterinary Medicine and Agriculture

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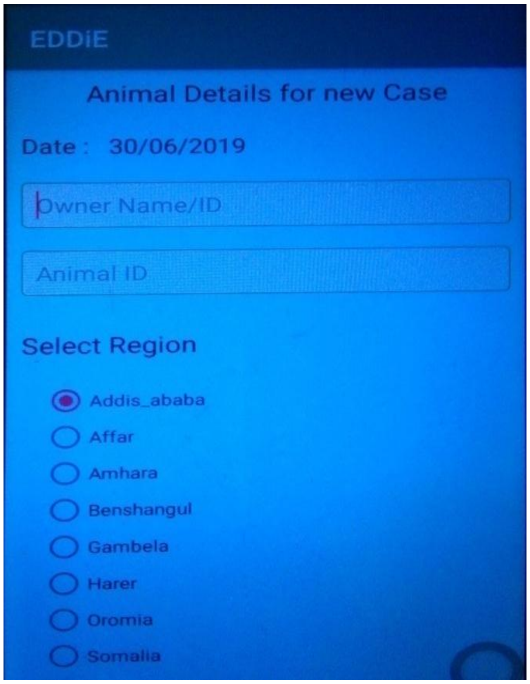
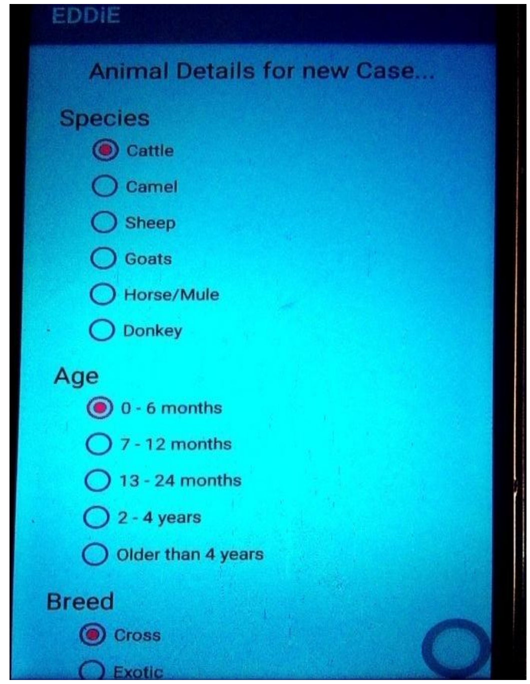
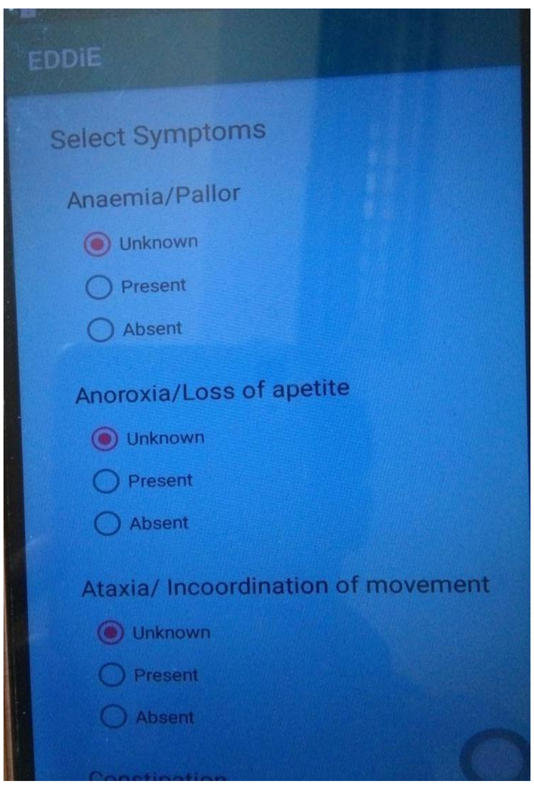
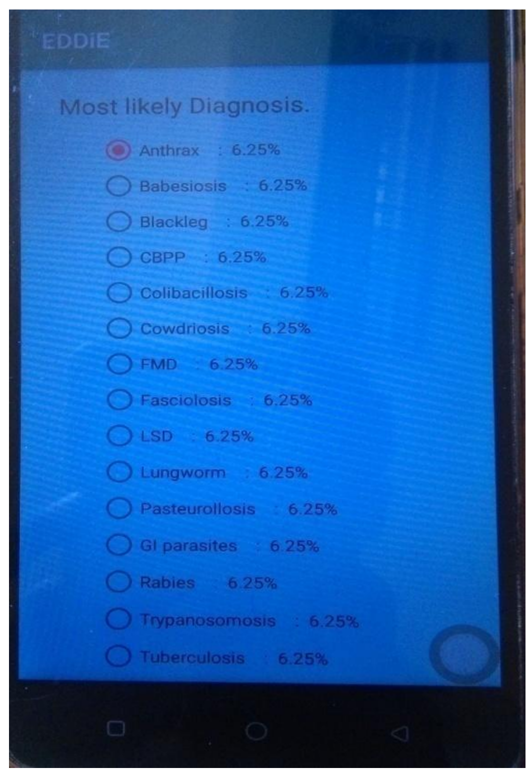
Annex 2: Ways in which EDDIE app works









Annex 3: Blood sample collection and result registration table in paper based reporting approach

Date ____________________

District's name____________

S. No	**Owner's name**	**Zone**	**PAs**	**Breed**	**Sex**	**Age**	**Blood Parasites Identified**	
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								