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Complete List of Authors:	Takuwa, Mercy; Makerere University, Biomedical Engineering Programme, Physiology Department Mbabazi, Shirley; Makerere University, Biomedical Engineering Programme, Department of Physiology Tusabe, Martha; Makerere University, Biomedical Engineering Programme, Physiology Department Mulindwa, Benedict; Makerere University, Biomedical Engineering Programme, Physiology Department Ngaju, Phillipa; Uganda Industrial Research Institute, Instrumentation Division Mulerwa, Martha; Uganda Industrial Research Institute, Instrumentation Division Kansiime, Enid; Uganda Industrial Research Institute, Instrumentation Division Muhanguzi, Donald; Uganda Industrial Research Institute, Instrumentation Division Reboud, Julien; University of Glasgow, James Watt School of Engineering Cooper, Jonathan ; University of Glasgow, James Watt School of Engineering Ssekitoleko, Robert; Makerere University, Biomedical Engineering Programme, Physiology Department
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Mercy Takuwa
Degrees: MSc. Candidate, Immunology and Clinical Microbiology, BSc. Biomedical Engineering, Makerere University
Organisation: Biomedical Engineer and Researcher- Biomedical Engineering Unit, Department of Physiology, Makerere University Uganda.

Shirley Elizabeth Mbabazi
Degrees: Master's Student, Computer Science, BSc. Software Engineering, Makerere University.
Organisation: Research and Teaching Assistant- Biomedical Engineering Unit, Department of Physiology, Makerere University Uganda.

Martha Tusabe
Degrees: MSc. Candidate, Technology Innovation and Industrial Development, BSc. Biomedical Engineering-Makerere University
Organisation: Technical Officer-Biomedical Engineering-WHO/AFRO, Biomedical Engineering Unit, Department of Physiology, Makerere University

Benedict Mulindwa
Degrees: BSc. Biomedical Engineering
Organisation: Biomedical Engineer and Researcher-Biomedical Engineering Unit, Department of Physiology, Makerere University

Philippa Ngaju Makobore
Degrees: PhD student in Biomedical Engineering, University of Calgary, MSE Biomedical Engineering, Purdue University and BSc Electrical Engineering, University of Alberta
Organisation: Instrumentation Division, Uganda Industrial Research Institute
Martha Mulerwa
Degrees: PhD candidate, BSc. Biomedical Engineering-Makerere University
Organisation: Biomedical Engineering consultant, World Health Organisation, WHO AFRO.

Enid Claire Kansiime
Degrees: Bachelor of Engineering in Telecommunications Engineering, Diploma in Telecommunications Engineering
Organisation: Uganda Industrial Research Institute

Donald Muhanguzi Birungi
Degrees: Bachelor of Computational Science
Organisation: Uganda Industrial Research Institute.

Julien Reboud
Degrees: PhD

Organisation: Advanced Research Centre, University of Glasgow

Professor Jonathan Cooper
Degrees: BSc, MSc (Oxon) PhD
Organisation: Advanced Research Centre, University of Glasgow

Ssekitoleko Robert
Degree: EngD, MEng
Organisation: Lecturer and Head of Biomedical Engineering, Department of Physiology, School of Biomedical Sciences, College of Health Sciences, Makerere University.

ABSTRACT

Background: Despite its strong growth in many parts of the world, mobile health access is still limited in low- and middle-income countries. Among the many factors restricting implementation are the lack of information security, insufficient evidence base, low sensitization, and user acceptance. Limited evidence has been obtained on current practices, perceptions and user acceptability in such settings. The aim of this study was therefore to evaluate the knowledge, attitude and perceptions on mobile health use among health workers and veterinary officers in Uganda.

Material and Methods: A cross section study was carried out, targeting health practitioners in both hospitals and veterinary laboratories/clinics. A structured questionnaire was used to collect data from the Central, Eastern, Northern and Western representative regions. Interviews with selected health workers were also conducted as well as a focused group discussion.

Results: Out of the one hundred and twenty health practitioners that were targeted, a total of eighty health workers and seven veterinary practitioners participated in the study of which 46% were male and 54% female. Majority of the health workers had encountered mHealth but had never used it, whereas the fifteen practitioners who had used it before the survey did not use it for disease diagnosis in hospitals but used it for ordering medicine online, for patient consultations with the doctors, result interpretation, tracking women menstrual cycles, TB assessment and phone in gloves resuscitating the baby.

Discussion and Conclusion: Participants expressed significant interest in mobile health as it addresses key challenges including challenges with management of patient data, and long patient queues, which would ultimately improve service delivery. However, there is some scepticism about access as many rural facilities lack access to smartphones and stable internet.

Key words: Digital health, Mobile health, Perceptions, Telemedicine

INTRODUCTION

The term “digital health” is broadly used in the disciplines of health informatics, medicine, and public health although there is no consensus on the definition[1]. Due to different perspectives among academia, scientific institutions, industry, and individuals, there is a lack of comprehensive and precise understanding of digital health. Furthermore, the terms e-health, m-health, telehealth and telemedicine are often used interchangeably in different disciplines[2,3]. Consequently, there is a strong need for both empirical and practical definitions for these terms as a basis for further application and research. According to the World Health Organisation, e-health is the “cost effective and secure use of Information and Communication Technologies for health and health-related fields” whereas mHealth is the “provision of health services and information via mobile technologies”[4]. Telemedicine, in contrast, is exclusively focusing on aspects of healthcare services delivered remotely by health workers and it is a sub-category of

eHealth[5].

Trends in digital health are bringing about great advances in global healthcare with more than a billion lives seeing great benefits such as reduced time wastage and transport costs spent when traveling to the health facilities, patient information from years before is easy to track and it doesn't get lost, it enables health care providers to easily make consultation from one another online to mention but a few [6,7] and many more starting to embrace it. There is increased awareness of the value of transitioning to digital systems, which has been made possible through numerous mobile technology innovations [8]. However, digital health is still a relatively new trend in low-and-middle income countries (LMICs) where there is limited evidence for interventions that have been implemented[9]. Nevertheless, the health workforce has much to gain from the field especially where resources are limited. For example, health workers based in rural areas can utilize digital innovations to collect, share and manage patient data, tracking vital signs in real-time, undertaking disease surveillance and intervention monitoring, receiving remote diagnosis support and training, as well as coordinating with peers in different geographical settings[10,11]. Many of these areas have seen a significant increase during the peak of the COVID-19 pandemic. Even in LMICs, mobile phones and mobile technologies are rapidly advancing beyond calls, simple short messaging service or voice messaging, to include mobile internet browsing, video calling, wireless data transmission and smartphone applications to transmit health-related information or direct care[12].

The market penetration of mobile phones has been estimated to reach 78% worldwide and according to the Global Speciale for Mobile Association (GSMA) 2018 report[13], In Africa GSMA believes that the region will hit the half a billion mark in 2021 for unique mobile subscribers, and a 50% subscriber penetration rate by 2025[14]. When it comes to mobile Internet usage, 272 million Africans are now connected to the Internet on their phones, which is just 26% of the population[14]. Platforms incorporating Artificial Intelligence are even taking prospects higher where minimal input is used for analysis. In Uganda, emerging digital-Health innovations include the EVA system an Artificial Intelligence-ready, mobile, and connected colposcope with teleconsultation capabilities that expands expertise at the point-of-care to women for cervical cancer screening and sexual assault forensic exams[15]. Another example is Rocket Health, an integrated healthcare platform where users can remotely consult with health workers, request for tests and receive results and medicines[16]. The FistApp technology is a software application that helps the doctor to carry out an automatic computation of the data entered and provides early warning signs of possible complications during labour that may cause child and mother death[17]. Neonatal care is a key area for digital health and Neopenda is another system including a device for monitoring vital signs of many critically ill newborns simultaneously[18].

The limited access and utilization of digital-Health especially in low resource settings, where the impact could be very high, calls for more research and understanding of the contributing factors and challenges[19]. Several research studies have described financial, social, legal and ethical barriers to implementation, at the individual and organisational levels[20] comprising users' lack of awareness of the benefits, low eHealth literacy, interoperability and a deficiency of evidence of cost-effectiveness as well as security concerns [21,22]. This has created the inability to scale up projects from pilot phase to regional and national levels, and the challenge of establishing a mutually beneficial and sustainable partnership amongst different stakeholders[21]. The aim of this study was therefore to evaluate knowledge, attitudes and perception on mHealth among health workers and veterinary practitioners in Uganda.

METHODS

In order to cover all health facility levels and ensure that a diverse range of health workers was reached, a cross section study was carried out in sixteen public health facilities including one National Referral Hospital (NRH), three Regional Referral hospitals (RRH), three Health Centre (HC) IVs and four HC IIIs and four HC IIs across four regions of Uganda Lira RRH, Amachi HC IV, Aromo HC III and Alik HC II were included in this study in Northern Uganda, Mbale RRH, Muyembe HC IV, Busamaga HC III and Buwasuguyi HC II in the East; Mbarara Municipal Council HC IV, Kakoba HC III, Nyamitobora HC II in the West, and Mulago NRH, Luwero General Hospital, Butuntumula HC III, Kigombe HC II and Komamboga HC III in the Central region. Veterinary clinics within the same regions were also included as shown in the Figure 1 below. The study enrolled doctors, pharmacists, laboratory technologists, radiologists, information technology (IT) personnel, and biomedical engineers. These along with veterinary practitioners made a total of eighty-seven participants. Data was collected using a structured questionnaire and a focus group discussion (FGD) that were carried out both physically and online through emails and phone calls. The online and phone interviews were held in an effort to minimize human contact due to COVID-19 and to access hard to reach areas due to restrictions brought about by COVID-19. Where possible, physical interviews were conducted at a social distance and these were recorded. These recordings were transcribed and documented. Figure 1 below shows the health facilities and veterinary laboratories/clinics where data was collected.

Figure 1: Map showing different Hospitals, Health centres, veterinary clinics and Veterinary laboratories visited in Northern Region(21 participants), Eastern Region (22 participants) Kampala Metropolitan region (18 participants), Central Region (21 participants)and western Region (5 Participants) in the study

Kampala, a region in the central area, was chosen for this study because it is where Mulago National Specialised hospital, the biggest National Referral Hospital, is located. It has a catchment area of the entire country with a population of over 48 million. In addition, the region has a variety of large veterinary clinics and laboratories. Luwero is a relatively rural district that has one general hospital with a small catchment and the rest are health centres IV, III and II. Wakiso was chosen because it has both urban and rural settings. Mbarara in the western region, Lira in the northern and Mbale in the Eastern region are cities with catchment populations of at least 2 million people.

The focus group discussion (FGD) included six participants: (1) a medical doctor from Rocket Health (mHealth Company in Uganda) and clinical researcher with Infectious Disease Institute; (2) a Biomedical Engineer from the Ministry of Health Central Workshop; (3) a senior Laboratory technologist and Lead on mobile phone diagnostics in sub-Saharan Africa working with Zoetis, a veterinary medical company; (4) an innovator and Project lead on Digital Health platform from Uganda Chartered HealthNet (UCH); (5) a senior Biomedical Engineer from Mulago National Specialised Hospital; and (6) a regulatory Officer at National Drug Authority. The focus group aimed at discussing their experiences of using mHealth platforms, with a focus on user needs and implementation procedures. Data from the focus group was analyzed using NVivo version 12. Quantitative data analysis was done using Statistical Package for the Social Sciences (SPSS) software.

ETHICAL CONSIDERATIONS

Ethical approval for this research was sought from the Makerere University School of Biomedical Sciences Research and Ethics Committee (SBSREC) and Uganda National Council for Science and Technology (UNCST). Permission was also sought from District Health Officers (DHO) and Directors of hospitals to engage with their staff. Participation in the study was voluntary for identified participants and informed consent was obtained. At the beginning of each interview or FGD, the research assistant/investigator would introduce him/herself and the people he/she would have come with after which the participants would introduce themselves. The research assistant/investigator would explain the objectives of the study, the expected benefits especially for the community, assure them of confidentiality and anonymity of the data collected and make it clear that they were free not to contribute when they felt they shouldn't, were free to withdraw any time.

RESULTS

A total of 80 health and 7 veterinary workers participated in the study, 46% of whom were male and 54% female. The majority of the participants were from Health Centre IVs with a percentage of 26% followed by Regional Referral Hospitals with a percentage of 23%. In addition, most of the respondents were nurses (31%) under middle management level. Many (44%) mentioned the diploma as the highest education level of the respondents. The average age of participants was 30 years. Table 1 below shows the participants categorised by the level of health, education level, age group, role, management level and their gender.

Table 1: Demographics of the study participants

Health worker smartphone access, knowledge about their smart model and documentation used in the hospital

Largest percentage of participants (93%) had access to a smartphone except a few from Health Centre IIs (rural) and IVs (semi-rural). All health workers in the veterinary sector had access to smartphones. Most health workers from the national referral hospital used messenger to send texts, text messaging and WhatsApp applications are used concurrently in most facilities (Table 2). Approximately half of the participants knew the models of their smartphones. Documentation of information in the veterinary sector is fully electronic; unlike in the hospitals where documentation is both electronic and paper based, use of electronic format increased with increase in level of health facility.

Table 2: Frequency (and percentage) of health worker smartphone access, knowledge about their smart model and documentation used in the hospital

About 40% of the participants stated that mHealth is a great initiative that will improve people's lives and is a good platform for disease monitoring. The participants from veterinary clinics and laboratories mentioned that mHealth has greatly improved veterinary services, quick information flow, services can be accessed from anywhere and would be worth exploring.

Besides the advantages of mHealth, participants mentioned significant challenges associated with mHealth. One of the participants from Mulago National Referral Hospital stated that "*mHealth is an interesting venture to explore, though I have concerns regarding the security and storage of patient data and challenges of network and high data costs that might hinder its progress"*.

A small percentage of the participants (3%) did not have any opinions on mHealth because they have never used it and even heard about it. "*I do not have any experience on mHealth and*

therefore have no thoughts'' said a diploma holder participant from Lira National Referral Hospital. Considering mHealth priority, health workers were asked to state the most important feature they would prefer to see mHealth do; 7% participants said it should be easy to use, 31% participants said it should be multipurpose, 15% participants said it should be cost effective, 7% said it should be able to diagnose diseases and 40% participants did not know about mHealth and hence did not have any opinion.

mHealth Usage in the different health facilities

The majority of participants knew about mHealth, however only 38% of the participants had used mHealth before, 55% had never used mHealth and 7% of them were not sure whether they had used it. mHealth usage was highest in Health Centre IVs and the National referral hospital. In this study, all participants in Health Centre IIIs reported they had never used mHealth and only one was found to have used mHealth in a Health Centre II. Interestingly, all participants from veterinary laboratories had been exposed and had used mHealth before. Figure 2 below summarizes the frequency of mHealth use at the various health facilities.

Figure 2: Frequency of mHealth Usage in Health Facilities levels

Focus Group Results

The focus group revealed three themes as follows;

a. **Government Involvement**

This theme was derived from the group's discussions around the low uptake of technology in the country, where 40% of the participants had never heard of mHealth and 38% have only used it for 1 to 2 years. Participants mentioned that The Ugandan Government has only limited laws or guidance targeted specifically at the mHealth industry, whilst they felt that there are many opportunities in Digital Health. "*Opportunities are many, however if not taken up by the ministry, they may never see the light of day*" participant (4) said. *There is also fear of data leakage because people are not sure of how their data is to be protected. e.g. End users will take up these innovations as long as they see the value and need, the platform, should also be easy to use for example Lab cards have been taken up by the end-users yet the ministry has not yet appreciated them. To overcome challenges in uptake of digital health innovations "the developers need to involve the central government right from the time of inception*" , Participant (4) added. "*Policy has been a challenge for example we have a tele-pharmacy, tele-lab and they both had to be regulated individually and right now there are no policies and licences on virtual operations and therefore things like cold chain are not catered for."* participant 1 said. All participants reported that there is no straight path or known regulatory body from the government that a researcher, innovator or developer can go to for clear regulations and policies to follow when coming up with a mHealth platform. This hinders the growth of mHealth in Uganda and most of the innovations remain on the shelf.

b. Systems-Development

Participants were concerned about the confidentiality of personal information and security of the data collected through mHealth platforms regarding who has the right to access. This, as well as the lack of communication among the systems such as Health Centre IV hospital's patient information systems do not communicate with Regional Referral hospitals. This can explain why developed mHealth platforms are not well received by the intended users and easily phased out. Participants all recognised mHealth as potentially a useful technology worth exploring and has eased diagnosis of diseases, reduced patient queues, helped to track the performance of medical devices both maintenance and inventory and participant (5) mentioned that "*without digital health we wouldn't have reached where we are, helps in*

collecting timely data from different places. The current app used is called the med-safety App, introduced by WHO". However, participant (3) added that "*There are quite a number of Ugandan digital innovations on Google Play store that haven't gone through any regulatory procedures.* Such innovations include but not limited to Restrack Uganda, Dynapharm, VHT App, PrEP Uganda App, among others. *He added that "on top of that, they do not communicate to each other". There is a need to design something that allows inter-communication between these platforms*." The future of mHealth is bright and certain challenges can be solved by working together. Participant (4) stated that "*We need to conduct a study on how data can be shared and narrow down the gap of inter-communication between systems. We do not have a central data server in Uganda to link the government and private data entities. There is a need for a central data server."* Most systems are developed independent of the others by different developers in different developing languages making it hard for systems to communicate and share data among the different health organisations.

c. Researchers and Developers Concerns

Protection of innovations as well as earning from the innovations is a major concern to both the developers and researchers as most of them innovate but never earn from their innovations. "*To avoid the frustrations, the developers need to bug the ministries to be a part of the digital health systems innovations. A lot of this data is needed by the ministries and it is a slow process to involve them but we should undertake it to create legitimacy"* said by participant (6). *"The developer needs to acquire a patent before they share their ideas to the public. Non-disclosure agreements should be signed by any participant in the project" (*Participant (3)*)* Most of the researchers and the developers are afraid of losing their projects to the people they partner with, to be on the opposite direction of the law if they do not follow the policies that are not well publicised or they do not know of.

DISCUSSION

Our results confirm that the concept of mHealth is still evolving. The penetration of mobile phone networks in many low-and-middle income countries surpasses other infrastructure such as paved roads and electricity, and often dwarfs access to fixed line internet[23]. Mobile tools are being used to strengthen different parts of the health system through voice, text and data access. These different modes offer the possibility of direct channels of communication with patients via phone calls (personal, automated, or through a free phone number), text messages (including personal text reminders or mass texting for community mobilization), data transfer for health record tracking or clinical decision support, and mobile telemedicine devices for patient monitoring or diagnosis[24]. However, the majority of participants had access to mobile phones but not smartphones, in line with the GSMA estimates that in 2021 Uganda would have a smartphone adoption of 16% , which is lower than the 30% average for Sub-Saharan Africa[25].

We also found that literacy levels on mHealth are still low among health workers in Uganda as shown by the limited number of participants who knew and provided reflections on the concept. This could be associated with the fact that mHealth is still a relatively new system in low- and middle-income settings, where a majority of mHealth initiatives are small-scale feasibility and pilot projects[26]. Indeed, although mHealth is picking ground globally, its reach in low- and middle-income countries, including Uganda, remains very low[27].

However, having explained the concept of m-Health and how it is used to participants, most of them reported the need for mHealth to reduce healthcare costs and enable access to better

quality healthcare for both people and animals, provided there is adequate infrastructure. Overall mHealth, as part of a public health program, has the potential to save millions of lives in Uganda by bringing them closer to the much-needed healthcare services[27]. The study provided supporting evidence on this potential for mHealth to improve patient outcomes.

In Uganda, the highest rate of mHealth usage is in the veterinary sector, and mobile applications have been successfully used to monitor animal disease. This can be attributed to the Zoetis-ALPHA (African Livestock Productivity and Health Advancement) Initiative, which was established to support the development of a sustainable veterinary diagnostic infrastructure in Uganda[28]. Through this Initiative, three veterinary diagnostic laboratories have received support in building sustainable diagnostic businesses that will ultimately fuel the growth of the livestock industry in Uganda through mHealth based diagnostics. Existing data also supports existing hypotheses that teleconsulting, together with wearable devices, and smartphone applications can improve animal care in areas where resources may be limited, including rural areas, developing countries, and other remote locations[29]. The challenges of providing veterinary care during the onset of COVID-19 and lockdowns in many areas led to a significant uptake and high interest in the utilisation of veterinary telehealth and human mHealth[29]. However, it is important to note that telemedicine as a tool is not appropriate for every healthcare issue, situation, client, or animal.

Despite the high level of interest in mHealth technologies in this study, health workers who had previously used them identified clear barriers to their adoption, including frequent power outages, subpar internet connectivity, and a lack in skills training. This confirms challenges hypothesised elsewhere citing lack of adaptability, excessive complexity, loss of trust among end users, and ineffective feedback systems as factors undermining implementation[21].

Ethical concerns around patient privacy, confidentiality and consent also pose unique challenges, especially in light of global cultural diversity. According to the report on global strategy on mobile Health 2020-2025[30] governments cited issues related to data privacy and security as two of the top barriers to the expansion of mHealth. Protecting personal health information that is collected and transmitted over mobile devices is essential for bringing mHealth to scale, but so is ensuring that patients and the integrity of mHealth projects are not compromised, whilst the general public's perception of trust should be increased[31].

The focus group discussion highlighted sustainability and scalability as main challenges to the strategic deployment of mHealth applications. This could be because of the huge gap between the applications being developed by innovators and what the governments consider as priorities. As a growing field, mHealth would greatly benefit from Governments' implementation of policy environments that foster technology use and encourage national and international investment in IT infrastructure development and skills training of the workforce[32]. Government action would also be important in extending the benefits of technology to all social groups[33]. This will pave the way for overcoming the important challenges currently impeding the acceptability and adoption of mHealth in Uganda.

CONCLUSION

Although mHealth has great potential to impact healthcare outcomes and to be scaled out in low and middle income countries in Africa, including Uganda, owing to the large access and use of smartphones, its use, applications and potential is still largely unknown. Many healthcare providers lack experience of using mHealth, telemedicine or digital health and therefore

acknowledged the great potential but could not give specific examples for applications.

Authors' contributions

RTS, JR, JMC and PM conceptualised the need to undertake the study. MT, SEM, TM, MM, ECK and DM gathered the data. RTS, SEM, MT and TM analysed it. MT wrote the first draft of the article; RTS, BM and JR revised it, providing substantial intellectual input. All authors read thoroughly and approved the article for final submission.

Declaration of conflicting interests

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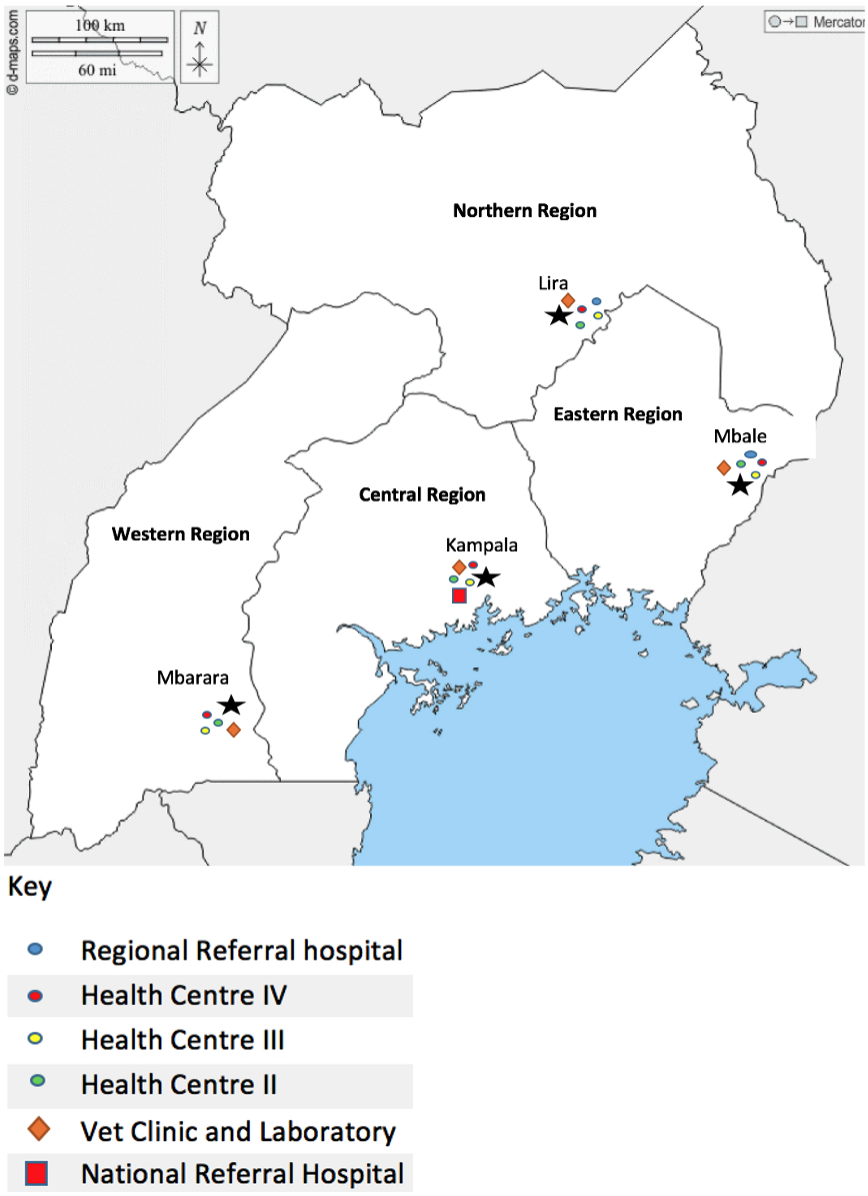

Figure 1: Map showing different Hospitals, Health centres, veterinary clinics and Veterinary laboratories visited in Northern Region(21 participants), Eastern Region (22 participants) Kampala Metropolitan region (18 participants), Central Region (21 participants)and western Region (5 Participants) in the study

156x211mm (144 x 144 DPI)

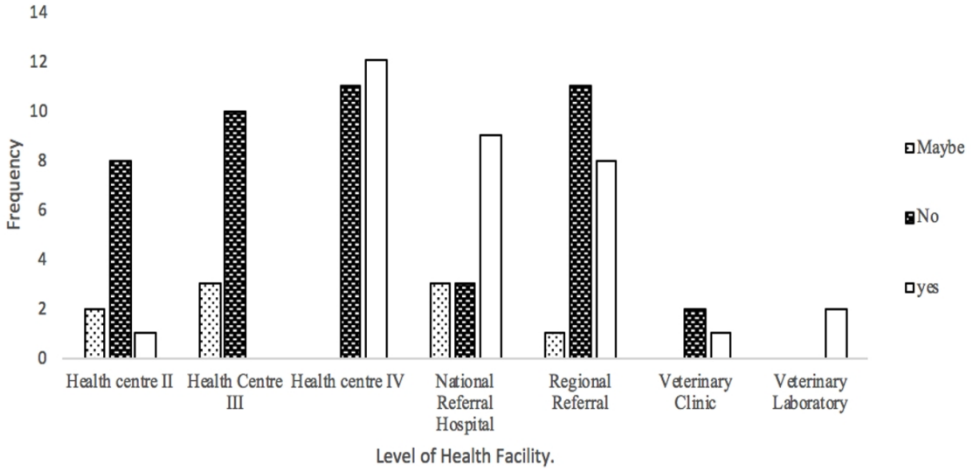

Figure 2: Frequency of mHealth Usage in Health Facilities levels

246x130mm (144 x 144 DPI)

		Frequency (%)
Level of Health Facility	***Health Centre II***	11 (13)
	Health Centre III	13 (15)
	Health Centre IV	23 (26)
	National Referral	15 (17)
	Regional Referral	20 (23)
	Veterinary Clinic	3 (3)
	Veterinary Lab	2 (2)
Education level	***O-level Certificate***	6 (7)
	Advanced Diploma	2 (2)
	Certificate	6 (7)
	Diploma	38 (44)
	Degree	23 (26)
	Masters	11 (13)
	PhD	1 (1)
Age group	***18-24***	2 (2)
	25-34	35 (40)
	35-44	27 (31)
	45-54	23 (26)
Gender	***Female***	47 (54)
	Male	40 (46)
Role	***Administrator***	3 (3)
	Biomedical Engineer	8 (9)
	Clinical Officer	6 (7)
	Data officer	3 (3)
	Doctor	4 (5)
	ICT personnel	10 (11)
	Lab Technician	12 (14)
	Nurse	27 (31)
	Pharmacist	4 (5)
	Radiologist	3 (3)
	Veterinary doctor	7 (8)
	Senior Management	31 (36)
Management Level	***Middle Management***	43 (49)
	Junior Management	13 (15)
M-health Usage	***Less than a year***	7 (8)
	1 to 2 years	33 (38)
	3 to 4 years	8 (9)
	5 years and above	7 (8)
	N/A	32 (37)

	Smart Phone access		Smart Phone Model		Common applications used for texting		
	No	*Yes*	*Do not know*	*I know*	*Messenger*	*Text messages*	*WhatsApp*
Level of HF	**F (%)**	**F (%)**	**F (%)**	**F (%)**	**F (%)**	**F (%)**	**F (%)**
Health Centre II	1 (9)	10 (91)	5 (39)	6 (46)	0 (0)	7 (64)	4 (36)
Health Centre III	0 (0)	13 (100)	4 (31)	9 (69)	1 (8)	6 (46)	6 (46)
Health Centre IV	1 (4)	22 (96)	23 (72)	9 (28)	0 (0)	13 (57)	10 (44)
National Referral	0 (0)	15 (100)	2 (13)	13 (87)	1 (7)	0 (0)	14 (93)
Regional Referral	0 (0)	20 (100)	8 (40)	12 (60)	0 (0)	7 (35)	13 (65)
Veterinary Clinic	0 (0)	3 (100)	2 (67)	1 (33)	0 (0)	0 (0)	100 (100)
Veterinary Lab	0 (0)	2 (100)	0 (0)	2 (100)	0 (0)	0 (0)	100 (100)