M-Health application for malaria health care workers

By

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Declaration

I declare that this thesis is my original work and has not been previously published or submitted elsewhere for an award of a degree. I also declare that this work contains no material written or published by other people except where due reference is made and author duly acknowledged.

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SUPERVISOR APPROVAL

I do hereby confirm that I have examined the master's dissertation of

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And have certified that all revisions that the dissertation panel and examiners recommended have been adequately addressed.
Sign:…… Date: 22ND September 2013

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Dissertation Supervisor

Acronyms and abbreviations

Acronym	Definition
API/SDK	Application Platform Interface/Software Development Kit
BGM	Blood Glucose Meter
CDMA	Code Division Multiple Access
CRM	Customer Relationship Management
CRM	Cardiac Rhythm Management
CRO	Contract Research Organization
DNR	Do Not Resuscitate
DSL	Digital Subscriber Line
EMR	Electronic Medical Record
FDA	Food and Drug Administration
GDP	Gross Domestic Product
GPS	Global Positioning System
M2M	Machine to machine
mHA	Mobile Health Alliance
MIP	Mobile Information Platform
PHR	Personal Health Record
PRO	Patient Reported Outcome
SMS	Short Message Service
TBI	Traumatic Brain Injury

ABSTRACT

Mobile and wireless technologies have been on the rapid increase and their applications in social sectors of life have also been growing. In the health care management, these wireless and mobile technologies have provided the possibility to prevent disease, improve treatment, advance health research, enhance diagnosis of diseases, reduce disparities, and increase patients access to the much needed health services and lower cost of health care service provision in ways previously unimaginable.

Continuous biological, real-time, behavioural, and environmental data collected by wireless and mobile technologies may tremendously be used to advance our understanding of the health issues and disease, especially when combined with data from areas such as electronic medical records and genomics

The need for rigorous research that examines the prospective and challenges of harnessing mobile technologies to improve efficient malaria management and treatment is critical. Mobile and wireless technologies are developing at an exponential pace; however, the integration, usage and translation of these cutting/leading-edge technologies into meticulously evaluated health research and health care tools have lagged behind as they have not been effectively converted into tools than can lead to the betterment of health care services.

Advancement in information and communication technology in the past years has revolutionised the way medical services are offered around the world. In general, mHealth applications leverage mobile phone features such as text or voice messages and video which can be educational or motivational for the patient. Chronic diseases and conditions are benefiting from near real-time monitoring of heart bit rate, blood pressure and changes in cholesterol levels etc. End users of mHealth applications are very diverse include caregivers, patients, healthcare providers, and families, which create a seamless mobile ecosystem to enable a more functional and productive lifestyle.

This research basically explores how mobile and wireless technologies can be used to help in the efficient management and treatment of the malaria menace in Kenya through real time

collection and transmission of accurate data and also live interaction between health care workers and patients in remote rural areas

The research methodology adopted by researcher is qualitative in nature .The study uses focus group research approach where two focus groups of six malaria health care workers each were selected in a purposively manner to participate in the research focus group interviews

The research sought to illustrate the usage of the existing malaria M-Health applications followed by definition of the technical requirements of malaria M-Health applications, and to design, develop and test a malaria M-Health application that will help health care workers collect manage and transmit the required medical data

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I owe a lot of gratitude to Dr Patrick Kanyi who supervised me in this project. His constructive and analytic criticisms, corrections and encouragement; which led to success of this piece work.

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CHAPTER 1: INTRODUCTION

1.1 Background of Study

Quality health care practices require complete, accurate and timely data, and the existing traditional paper-based data collection and reporting methods do not perform this role adequately. The availability and prevalence of wireless communications technologies offers prospects and opportunities to facilitate direct data exchange between health workers in remote areas and their supervisors in urban areas

The ways through which people have been communicating with each other have also changed significantly over the years. Social networks, Mobile telephony, E-mails and videoconferencing have offered new ways for sharing perspectives in the medical field. Digital, Mobile and wireless communication technologies have made it possible for images and the voices of both patients and doctors to be more accessible through Television, radios, video, and also through the Internet, which have helped people to share their knowledge, opinions, experiences etc. This in turn has led to the resolve to regulate the many of the available ICTs and broadcasting systems found in many countries, which in turn has opened up spaces and platforms, such as the deployment of digital TV broadcasts, 3G and 4G network etc among others, which has increased communication exchange of visual images and the voices communications

Mobile health or simply M-Health has capitalized on the successes of growth and rapid expansion of mobile and wireless technology industry to deliver health information and care in an efficient and personalized manner. In the developing country context, M-Health is synonymous with using mobile telephony technologies to access and care for vulnerable communities and individuals.

There are a several challenges that developing nations' face in their endeavour to offer health care services. Most hospitals are burdened with patients suffering from various diseases such as Malaria, HIV and Tuberculosis WHO report (2008). All this against a backdrop of very few healthcare professionals especially within the rural areas as a result of rural urban migration WHO report (2006) and also very limited resources

Mobile devices have made their way into a wide number of professions. The medical field is one of those professions that are reeling the benefits of this transition. Medical practitioners can benefit in using of mobile textbooks, diagrams, and applications. Some of these applications allow doctors to carry out their core duties effectively and efficiently

1.2 Problems with current M-Health Applications

Wireless technologies application in healthcare industry is continuing to drive high degree of innovation, supplanting and helping to replace convectional and established ways for the provision and delivery of healthcare services. The fundamental trends that have be seen are real-time and online access to clinical systems mainly through online portals, outreach and extension of clinical operations, wireless-point-of-care which are both workflows and some times clinical processes, wireless medical imaging, the medical home and (chronic) disease and wellness management.

Security of M-Health applications and their subsequent interoperability are some of the primary needs to developing extended healthcare enterprise infrastructures. Application and mobile device security is of great importance within the healthcare enterprise networks where highly sensitive information (e.g., clinical information) is sent over cables and wireless links.

Quality of Service (QoS) -The M-Health applications is basically supposed to be used by users anytime, anywhere and under dissimilar conditions. At the same time, they need to be fulfilling the Quality of Service (QoS) needs. Some of this needs include long device battery life-time, low application delay and seamless user mobility support along with little financial cost of networks usage. In the view of the fact that mobile applications function on a hybrid of different networking infrastructure, which comprises of wireless and wired data communication networks owned by different entities, the quality of service offered by this infrastructure a critical factor that influences the application quality provided to the user.

User Mobility: The usage and deployment of mobile devices prevents the need to install new infrastructures hence makes a totally new style of networks. Flexible and easy mobility of the systems facilitates monitoring of patient outside of a hospital, thus leading to the actions of the sick people not being limited only to the hospital. When the sick person perambulates around, the wearable system and devices equipped with them monitor their status, sending medical information to a healthcare information processing centre. The mobile applications also help the patients to get instructions from the health care centers or medical practitioners

assigned to them. Based on the mobility offered by wearable devices, an M-Healthcare user can be served by constant patient monitoring anywhere and anytime.

Data Transmission: Unlike ordinary health care management systems, where most patients are only allowed to access medical care services or monitoring in specific places at a specific time, mobile and wireless technologies offer continuous monitoring of patients. In this case, communications greatly relies on wireless communication channels instead of usual cables.

Flexibility of Medical Service: This is a benefit enjoyed by both the patients and healthcare providers as these systems introduce some form of pervasive communications and mobile devices. Mobile healthcare applications and services also allows medical practitioners to access the patient's health records at any place and at any time; this in essence means that they can more flexibly diagnose and monitor the patient's health status, and issue prescriptions accordingly.

Remote Medical Control: This is one of the essential requirements of M-Health applications as it helps to facilitate real-time data transmission, monitoring and remote medical control. Medical practitioners can effectively carry out remote surgery, diagnosis and other operations on a patient even when they are in far and remote places.

1.3 Problem Statement

Effective treatment and management of malaria in Kenya like elsewhere in Africa has for many years been negatively held back by poor resource allocation and use ,lack of complete and timely data and relevant information on disease incidence and. The aftermath of this has been that, the planning and implementation of many interventions to manage malaria effectively have severely hindered as evidenced by the increased number of malaria deaths especially among the infants (**Ministry of Health-Kenya malaria report, 2012**)

Several interventions have been deployed in trying to collect the much needed information for example after data has been recorded in clinical books, it is later typed and stored in Ms excel for analysis and transmission, this has not achieved much because the availability and accessibility of data to help in the efficient management of health related programs, whether on medicine stock levels, disease and illness incidence, or the number of patients already attended to, has remained insufficient and in most cases of meager quality.

The available data collection methods have tended to depend so much on paper-based systems, which in most cases are laborious; often the medical reports are often sent when they are late mainly because of monetary transfer costs involved in the transactions. This happens even as they may be incomplete, and require transcription for electronic data entry and analysis once at county or national level. There have been worldwide pressures on health care systems particularly with the ageing populations, rising expectations, declining health care workforce etc. There is a prevailing and dominant agreement that for using wireless telecommunications technologies can help medical practitioners remotely diagnose, monitor, manage patients, and make people to engage in their own wellness and health

1.4 Purpose of research

The main aim of this research is to develop an M-Health application for malaria health care workers that will help with data collection, transmission and storage

1.4.1 Specific objectives

Identify the usage of existing malaria M-Health applications

a. Define the technical requirements of a good malaria M-Health application
b. Design the malaria M-Health application for data collection, transmission and storage
c. Develop and test the application

d. Test the application
e. Validate the application

1.5 Scope of research

The researcher is not developing an application for the other players in the health care industry like patients, health care providers or payers; neither does the researcher seek to propose M-Health application for other health care problems. Its scope is only limited to the health care workers involved in the management and treatment of malaria

There exists a deliberate need to rigorously research and examine the potential, as well as the challenges, of using and harnessing mobile and wireless technologies to improve efficient malaria management and treatment is critical. M-Health applications leverage mobile phone features such as text or voice messages and video which can be educational or motivational for the malaria patients if well used by the community health care workers. Malaria menace and conditions can benefit from near real-time monitoring of heart rate, blood pressure, temperatures, and changes in cholesterol levels.

This research therefore explores the how mobile phone technologies can be used to aid in the efficient management and treatment of the malaria menace in Kenya through real time collection and transmission of accurate data and also live interaction between health care workers and patients in remote rural areas

1.6 Significance of the study

The mobile network usage and infrastructure penetration has been growing tremendously and **w**ith approximately 80% of the world's population using mobile phones **(ITU, 2012)** plus remarkable fall and reduction in costs of mobile phones, wireless and mobile technologies have emerged as better and good tools that can be used to make a major contribution in the health care industry.

Utilization of mobile telephony technologies will lead to significant reductions in management burden especially on the part of health care workers dealing with malaria and the overall improvements in patient care will be achieved through effective and efficient strengthening accurate data collection, management and transmission.

One of the significant reasons for this study is to reduce the amount time spent by malaria health workers on non-clinical tasks through the computation of reporting processes, and improve the quality of health information data collection and aggregation by malaria health workers with the use of mobile telephones for data capture

The research is therefore significant to the following group of individuals

- **Government-**The government specifically benefits because the cost of malaria management has the potential to be significantly reduced through automated data collection and management and transmission-hence easily available
- **Health care workers-**Their work will be made easier by the availability of the necessary M-Health applications and infrastructure described in the research
- **Patients-**With accurate data collected and easily transmitted, then they stand to benefit from improved service delivery

1.7 Problem justification

Treating and management of malaria related cases are hard, tiresome and hectic work for health workers especially in this part of the world where the resources are very limited**.** Communications has emerged as one of the most essential function in the delivery of effective health care services. Information has to be shared among the various stakeholders; ideas need to be distributed; and health care workers and their respective clients always want encouraging messages. Within this context, M-Health appears a viable solution, to help in serving the serious healthcare increasing needs and demands through its low cost and high reach solutions. M-Health has emerged as a catalyst of change in the healthcare industry by ensuring that the relevant and correct information gets to the right people and at the right time

Malaria control and management effectively depends on timely acquisition of information on new and fresh cases, their frequency and their location so as to plan on how to intervene, work out on how deployment of supplies will be carried out, or focus attention on precise locations appropriately to intervene and prevent an upsurge in transmission. The health care system has long been hampered by problems such as diagnoses being scribbled illegibly on paper, doctors not being in a position to easily access patient information, and limitations on space, time and personnel for monitoring patients **(Tesfa Tegegne1 and Theo Van Der Weide, 2008**).

Some of the reported repercussions connected with the inherent delays associated with paper-based reporting reports have been documented as follows**(Curioso, Walter H. and Ann E. Kurth, 2007**);

- frequent stock-outs of health commodities that normally deprives the target populations of access to efficient health care services ,
- De-motivated and demoralized health care staff personnel
- Dented credibility of health care programs.
- Delays in provision of medical diagnosis reports

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter provides information from literary sources and researchers who have previously written on the usage of mobile and wireless technologies in the provision of health care. The researcher will use the information obtained on this chapter to form basis and get insights into developing the research framework

2.2 State of the art: Mobile technologies applications in healthcare

There is growing body of literature including various documented studies and initiatives that are exploring the widening scope and range of M-Health in developing countries. The result of this initiatives points to a considerable and clear indication of a rapidly increasing field. The literature review identified and acknowledged some notable gaps in M-Health knowledge originating from the inadequate scale and scope of M-Health implementation and evaluation, plus a policy framework environment which does not connect health goals and related metrics to existing M-Health tools and systems, and modest investment in cost-benefit studies to assess M-Health value and health outcomes research to assess success factors and weed out poor investments.

Electronic health (eHealth) is defined in this literature as the emergent convergence of a number of wide-reaching technologies like Internet, telephones, smart phones, PDAs and to help access health care management, education, healthcare providers, and wellness (DeLuca and Enmark, 2000). (Brommey, 2004) further defines it as the use of ICTs to provide and support health care wherever the participants are located**).** On the other hand, M-Health is defined as a subset of eHealth which uses mobile devices to deliver health services to the customers (Mechael, 2009).

M-Health is a novel paradigm of an up-and-coming IT artefact. As an extension of electronic healthcare (or eHealth), M-Health has innately provided superior flexibility and mobility in healthcare information services (Ahuwalia & Varshney, 2009). In its broadest nature, M-Health involves using mobile and wireless technologies to transmit and enable various data contents(audio, video) and services which are simply accessible by health workers through

the use mobile devices such as PDAs, laptops, mobile telephones, smart phones, and Tablet PCs (United Nations Foundation and Vodafone Foundation, 2009).

Though M-Health is defined as a subset of eHealth, it is widely identified as a separate healthcare paradigm. M-Health alone has all the potential to automate and expedite the healthcare delivery processes, reduce costs, engage with patients and offer them more convenience and appeal through this new service (Akter and Ray, 2010). Furthermore, M-Health is based on some unique attributes (e.g., ubiquity, instant convenience, connectivity, personalization and timeliness) which can be leveraged to empower patients and healthcare service delivery in any setting (Mechael, 2009).

Mobile, wireless communication technologies are apparatus and devices that may be used to sustain existing information movement within each of the areas specified above. There is much learning from eHealth which offers significant ways which be used when reviewing current technological applications and their ever changing trends. Mobile and wireless technologies are for instance not objects, but tools, that are supposed be used and applied in ways that will lead to the achievement of regional, local and national health objectives (Mechael, 2009).They will also contribute to the overall continual improvement of the lives of people. Secondly, there is inadequate impact data about how mobile and wireless technologies are impacting health outcomes, creating challenges to replicate and identify some of the best practices (Kaplan, 2007; Shields, Chetley, Davis, 2005).

The prospects of mobile and wireless communication technologies to turn around clinical intervention and the general healthcare industry in the local rural communities have been on a remarkable rise. A number of studies have looked into the how the usage of digital mobile and wireless communication technologies can be used to support public health interventions, help improve healthcare and, in collation and subsequent collection of data (SAPAL TACHAKRA et al, 2003)-

2.2.1 ChildCount+

ChildCount+ (http://mvpdev.github.io/rapidsms/intro.html) is one of the most commonly used M-Health systems that was designed purposely for everyday use by community health practitioners in carrying out their day to day activities. Specifically, it does the following:

1. Helps in collection of health related data from community health practitioners(by paper forms or by text message),
2. This message are then sent as alerts to health workers and health managers,
3. Produces brief printed routine reports for Community Health Workers and their managers.

2.2.1.1 How it works

ChildCount+' is basically used by rural community health practitioners to submit data to the ChildCount+ server by away of text message (SMS). Based on the handed in data, the server then periodically sends the relevant information and message alerts to the community health practitioners who are scattered in the different rural places.

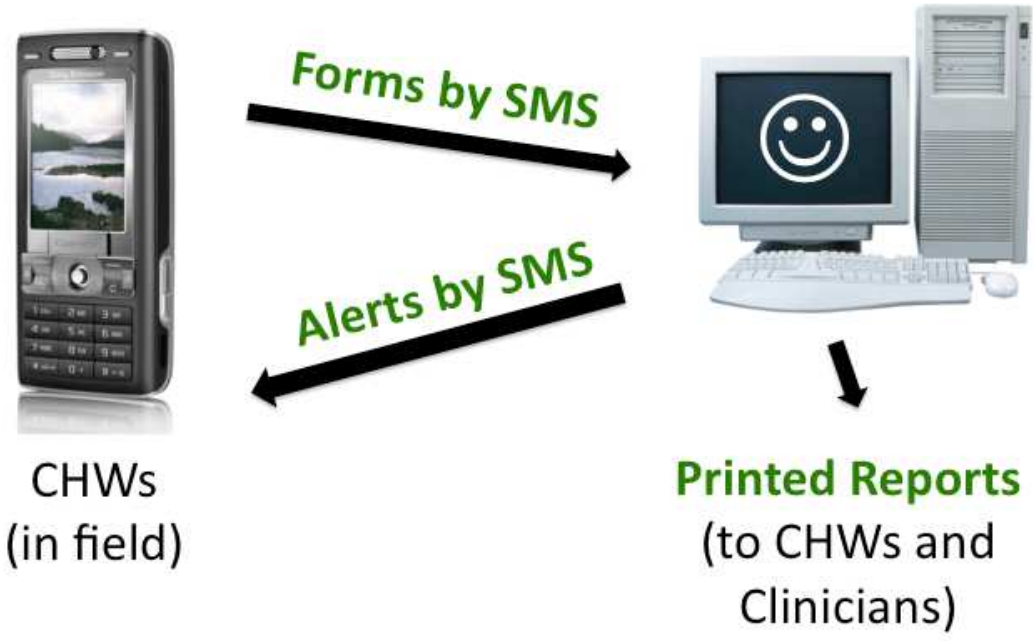


Fig 1: An illustration of the mobile -based ChildCount+ workflow.

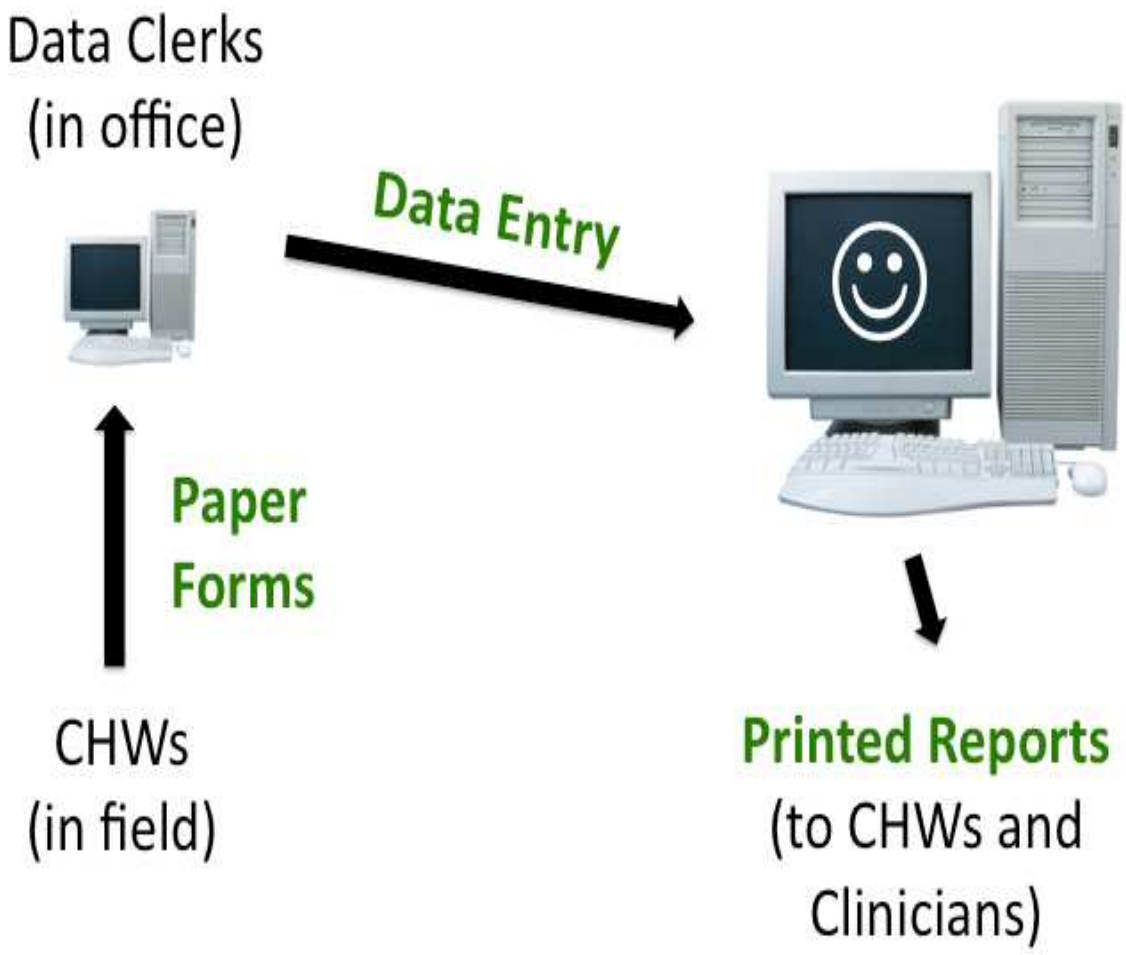


Fig 2. An illustration of the paper-based ChildCount+ workflow.

2.2.1.2 Uses of ChildCount+

ChildCount+ employs the use of SMS-based text messages to aid in the functional activities of community based health care workers. Using the normal or ordinary mobile telephones, medical practitioners are in a position to use SMS-based text messages to register and record patients and submit the subsequent health report status to a central web server located in some location that facilitates provision of real-time outlook of the health of a particular community. The messaging characteristics of the application help to make possible sharing of information between the members of the community medical health system and a computerized alert system that helps reduce known problems that inherently exists in managing of a number of diseases.

ChildCount+ specifically does the following 5 things is outlined below:

1. Registration of all children and pregnant mothers in an area – This through the creation of a database of all kids under the age of five and expectant women in a community. This list provides the foundation for community health teams and medical practitioners to monitor the health condition of their children and women who are to give birth.
2. Recording of the health related data of children who are of 6 months to about 5 years every 90 days. Children with severe malnutrition are provided with support via ChildCount + systems
3. Check TB, diarrhea, malaria, and pneumonia – examine and assist in treatment the some of the major avertable causes of mortality in children under 5 as named above. The system thus provides support for home-based dosage, oral rehydration salt usage, pneumonia testing, diagnosis and treatment
4. Full immunization of children support – The system has the capacity to group the children in terms of their monthly age groups to know their exact immunization dates.
5. Recording all births and deaths – Record the number of kids born and those who lost their lives and also when pregnancies don't come to term.

2.2.2 EpiSurveyor

EpiSurveyor is a mobile invention of DataDyne.org, a social enterprise that uses wireless and mobile communication technologies that include hand-held computers, mobile telephone, Internet, and GPS, to ensure sustainable and efficient flow of the much needed information in and to break down the barriers to collection, analysis, reporting, and utilization of data.

It is a mobile telephony based-application that is easy and simple, and an award winning mobile based solution for collating and data collecting in the field during rural-based surveys. This application is combined with the www.EpiSurveyor.org website to devise and deploy surveys. The forms are usually designed on www.EpiSurveyor.org and then downloaded to a mobile telephony. The whole of the data collected with the mobile application is normally backed up somewhere in a remote server, where it is later analyzed as required by the community health care practitioners.

Computing machines are only needed the moment the survey designer comes up with forms to be used in the survey of patients. The survey designer and the other people in field only need the basic computer skills to use application. The data collection process normally utilizes and uses a very user friendly interface that even beginners can enjoy using.

EpiSurveyor Mobile is available for many common mobile telephones, as well as Blackberries and Android

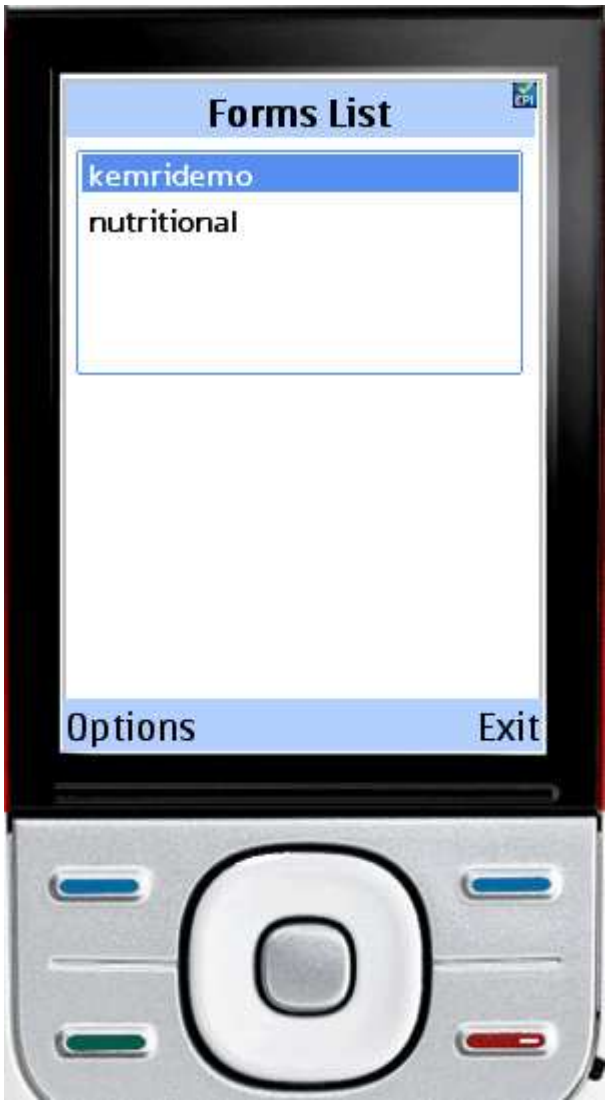


Fig 3. Example of EpiSurveyor Mobile on a Phone

2.3 State of the practice: current case studies of clinical Applications of M-Health

The advent of mobile telecommunication technologies over the years has come with a lot of its advantages For example it is now become very easy to send multimedia information in large amounts in a very faster way over long distance quickly. This is one of the things that have been realized by the health-care sector as more and more practitioners move towards Mobile telemedicine

2.3.1 NASA space program

One of the areas where there has been efficient usage of mobile telemedicine has to be in the space program, which has entirely relied on telecommunications to conduct regular medical operations. One of the telemedicine applications developed and deployed for clinical usage at NASA comprises of the patient, the medical practitioners, the hard ware used for data acquisition and handling, and telecommunications connection and the software. A device called, Telemedicine Instrumentation Pack usually just abbreviated as (TIP), was developed to help in collection of video, medical audio messages and data collected from patients who are in space.

There is a wide range of data capabilities which can collected by the application including blood oxygenation, blood and pressure and the heart bit rate, The application also has some medical video capabilities that can collect data including throat, eye, ear, general macro-imaging, nose, and skin

An electronic digital stethoscope allows for the collection of auscultation data. Data collected with this application (the TIP) is normally obtainable as the digital outputs well-matched with the communication applications of the space vehicle and then they are sent back on the earth surface where medical practitioners make use of them by utilising them for their practice.

2.3.2 Ambulance emergency services

There has been an emergency of Mobile Telemedicine System (MTS) established for many ambulance emergency services in a number of hospitals. A typical mobile telemedicine system comprises of two most important components: a mobile unit for installed in an ambulance and a receiver base station for hospital Intranet connection

The real-time data of patients mostly comprising of audio messages and visual images are taken from the activities from inside an ambulance and are later transmitted in real time to a trauma center in a central place-mostly in a hospital using wireless digital cellular communications technologies and intranet technology found within the hospitals. Inside the ambulance, patient vital data on disease symptoms and signs are obtained from the monitoring apparatus by the patient records computer.

The system which is used for transmitting both real-time and recorded patient data, that is, audio messages, and visual images of patients related clinical activities from inside an ambulance on their way to a centralized trauma center using wireless digital communications and intranet technologies installed inside hospitals.

The systems which are built inside the ambulance normally employs the usage of a video-based system and a patient monitor interface to obtain visual images without human intervention from a moveable camera placed at the top of the ambulance, just close to the patient's head. The captured data images are the compressed by the of GIF standard and sent over the available digital transmission spectrum, using up to four digital cellular wireless telephony lines to transmit data voice, and images. Developing countries currently have bandwidth which is limited at about 10 Kbps per telephony line, a factor which has led to limiting the usual cumulative transmission speed rates to about 25 Kbps. The wireless digital signals are transmitted to a centralized server installed and used at the John Hopkins University hospital. One's at the hospital, the signals are forwarded to the available computer machines of any enabled practitioners on the hospital Intranet, where they can be viewed in a browser of a computer that has internet.

The capturing of video images happens at 40 data frames in one particular second. However, in the view of the fact that wireless digital communication bandwidth is limited to about 25

Kbps, the obtained data images are sent over a communication line in a very slow fashion of approximately 2 image after every 3.5 seconds at a resolution of (325 bits 3 340 lines 3 24-bit depth) (Ahuwalia & Varshney, 2009). This kind of technology has allowed on-the-fly tradeoffs between motion handling and a special press button that allows the emergency people stationed within the emergency ambulance to capture patient data images messages or video clips at 6 fps, which are normally sent in a store-and forward manner.
The system combines previously existing, used and tested business technologies and the use of open-system standards (Ahuwalia & Varshney, 2009).

2.3.3 Biotronik Home Monitoring System

Germany invented and deployed a new mobile device, simply referred to as the Biotronik Home Monitoring System, is being used by doctors to allow them keep a follow up of patients' heart condition between office visits (Shields, Chetley, Davis, 2005). The device has a transmitter that allows for sending of patient heart details to a mobile telephone-like device carried and used around by the patient (Shields, Chetley, Davis, 2005). The telephony in turn then facilitates the transmission the information to a centralized service center, where it is directly faxed to the patient's doctor. The mobile device has been programmed and set in such way that it can collect and obtain data as needed by the doctors; it can be, from once a day to once a month. The whole system can be deployed and used from any location and place that provides digital cell telephony service.

2.3.4 Mobile telemedicine in India

India put in place its pioneer mobile telemedicine system in the 2010. The fully integrated mobile application system is built in a multi-utility vehicle (Akter and Ray, 2010).
This mobile unit facilities for direct online sending of patient related data like microscopic images, X-rays, and other very important parameters of patients details to other places where it can be put to use. Communication among various stake holders is normally than by employing a variety of options, including mobile telephone, ordinary telephone lines, and wireless digital local looper V-Sat (Akter and Ray, 2010).. The mobile unit is also used when conducting and performing direct and synchronized videoconferencing between four different locations.

2.4 Technological advancement in M-Health

The speedy technological advancement in M-Health continues to generate both opportunities and challenges that include for instance how to create and evaluate scalable systems capable of collecting unprecedented amounts of data and conducting interventions—some in real time—while at thse same time providing value and protecting the safety of participants. Emerging issues and trends of interest within M-Health comprise using mobile technologies in a number of situations and capacities as indicated below (Mechael, 2009).

2.4.1 Treatment compliance

Treatment compliance is basically the sending of reminder data messages by SMS or voice, to patients with the sole intend of achieving preventable disease eradiation, medical treatment compliance, and overcoming challenges such as drug resistance (Fuscaldo, 2004).. In most cases, it has also been used to support and maintain patients suffering from conditions like HIV/AIDS, TB, diabetes,

2.4.2 Appointment reminders

Appointment reminders are also a popular M-Health application where voices or mobile phone messages (SMS) are sent to the relevant patients to help in scheduling their appointment or attend an earlier scheduled appointment. In third world countries, access to basic telecommunications technologies is minimal and quite erratic. In some developing countries, however, fixed line telephone systems are being replaced with digital mobile phones, the mobile telephony is quickly becoming the principal means of receiving appointment reminders(SatelLife, 2005)..

2.4.3 Raising awareness

Raising public awareness among various health industries stakeholders comprises using health information products like quiz programmes or games to enlighten rural folks on the emerging and contemporary health topics (Kaplan, 2006). These initiatives are often available to be downloaded onto the mobile phones that have access to internet

2.4.4 Mobile telemedicine

Mobile telemedicine's definition is given as the transmission, consultation or communication between health practitioners with and regarding patients employing the usage of text, imaging, voice, data, and mobile video functions of a mobile phone device

Mobile telemedicine can also be applied to some other different situations; for example in the management and treatment of chronic diseases of affected patients who just live at home. In developing third world countries, as well as underserved rural and other urban areas of developed countries, medical practitioner's shortage in the health care service sector continues to pose major and serious hurdles to a patient's continued access to the effective treatment and/or specialized care. Mobile and wireless technologies offer a chance to circumvent and avoid this challenge by connecting and linking community health workers, patients and physicians in rural and urban areas to improve the overall quality of health care at the point of care and eliminate unnecessary referrals.

2.4.5 Public health emergencies

Public health care emergency systems response in this particular context of M-Health can simply defined as the use of mobile phone and wireless devices to react and respond to and administer emergency and disaster situations such as disease outbreaks, conflict and natural disasters

2.4.6 Health surveys and surveillance

Health surveys, insofar as M-Health is concerned, are basically referred to as the use of mobile phone devices for medical-related data collection and reporting (Mechael, 2009). In the same vain, surveillance is referred to as the use of mobile phone devices for inputting and transmitting data that will help in tracking diseases for existing surveillance programmes.

2.4.7 Patient monitoring

As far as M-Health is concerned, patient monitoring can be defined as using wireless communication technologies in management, monitoring, and treatment of patient's ill conditions from far (e.g. cardiac patients and diabetes) (Curioso, 2006). Remote sensors are normally installed in people's home or within the imaging devices connected and linked to mobile telephones. These are often used to facilitate with online data transmission to the health care providers. This can be greatly used to reduce the need for visits to a health centre for periodic check-ups.

2.4.8 Patient records

The existing usage of mobile phones to aid in the treatment and management of patients (that includes collating, collecting and displaying patient records) has become more common in developed countries as a result of the adoption of M-Health applications(Lacal, 2003).. This

side of M-Health facilitates timely access to electronic medical records (EMRs) at point-of-treatment through mobile technologies which help medical practitioners to effectively carry out their mandate

2.5 Existing technologies & Technological Capabilities of M-Health

Over the past ten years, mobile communication technologies have entered the mainstream in high, middle, and low income countries in unprecedented and unanticipated ways. News articles ,case studies, peer-reviewed journal articles, and reports are now beginning to provide insight into the health-related benefits that are being derived ((Curioso, 2006); (Istepanian, 2004), (Istepanian, Lacal, 2003), (Kaplan, 2006), (Mechael, 2009)
What remains lacking, however, is a systematic evaluation of such technologies and their effect on the overall delivery of healthcare (Fontelo, 2007).

As such, key mobile and wireless digital technologies being reviewed in this thesis include:

a. Digital Mobile telephones
b. Smart phones and Personal Digital Assistants
c. Digital Patient monitoring systems
d. Mobile Software and Hardware Development

2.5.1 Uses of Digital Mobile Telephones

According to a Vodafone Policy Paper, mobile telephony and health studies have been largely based and focused on the existing potential advantages and benefits of the technology within the healthcare sector and their usage in the world developing countries, rather than developing countries (Vital Wave Consulting, 2009). Many of the conducted and documented studies focus on the voice and text functions as contributing to improved accessibility and the overall efficiency within health care as well as the means by which many people can access confidential and private health-related information (Vital Wave Consulting, 2009). As observed in other reviews, most of the existing applications are still being piloted and are thus yet to be fully put into practice

An empirical study and analysis of medical-related usage of mobile telephones in Egypt, a low middle income country, explored how the general public along with the health sector was benefiting from mobile telephones in 2002-2003 (Mechael, 2009). The findings of the study

included that with no external stimulus; mobile telephones are improving efficient accessibility and coordination of emergency and normal general routine health services as well as contributing to overall family well-being (Mechael, 2009).

2.5.2 Smart phones and Personal Digital Assistants

A study of the degree to which PDA-based clinical reference information such as formularies, clinical databases and algorithmic diagnosis decision support software can assist clinicians at the point-of-care in remote parts of low and middle income countries is in preparation. Comparing cost effectiveness over the long-term and actual use to influence decision making in comparison to traditional print resources is planned in Kenya. Apart from qualitative impressions, it is difficult to ascertain how the use of PDAs is contributing to improved health outcomes more specifically in low and middle income county settings where patient follow-up is difficult (SatelLife, 2005).

Smart phones are also being used to provide bedside support (point-of contact) for clinicians in many high income countries, through access to web-based information resources and patient data. One study conducted at Prince George Hospital in Maryland, USA showed that availability of reliable updated information from reliable web-based sources through smart telephones improved evidence-based practice particularly for community hospitals and ambulatory clinics without wireless networks (Leon, Fontelo, Green, Ackerman, and Lui, 2007).

2.5.3 Digital Patient monitoring systems

Mobile telemedicine devices and applications have mostly been deployed and used in countries with very high GDPs. These applications and systems have been produced and developed as standalone technologies that use both guided and unguided transmission communication telecommunications systems infrastructure to transmit/send patient information or are integrated as an add-on to mobile telephones. It is perceived and noted that sensor-based telemedicine applications and devices will produce major cost savings for the healthcare sector by causing a drop in the number of patients visiting healthcare facilities and thus help to enhance detection of causes for action. In circumstances, the “patient will definitely become the primary focus of care, not the medical practitioners or the hospital” (Fuscaldo, 2004). There exists some medical devices that allow and facilitate monitoring/diagnosis of blood pressure (hypertension), self-measurement and lung function through a spirometer (respiratory disease) and controlled treatment through an inhaler,

exercise and fitness, among others. Self monitoring for patients offers security, higher autonomy and control over their own health (Lacal, 2003).

2.5.4 Mobile Software and Hardware Development

While eHealth symbolizes the future of health, and especially health care, its future lies in divergent technologies and ubiquitous technology systems. Increasingly, mobile communication technologies can run a rapidly increasing range of software applications (Lacal, 2003). Mobile software development is booming, particularly in high and middle income countries where the Windows Mobile Platform and Open Source are enabling smart telephones (mobile telephones and PDA hybrids) to provide basic computer functions while in motion (Iluyemi, 2007). Software development is also on the rise in low income countries. A recent *New York Times* article illustrated the proliferation of mobile software development in Nairobi, citing both opportunities for digital innovation and challenges for local developers.

2.6 Critique of Literature

As shown throughout the literature, the current single-solution focus of M-Health needs to be replaced by using M-Health as an extension and integrator of underlying health information systems along the continuum of malaria health care.

End-to-end patient care systems and point-of-care support for health workers are needed whereby M-Health applications are interoperable and integrated with provider systems linking the most remote community health worker with the most appropriate sources of information when and where it is needed. Such systems will have the ability to generate individual level data at the household and facility level that when aggregated can serve as the basis for health information and disease surveillance systems as well as link into financial systems for claims and reimbursements.

The literature though very rich in expounding on the technologies used by medical practitioners and how they are used, it doesn't acknowledge the fact that health care workers should be aware of what applications they should be using in effectively carrying out their core duties of health care administration. The liberty to compute in motion together with the proliferation and expansion of medically-based mobile applications has turn out to be a great match for the majority of the medical practitioners. Accessibility of the to up-to-the-minute

new medical drug and treatment information has been another reason why doctors are pushing themselves to get online thus the application being developed by the researcher will be able to provide functionalities that will help health care workers to collect, manage and transmit data from anywhere at any time.

The analysis of the literature and the existing frameworks reveals that though they may be of help, they lack the specific ingredients that would make them to be fully and efficiently implemented in the developing world context. These are due to the following reasons:

- The analysis of how the implementation is to be done with each and every stakeholder in the healthcare industry is not clear
- The idea of medical practitioners being seriously trained in ICT is not discussed in the literature
- None of the frameworks can solely be relied upon to implement m-health solutions because they are incomplete.
- Some of the ICT technologies provided in these frameworks favours industrialised countries and may not favour the developing world.
- The policies mentioned need to be contextualised.
- The developing world needs to look into solutions that address issues within its context.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

This chapter provides a description of the methods and procedural activities that the researcher will use to collect data from the population on study. The chapter discusses the research design to be adopted, target population for the study, sample size and sampling procedure.

3.2 Research design

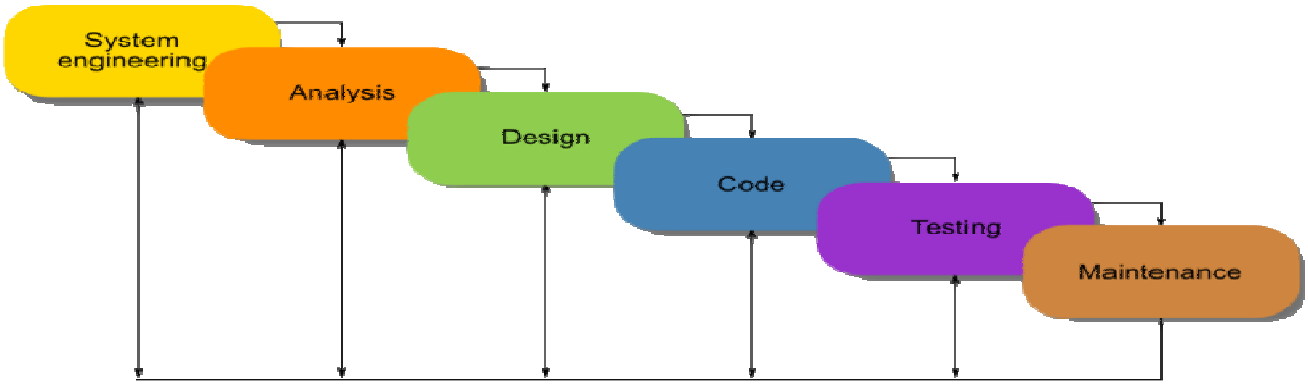
This research work employs the focus group. Essentially, focus group research is basically a method of collecting qualitative data, which entails engaging a small group of people in an informal like group discussion.' focused' around a particular and specific subject topic or set of issues for discussion.

The goal of a focus group is usually to gain and insight and understanding about a topic by hearing from people in depth. The main benefit of focus groups is that it heavily involves group interactions which normally reveals and highlights the participants' thinking, attitudes, perceptions and outline of understanding, including helping to identification of group cultural values, norms, sub-cultural

3.3 Current application development methods

Development methodologies used in system or software development; refers to the outline normally used to constitute, plan, manage and control the method of developing, deploying and implementing a working information system. A number of methods exists and continue to evolve and as they are put into practice for system application development, each one of them with its own specific strengths and weaknesses. A given methodology might not necessarily be suitable for development by other projects. Each of these methodologies is well suited to be used when dealing with particular types of system projects, based on a number of organizational, technical, project and team considerations.

3.3.1 Waterfall

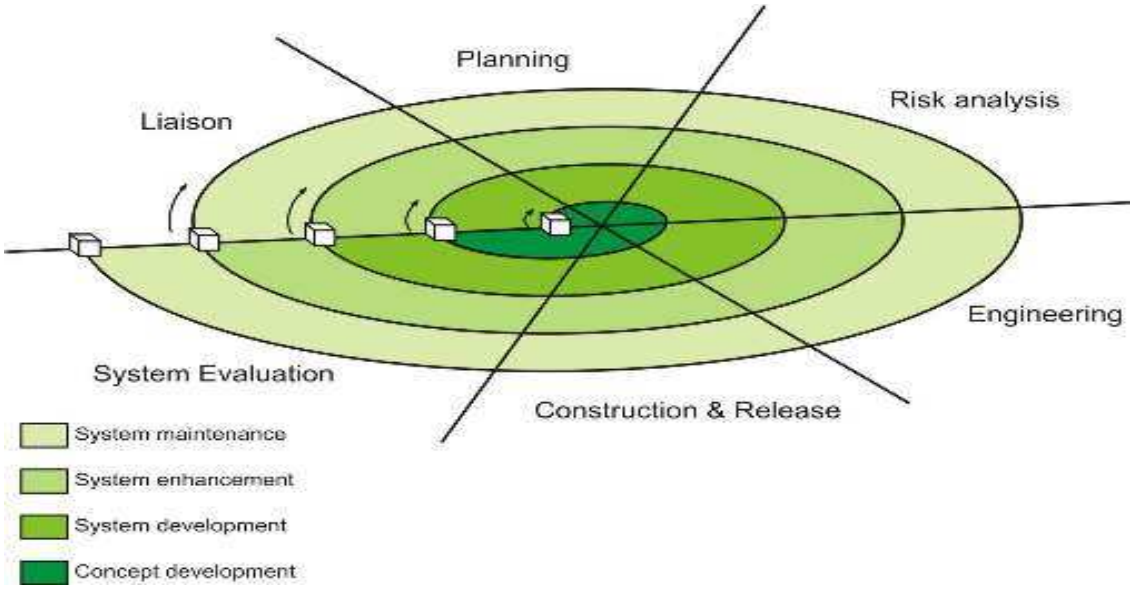


Source: Winston W. Royce

3.3.1.1 Major characteristic:

1. Development work is subdivided into phases/stages in a sequential way/manner
2. Places its emphasis more on budgets, time schedules that are tight, planning, target timelines and completion of a complete system at one's
3. There is firm control during the whole life cycle of the project

3.3.2 Prototyping

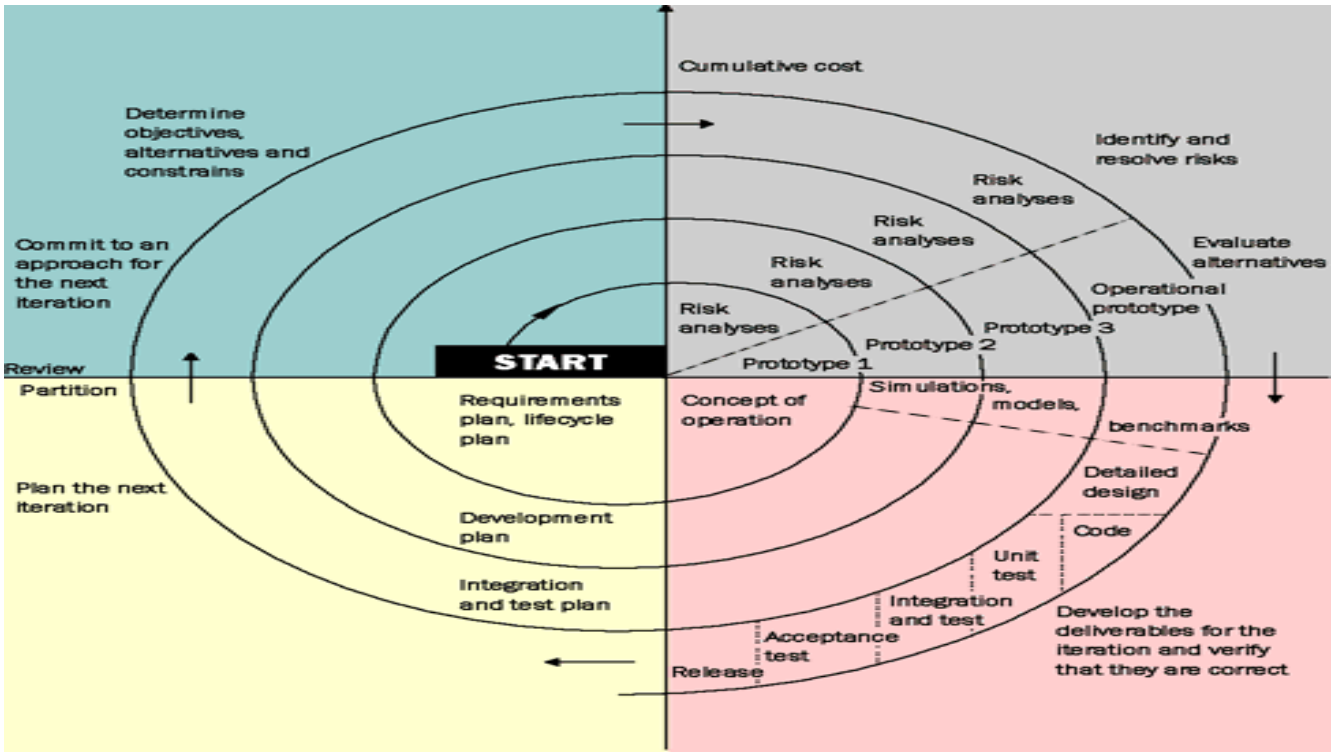


Source: Noor-E-Alam

3.3.2.1 Basic Principles:

1. Cannot be viewed as a separate, absolute system development methodology, because it just another approach to managing special parts of a larger system.
2. Tries to trim down inherent and obvious project risk by subdividing a project into smaller parts and providing more ease-of-change during the entire development process.
3. User participates throughout the whole process, thus increases chances and likelihood of end-user acceptance of the final deployment and implementation.
4. Prototypes of the system application are developed systematically following an iterative alteration of the whole process
5. Majority of the designed prototypes are designed, developed and implemented with the hope that they can be easily thrown away, sometimes it is a possibility that a prototype can evolve to a full functional system.
6. An understanding and appreciation of the fundamental and simple business problem is necessary to avoid solving the wrong problem.

3.3.3 Spiral



Source: Bernie Thompson

3.3.3.1 Basic Principles:

1. Focuses mainly on the areas risk assessment, mitigation and on minimizing project risk by breaking a project into smaller segments and providing more ease-of-change during the development process, as well as providing the opportunity to evaluate risks and weigh consideration of project continuation throughout the life cycle.
2. Each project cycle involves a sequence of progression through the same sequence of steps, for each portion of the product and for each of its levels of elaboration, from an overall concept-of-operation document down to the coding of each individual program (Boehm, 1986)
3. Each trip around the spiral traverses four basic quadrants: (1) determine objectives, alternatives, and constraints of the iteration; (2) evaluate alternatives; identify and resolve risks; (3) develop and verify deliverables from the iteration; and (4) plan the next iteration (Boehm, 1986 and 1988).
4. Each cycle begins with an identification of stakeholders and their win conditions, and end each cycle with review and commitment (Boehm, 2000).

3.3.4 Rapid Application Development (RAD)

3.3.4.1 Basic Principles:

1. Emphasizes speedy design and development, deployment and delivery of a high quality system at a somehow low down investment cost.
2. Helps to decrease project risks by breaking and subdividing a project into smaller parts and providing more ease-of-change during the entire development process.
3. Produces high and good quality systems rapidly, through the use of iterative Prototyping, vigorous user involvement, and automated development tools.
4. Emphasis mostly on gratifying business needs, at the same time engineering and technological brilliance is not of higher importance.
5. Project management entails setting up very clear development goals and objectives and later on defining delivery deadlines or “timeboxes”. If the project begins slipping, the emphasis shifts on reducing requirements to fit the timebox,

3.4 An evaluation of current system development methods

Applications being currently developed are having to content with a more and more complex and fast changing technological environment (Iluyemi, 2007). Such technological trends and advances such as android development, mobile computing is accelerating as time moves.

There also a number of changes occurring in the business environment due to the fact that we have to contain increasingly domestic and world wide competition and changing economies have continued to force application developers to deliver and deploy systems on very strict deadlines so as to exploit the very few business opportunities available in market.

3.4.1.1 The waterfall model- Situations where commonly used

1. This model is mostly used when developing and designing of a transaction-based batch system.
2. Also used in instances where there is absolutely no pressure for immediate implementation.
3. System project with functional requirements which are comprehensive and unambiguous in nature
4. Project requirements which will not change in the long run and are very stable during the system development duration

3.4.1.2 The waterfall model –Instances where it may not be appropriate:

1. Not suitable in gigantic projects that have their requirements not well understood or requirements cannot be changed because of any given reasons be it changes in budgetary allocations, external changes, changing user expectations.
2. Online based information systems- This is due to the load of implementing online based information systems project quickly; the repeated changing of the project requirements; the need for flexible and qualified project team members drawn from different areas; and the inability to make assumptions as regards the users' system knowledge level.
3. Real-time systems.
4. Event-driven systems.
5. Leading-edge applications.

3.4.1.3 Prototyping- Situations where commonly used:

1. In designing and development of online-based systems requiring wide-ranging user dialog, or for a less well-defined expert and decision support system.
2. Well used also in situations where the project is huge with several expected interrelationships, users, and functions, where project risks relating to system requirements definition needs to be reduced.
3. Team members are well experienced

3.4.1.4 Prototyping-Situations where least appropriate:

1. Does not work well with mainframe-based or transaction-oriented batch systems.
2. Internet-based e-business systems.
3. Projects where team membership is unstable.
4. In cases where future scalability of the design is crucial.
5. Project goals are very clear, obvious and under stable

3.4.1.5 Incremental- Situations where commonly used:

1. Very huge projects where project requirements are not well articulated or are changing due to budget changes, external changes, changing expectations, or where there is rapidly changing technology.
2. Internet-based Information Systems (WIS) and event-driven systems.
3. Leading-edge system applications.

3.4.1.6 Incremental-Situations where least appropriate:

1. Very small projects that don't take a very long duration.
2. Where system integration and the overall architectural risks are low.
3. Extremely interactive system applications where the data especially for the design of the project already exists

3.4.1.7 Spiral- Instances where it may not be appropriate:

1. System which are safety-critical or they are hard real-time systems
2. Risk avoidance and prevention have been given a high priority.
3. System requirement have already been documented strongly approved by project team

members

4. Project which are likely to benefit and get some assistance from a mix of other development methodologies.
5. System development projects which emphasizes high level of accuracy as an essential requirement.
6. The overall system deployment has a priority over the system functionality.

3.4.1.8 Situations where least appropriate:

1. Risk avoidance mechanisms are of low priority.
2. A high level of accuracy is not necessarily essential.
3. Functionality of the system has a higher priority over implementation.
4. Minimizing of project resource utilization is an absolute priority.

3.4.1.9 Rapid prototyping - Situations where commonly used:

1. Project size is of small-to-medium scale and of short duration (in most cases not more than 6 man-years of development effort).
2. Project scope is very much focused, such that the business goals and objectives are well defined.
3. Data for the whole of the project already available (either the whole of it or in part), and the project itself largely entails of analysing or reporting of the data.
4. Technical architectural design is well and clearly stipulated.
5. The major technical requirements and components are available and tested.

3.4.1.10 Rapid Prototyping-Situations where least appropriate: :

1. Doesn’t work well with large, infrastructure-based projects; especially large, distributed information systems such as ERPs.
2. Systems that are generally complex nature, where very complex and huge data must be designed, analyzed, and created within the overall scope of the project.
3. Project scope that is much broad and the systems business objectives seem obscure.
4. Systems in which the main functional requirements need to be fully documented and specified before any programming starts
5. A large number of people must be involved in the decision making on the project work, and the decision makers are unavailable on a timely basis or they are

geographically dispersed.

6. The project team involves many people or there are multiple teams whose work needs to be coordinated.

3.5 Proposed method(The waterfall model)

The Waterfall model is where software developed progressively in a linear way starting requirements elicitation, system design, system implementation/development, and finally system testing) . This model was introduced (but never given a name) by Winston Royce in year 1970 during the days when computer systems were still number-crunching entities, monolithic, with rudimentary front ends (if measured with the existing standards today)

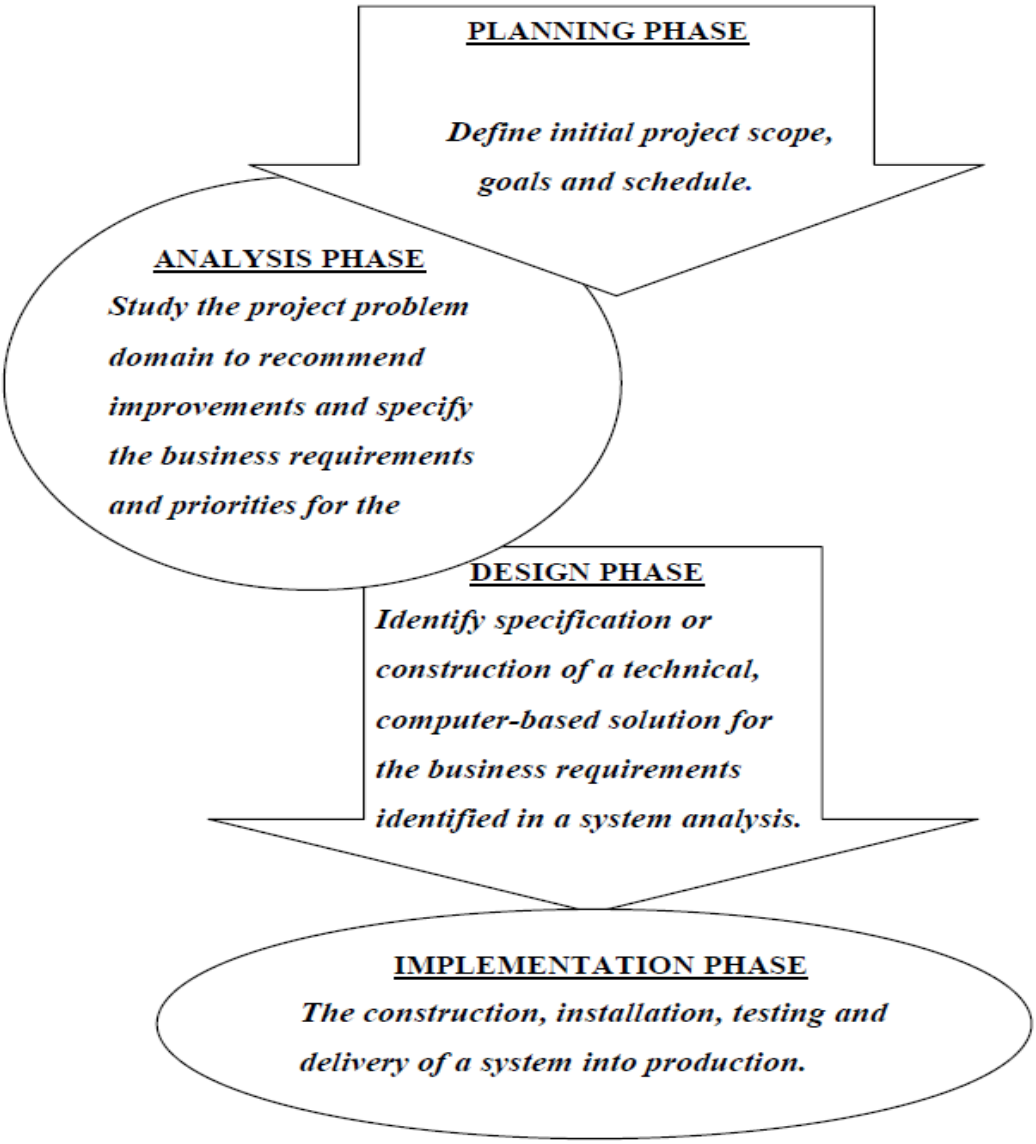


Table 3.1 Development phases activities & deliverables

Phase	Activities	Deliverables
Planning	Identify application objectives. Define the application scope.	Application objectives list. Scope statement.
Analysis	Study relevant literatures. Needs assessments. Analyze user requirements. Gathering requirements	Identify common features & functions, address possible limitations & constraints. Functional & non-functional requirements. Identifying the suitable gathering technique.
Design	Identify system requirements. Conceptual design. DB planning & design. DB construction. Program Design GUI design	System models & application data model. Conceptual model. Database design (class diagram). Logical /physical design. Architecture Design

Implementation	Application development. Application evaluation. Testing	System prototype. Advantages and deficiencies of developed application Testing plan

3.6 Characteristics of M-Health application

The application will have the following characteristics

Best user experience: Once installed, the mobile app gives users an optimal and high-quality user experience due to the full control of user interface, screens, phone functions, and timing of server connectivity. The user experience can be delivered consistently for multiple devices.

Highest security: A key issues with the health information, the application provides the highest levels of security and authenticity for mobile health users.

Native phone functions support: The application gives the user an opportunity to leverage the native components of the phone, such as location-based services, using the GPS, or capture-based features (e.g., remote deposit capture) using the phone's camera. This support allows for broader functionalities and more complex transactions.

Highest transaction speed: The application captures a lot of data, thus transactional information is exchanged between the mobile device and server-based components. This improves transaction speed and reduces mobile data costs for the health workers.

3.7 Focus groups

Focus groups were conducted between 8th July 2013 and 29th July 2013 with two populations of malaria health care workers .One group at Busia sub-district hospital in Busia County

using EPISURVEYOR APPLICATION and the other at Chwele sub-district hospital in Bungoma County that has been using CHILDCOUNT+ application since February 2012.

The main objectives of the focus groups was to interrogate the malaria health care workers who were using the two mobile applications on what their thought and perception was about the privacy and usability (how ease was it to use the applications) they had . Those who participated in the Focus groups were queried and interviewed by the focus group facilitator (this researcher) on the issues of efficiency, effectiveness, attractiveness of features of the two mobile applications and acceptability. During all this time, interview notes were noted on their behaviours, conduct and verbalization. The documented notes were later on analyzed by the researcher for significant incidents like (issues of usability identified) and difficulty in performing tasks. Systematic conclusions were arrived at from some erroneous assumptions and actions, and from user tasks that appeared to take longer than anticipated times. Participants were also encouraged to give suggestions on any changes, corrections, comments and on the interface design of the application. Each focus group discussion lasted for about 2hours.

The researcher developed a thematic research theme/topic that guided the whole focus group discussion interviews. The first query in each of the two focus groups was put as: “Is the current application serving you well”? This was followed by a discussion that was based on the following themes: efficiency and effectiveness of the applications; the ease of use; and the perceived privacy of the application. The focus group discussions interviews were all audio-tapped and recorded onto a camera and later transcription.

3.7.1 Participants

Social scientists have over the years differed on the most favourable number of respondents and people that ought to be included in a focus group research. By and large, acceptable numbers range from six to twelve individuals who need to be homogeneous to some variable (e.g., age range, gender, educational standards etc). Fewer people participating may not produce enough active conversation, while too many people involved in a group may make some respondents not to express themselves (**Krueger & Casey, 2000).**).

The study consisted of two focus group interviews between health care workers of the Busia sub-district hospital malaria department in Busia County and Chwele sub-district hospital in Bungoma County. The two focus groups were made based on the prior experience of handling malaria cases. The focus groups comprised of female and male healthcare workers. A typical focus group comprised of five to six participants in each group (a total of 11).

3.7.2 Characteristics of the Participants

AGE	GENDER		Speciality	TOTAL
21-25	MALE		Community worker	2
	FEMALE		Nurse	1
25-30	MALE		Community worker	1
	FEMALE		Clinical officers	1
31-35	MALE		Community worker	1
	FEMALE		Nurse	1
36-55	MALE		Community worker	2
	FEMALE		Nurse	2

3.7.3 Sampling Size and Procedure

Participants were purposely recruited by the researcher with the help of the Medical Officer In charge of the stations from a group of the health care workers in the malaria department. This approach was aimed at ensuring both homogeneity and heterogeneity in the group construction **(Morgan, 1997).** Thus, the focus groups were characterized by experience as the factor of homogeneity to ensure some degree of commonality among participants, but with sufficient variation in age and gender to allow for contrasting opinions

3.7.4 Data Collection

FOCUS GROUP1 QUESTION	MEMBER1	MEMBER2	MEMBER3	MEMBER4	MEMBER5
1. Overall, are you satisfied with how easy it is to learn and use the application?	Not satisfied because of missing features	A bit complicated	Satisfied	Registration of a patient takes time	Some functionalities missing
2. Can you effectively complete your work with this application?	Drugs cannot be registered	No-a number of medical information can't be collected by the tool	No	No	No
3. How do you rate the quality of data collected on the Android device?	Very little is collected	A lot of personal information missing	Quality is not good	Some data is not captured	A lot of data is left out
4. How fast can you collect data using the Android device?	Very slow	fast	Very fast	moderate	moderate

5. Would you want an improved system with more functionalities	Yes	Yes	Yes	Yes	Yes

3.7.5 Direction of the Focus Group

Most the respondents were not satisfied with the working of the ChildCount+ application especially as far as accomplishing their tasks was concerned. The ease of use, efficiency, effectiveness and thus generally usability of the system was put into question as majority of them felt that that the current application was not up to the task.

They therefore strongly recommended for either the improvement of the current application or the provision of the new application probably based on the Android application. This was because most of the said they had Samsung Android smart phones

3.8 Functional Requirements of the M-Health application:

After data gathering from focus groups the functional requirements were designed to be handled by the proposed application as summarized below.

Users Type	**Proposed application Functional Requirements**
Community Health worker	• Login to the application • Add new patient records to database. • Add new drug records to database. • Generate new reports. • Perform queries on disease incidence & prevalence,

3.9 Non-functional requirements of the proposed M-Health application

The advent of iphone and Android OS has enabled the creation of large markets for mobile applications and services throughout the last few years. A closer and keen look at successful Mobile applications reveals six major characteristics that they have in common.

Connectivity-The users of these applications are always online as the device is constantly logged in to the mobile network for internet accessibility. When combined with the ubiquity of mobile applications, it can turn out as one of the most significant quality of mobile telephones.

Convenience- A good mobile application should be able to do its job in different contexts and fast varying situations (whether in changing environmental light and noise or in an unsteady movement of the device, etc.). The designed information architecture and the overall usability of the application must therefore be done with care to create a appropriate and pleasurable interaction.

Localization-Localization of mobile applications and the opportunity to provide location-based information is a fundamental issue that has made mobility exciting and practical. It separates the wheat from the chaff by embedding the application to the expected users.

Reachability-Reachability is a more social attribute that is brought by the nature of mobile devices themselves. A good and vibrant mobile application should be used anywhere at any given moment in time. One of the major characteristic of mobile devices is the fact that they can be used anywhere at any time. The same can also be said about applications where the pertinent issue reachability has become availability, in the sense of usage, updating information and perpetual usefulness.

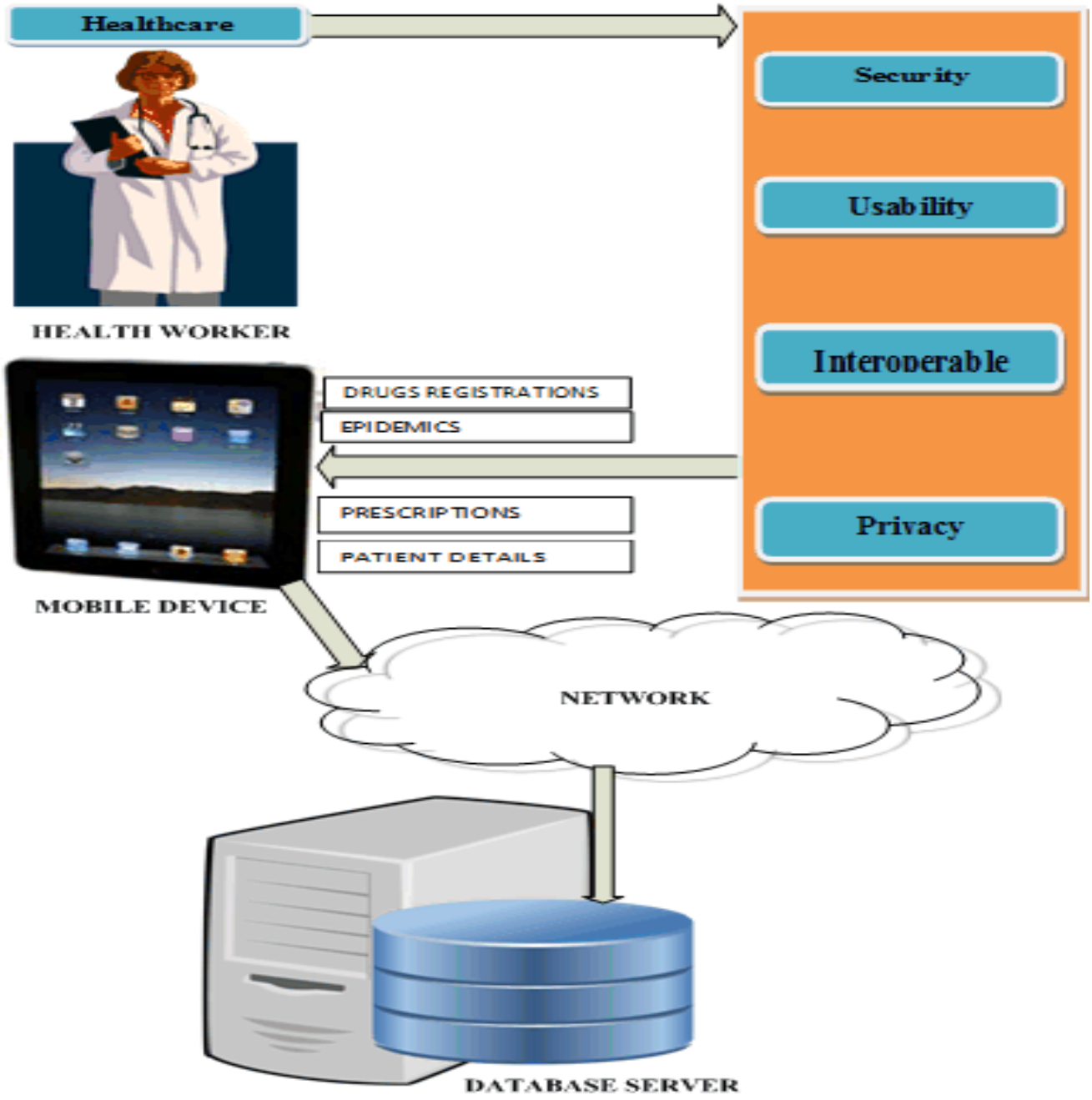
Security-Security manifests in itself in different ways. The data which is being transferred and sent over the network must be encrypted through the network. As applications sync information with web-based applications, the storage of this patient data on the main server must also be protected and secured especially against unauthorized access by unauthorized users

Personalization-Developing personalized content based on individual needs or context is another characteristic of mobile applications. Users want applications that can comfortably fit into their needs and also those that perform the way they want them to perform

3.10 Conceptual Design

The conceptual design is used to set forth strategies for utilizing mobile technology to improve malaria health care provision. The design unpacks the components for using M-Health, providing the rationale and conceptual components for using M-Health to improve health care services and provision especially in developing countries.

Fig 4: Conceptual model for an M-Health application for malaria health care workers



3.10.1 Conceptual model discussion

a. **Usability**-The ease of use, efficiency and effectiveness of this application is a very significant issue for the healthcare workers. Usually, most health care workers are based in remote and rural areas where accessibility of technology is limited. It is because of this fact that the application has been designed to be usable to the user, and the necessary interface functionality made to be as accessible as possible.

b. **Privacy**-Using and disclosing of personal information is the major thing in as far as M-Health is concerned. Hence, securing and preserving end-users' privacy has become more important than ever especially due to the increasing frequency of scandals related to data mis-usage and different kind of attacks on end-users' privacy.

   Privacy should therefore be enhanced by providing fine-grained privacy settings. These settings include hiding one's database profile. This is done in order to provide a fair amount of privacy to the personal user data, especially the personal details, which can easily be used to get clues about the real identity of a person.

c. **Security**- To secure the personal communication data and prevent interception, all messages must be encrypted. Android applications naturally support TLS encryption to secure client-server communication. Because of the fact that the messages and also location data could be read in plaintext on the server side, and also due to the fact, that server to server communication is not encrypted by default, it is necessary to use additional encryption mechanisms.

   Therefore the client generates and publishes a public key, which enables other users to send encrypted messages or to encrypt the location data, so that only the contact who is supposed to read it can decrypt it. It is very imperative that data is encrypted both in transmission and at rest. Mobile networks already encrypt traffic in store, but strong encryption has not been widely established for data at rest on the current generation of mobile devices (GSM, 2012).

d. **Interoperability** is basically the ability to create end to end solutions by interconnecting components and systems from various solution providers in a network. It is one of the integral factors towards supporting the broad adoption and effective utilization of M-Health).

3.10.2 The benefits of the proposed M-Health application:

The conceptual model if implemented will contribute to the overall efficacy, quality, efficiency, and safety of malaria treatment through the effective improvement of the general information workflow and on time information that will help provide tailored, customised and targeted therapies; faster clinical research process, drug tracking, regulations and standards compliance, improved protocol approval, adverse event reporting, patient

monitoring and patient compliance among other benefits. This will definitely lead to much increased service productivity, safety, effectiveness, and integrity due to better access, intervention

3.11 The mobile application device

The application device is a set of devices that are needed to use the malaria mobile health Service and to connect to the mobile health Platform. Smart mobile devices such as iphone, iPad, Tablets, Blackberries are examples of the mobile health device that the Applications can be installed into to help collect contextual information

This devices should have an interaction portal which is developed on the J2ME (Java to Micro Edition) platform. This technology supports consumer wireless device platform. J2ME is one of Java Platform designed for mobile and embedded systems. Java ME files implement a Profile.

3.11.1 Functionality of mobile application Device

1. The mobile application device must be easy to use suiting the capabilities of the target group of practitioners in terms of usability.
2. The device must have a unique identifier for easy identification on the network
3. The mobile health device should have a GSM connectivity that is complied with the licence condition of the market it is being operated in.
4. As far as security is concerned the device must be secure as described below:
    a. It must provide data confidentiality while Patient data is processed or stored on the mobile health Device
    b. The mobile health Device must ensure data integrity while Patient data is processed or stored on the mobile health Device

CHAPTER 4:DESIGN AND IMPLEMENTATION

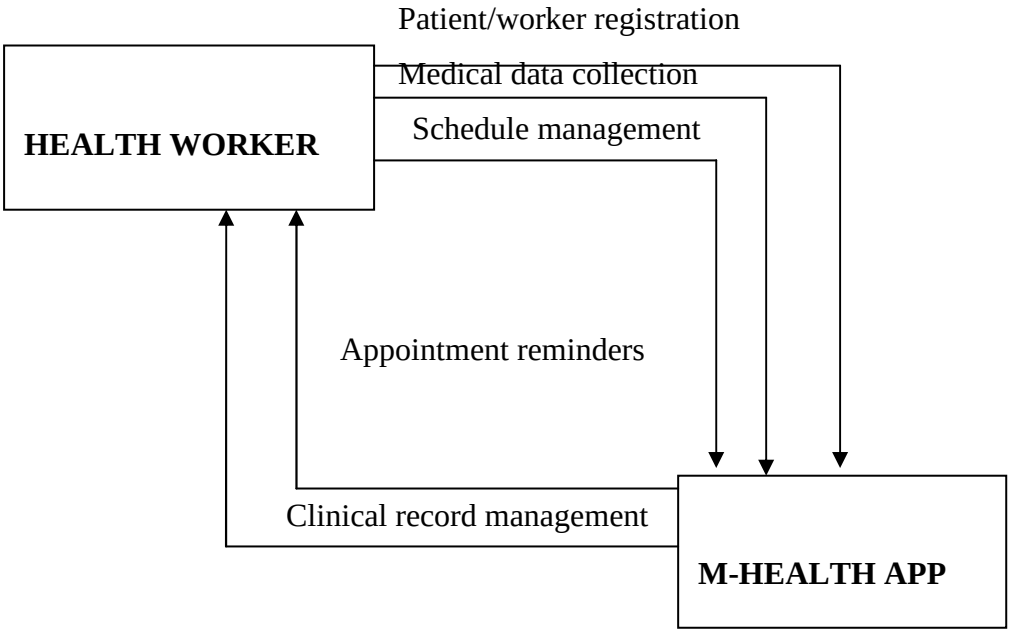
4.1 Proposed application functionality

The mobile application interacts with the user (health worker) as shown in Fig 5. The health worker can register the personal details of the patient; collect other medical information like

data on disease outbreak, mortalities, drug stock levels etc. They can also send confirmation, cancellation or postponement replies for appointment remainders.

The application also helps the health workers to access the medical history of records

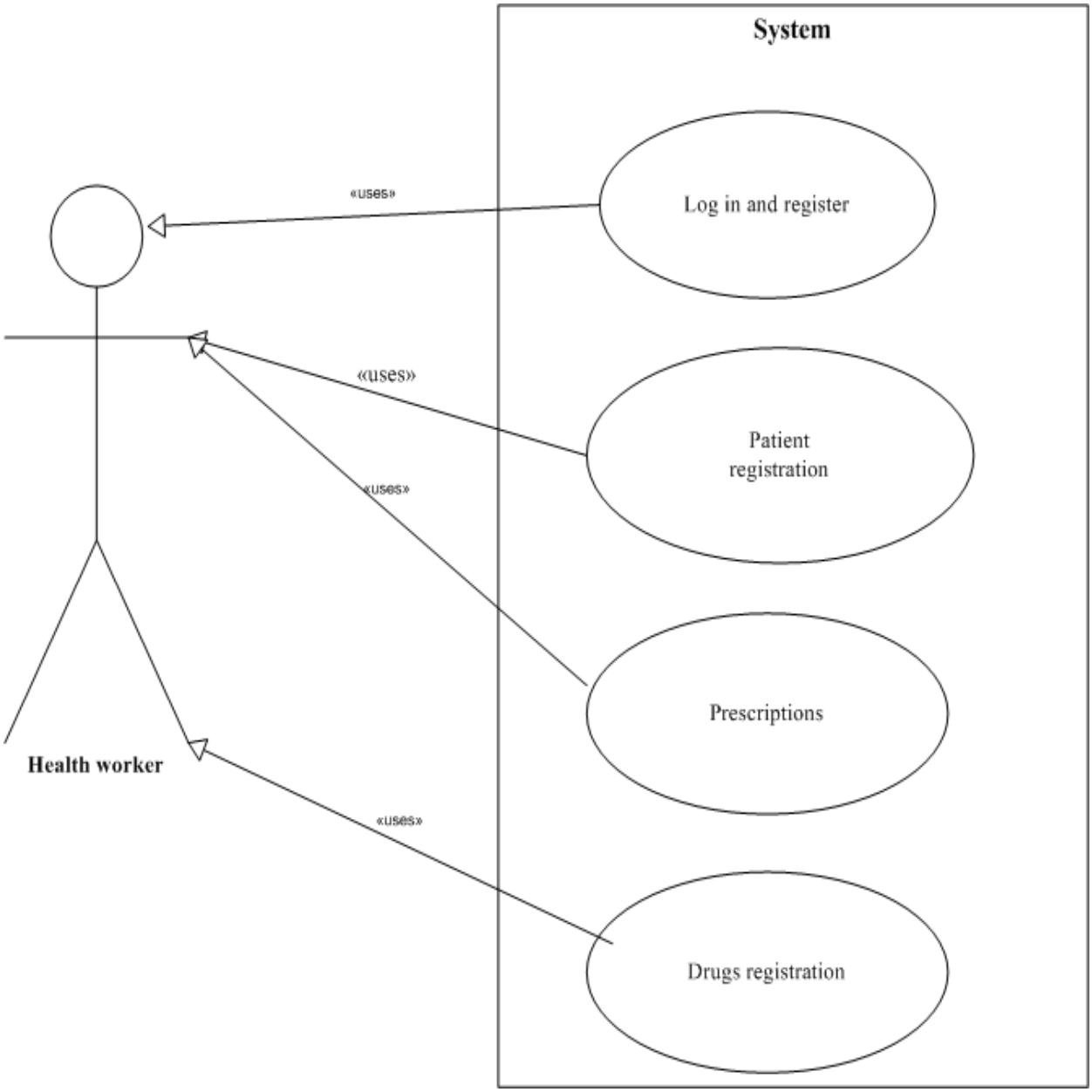
FIG 5: M-Health Application functionality



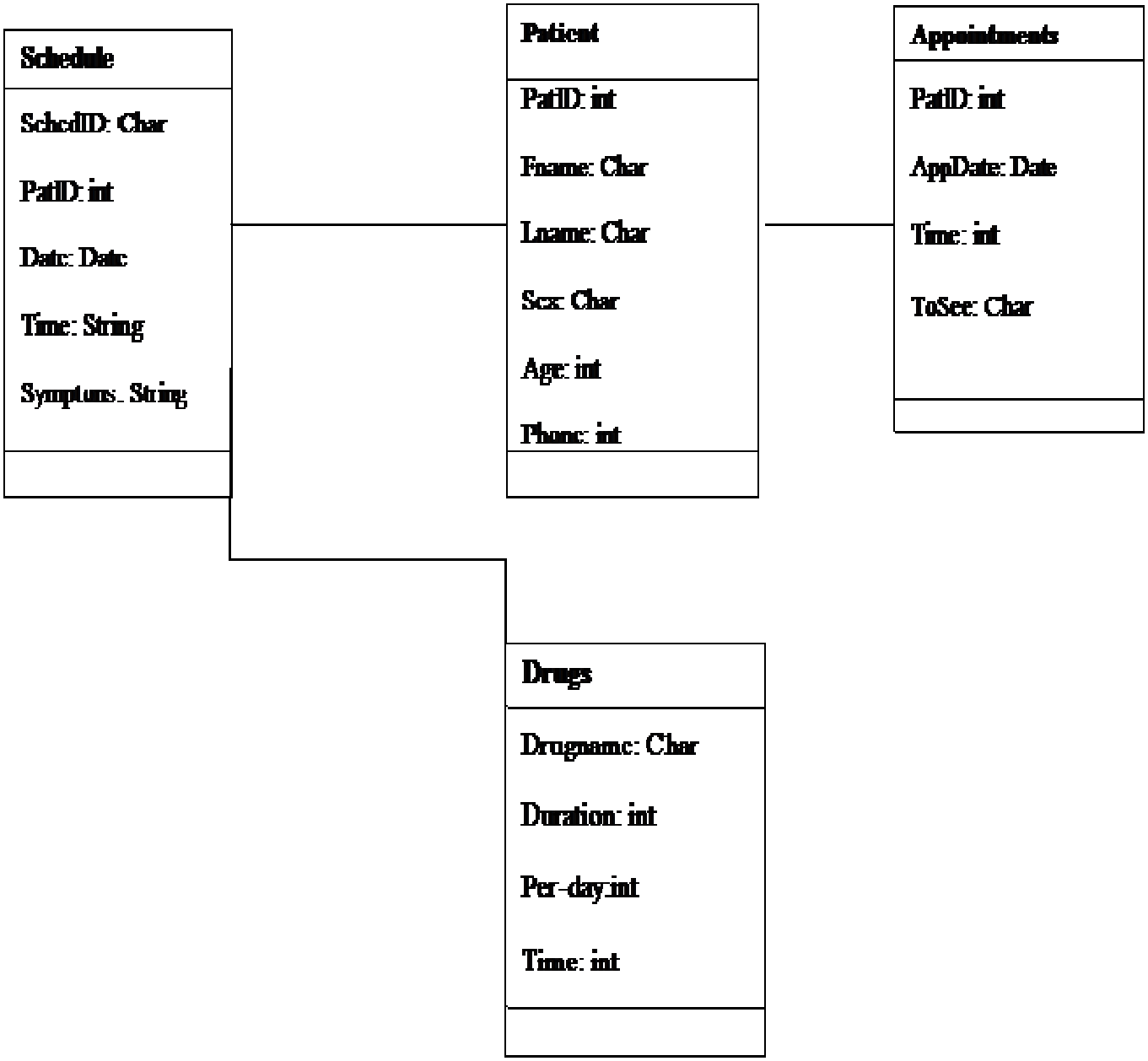
4.2 Process modeling

A use case diagram offers a clear graphical view of system functionality generally provided by the application in terms of the actor (The health worker) and their goals with the application

FIG 6: Use case diagram of the process



4.3 FIG 7: Database Design of the proposed application



4.4 M-Health application Architecture

FROM THE HEALTH WORKER

1. Register patient
2. Search for patient's details
3. Record drugs
4. Schedule appointments
5. Record prescriptions
6. Record drugs dispensed

FIG 8: M-Health application Architecture

4.5 Implementation

The development and implementation of the M-Health application for malaria health workers is based on conceptual model developed by the researcher. The application runs only on android enabled phones

The implementation of M-Health applications for malaria healthcare management creates what is called the malaria mobile-based healthcare system (MMBHS). An MMBHS is defined as the carrying and delivering out of malaria healthcare-related activities like collecting patient's data, storing and transmitting patient's medical records using mobile devices such as PDAs, wireless tablet computer, or a wireless-enabled computer.

An action is triggered when authorized healthcare staffs and personnel access the administrative and clinical systems of a healthcare institution using mobile devices. The transaction is completed the moment medical personnel decide to access medical records (patient or administrative) via a mobile network to either browse or update the record.

FIG 7: THE HOME PAGE OF THE APPLICATION

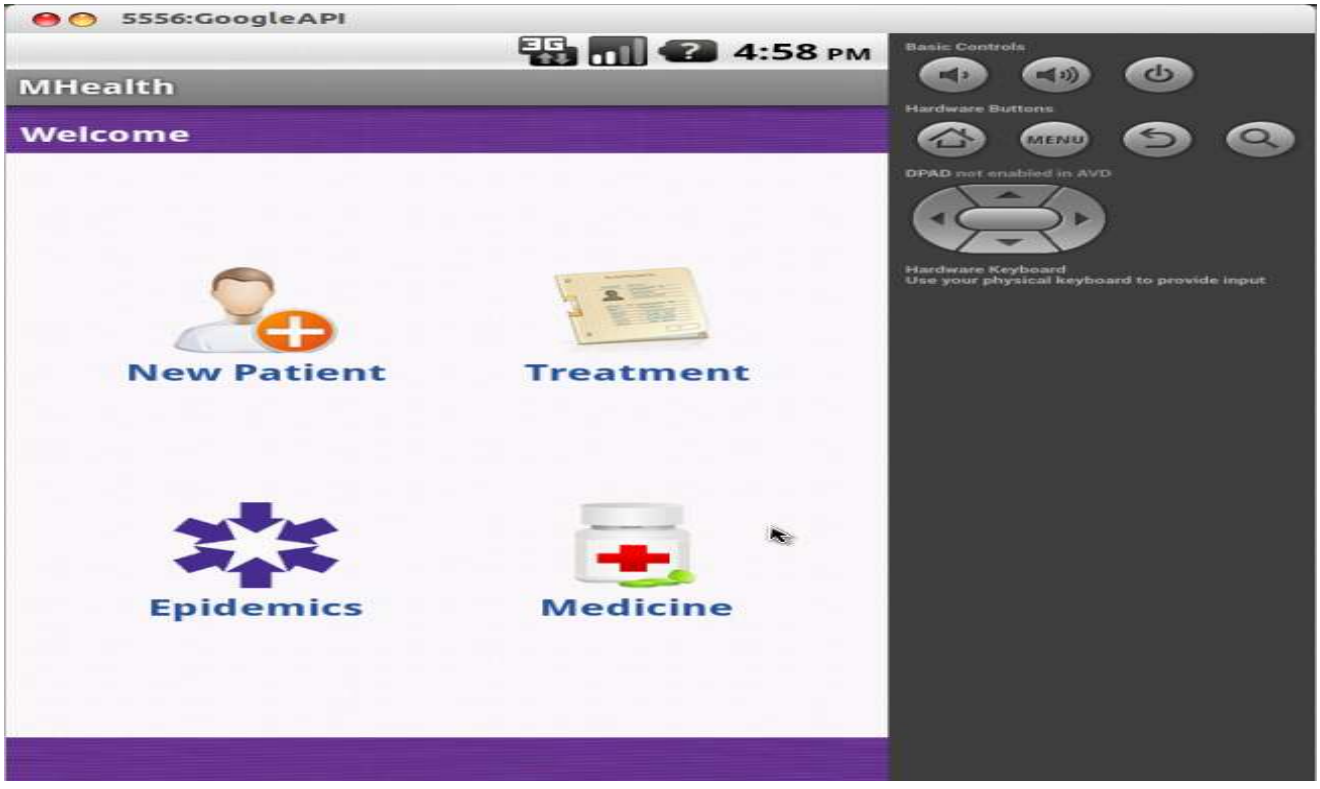


FIG 8: THE LOGIN PAGE FOR HEALTH WORKERS

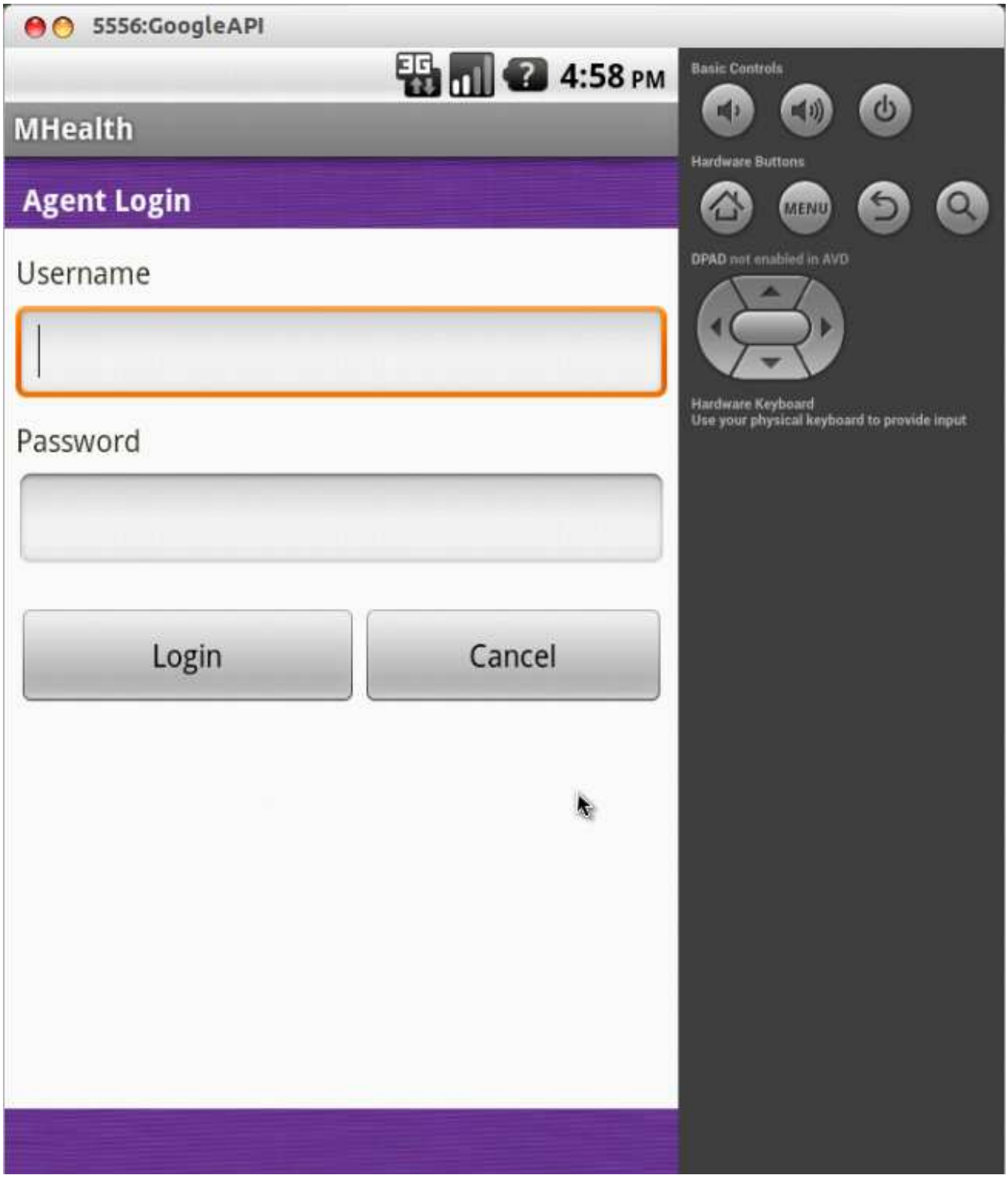


FIG 9: DRUG DISPENSING RECORDS

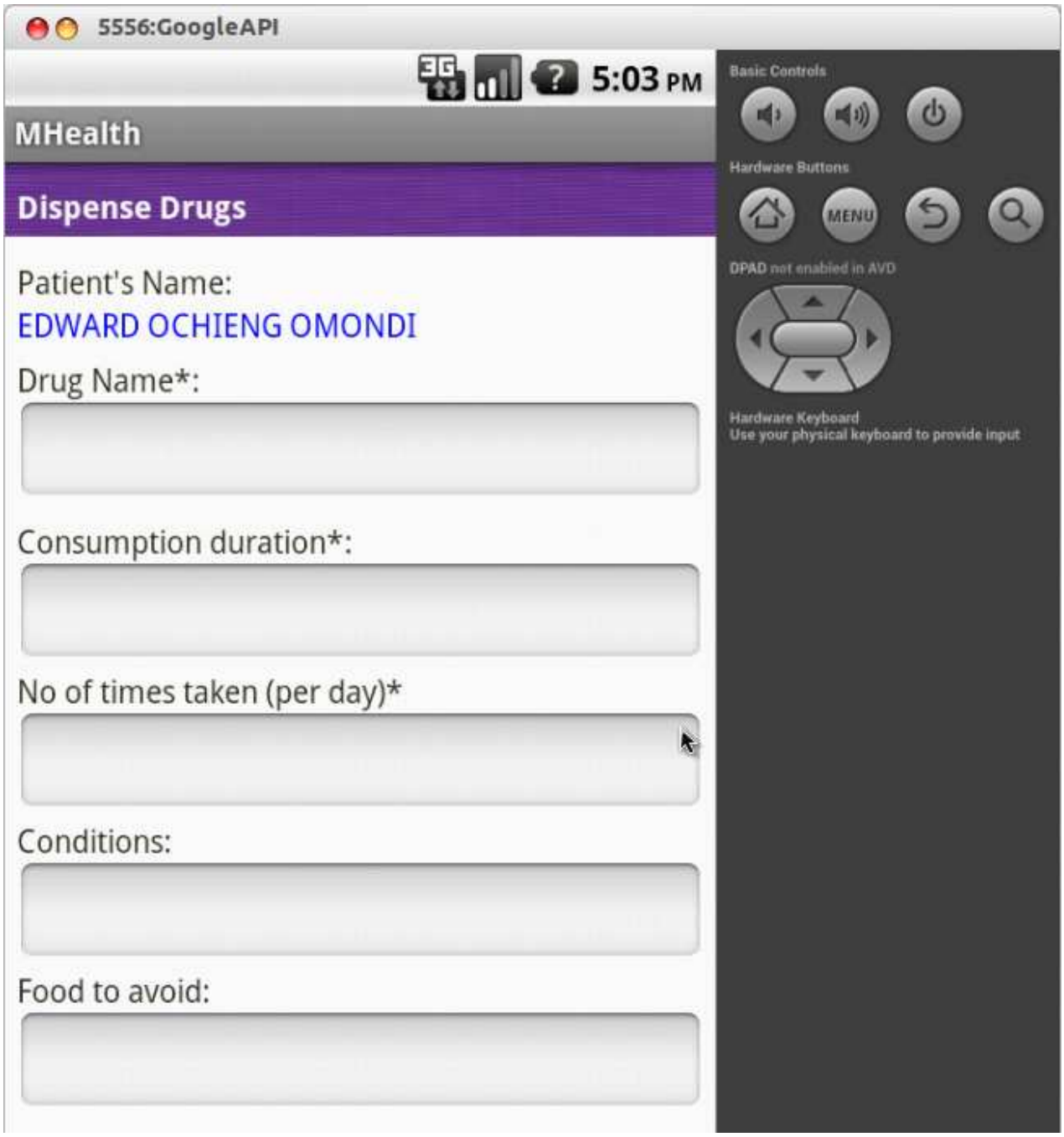
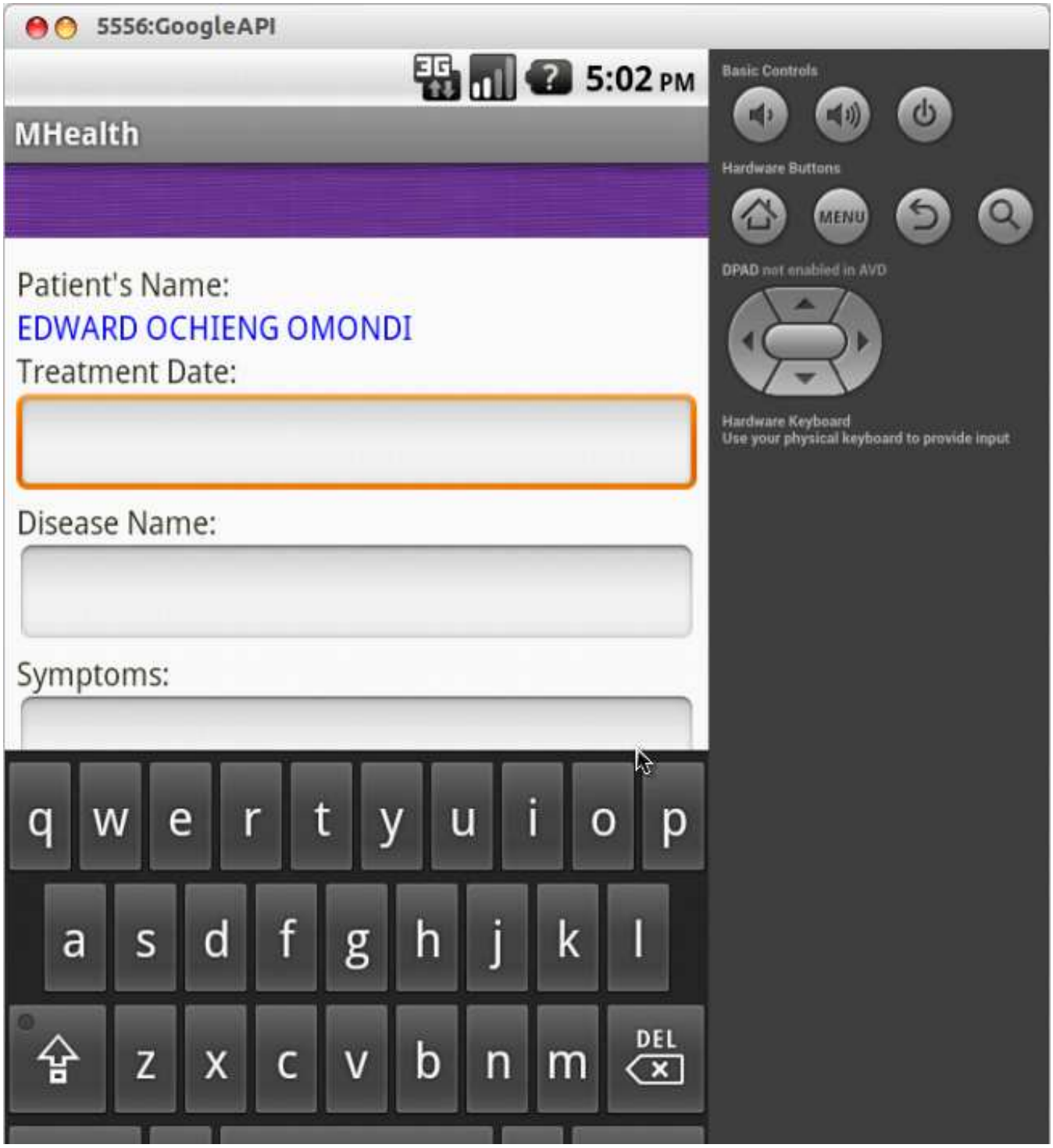


FIG 10: SEARCHING FOR PATIENT'S RECORDS

FIG 11: RECORDS OF A PATIENT'S DIAGNOSIS


5556:GoogleAPI
5:02 PM
MHealth
Patient's Name:
EDWARD OCHIENG OMONDI
Treatment Date:
Disease Name:
Symptoms:
Basic Controls
Hardware Buttons
MENU
DPAD not enabled in AVD
Hardware Keyboard
Use your physical keyboard to provide input
q w e r t y u i o p
a s d f g h j k l
z x c v b n m
DEL

4.6 Assumptions of the study

The study basically makes assumptions that future work shall be done by other researchers and developers to come up with applications that will be able to support the other stakeholders in the health industry because this application will only be helpful to malaria health workers.

4.7 Testing of the application

User experience testing is an approach that the researcher adopted to check for application characteristics that might detract the user experience or interfere with system functionality and performance. The testing involved user interaction with the application and the users later on provided feedback regarding the correct execution of the actions performed and the quality of the application performance.

High level functional or acceptance tests were done.completeness and correctness of the user requirement or features were the main points that users were expected to note. Performance tests were also done to measures performance characteristics of the components in the application as experienced by the users

Usability testing was conducted to ensure that the application users could complete the tasks they are expected to complete. More importantly, was to find out if they could be able to do so easily and without becoming frustrated. The following were evaluated with the users

- **Functionality:** If the mobile application presented the user with the appropriate functionality.
- **Layout & Design:** To ascertain if the layout and design of the application allowed a user to easily complete tasks.
- **Interaction:** This was aimed at checking the flow of the application and whether it was natural and would allow the user to easily complete tasks.

4.7.1 Logging in

Insofar as logging in is concerned, the researcher asked the application users to execute the login procedure by presenting the application to the intended users. The researcher noted all the actions of the users as they used the application and recorded the additional suggestions as they were presented by the users.

User one: After his interaction with the application, his suggestion was that the developers needed to introduce the use of the "have you forgotten your password?" link to be included in the design. This alternative was not present in the initial design of the application. Otherwise it was very easy for him to understand the first page of the mobile application.

User two: In her interaction with the application, this user was of the view that the insertion of some wide-ranging information about the application in the login page of the application. This was to offer users some concise explanation of what the application was all about. Her general proposition was to make the page a bit more enlightening and nice-looking than to simply have a username and password option.

User three, four and five: This group of users did not have a lot to say instead they just said almost the same things as had been suggested by the previous users.

User six, seven and eight: Some of the suggestions they made were just part of the overall appraisal tests which will be explained in details within the design chapter of these study work.

User nine-When she started inputting data in the username text box, her instant question was if the application content and login forms were case sensitive. One of the suggestions she gave was that the text boxes should be kept case insensitive. In the password text box, however, she suggested the use of ASCII characters while setting the password.

User ten, eleven: Did not make any notable suggestions.

4.7.2 After logging in

After successful logging in, the application users were told to proceed with the tasks to the user account to see and complete options availed through the page.

User one, two, and three: The three, were successful as they clicked on the register tab to continue to the registration page. By doing so, they were able to register patient's details on the page. One noteworthy suggestion made by these users was to contain the "change the password" alternative for the patient account. This was supposed to help with the privacy of patient's accounts. The password could however be viewed by the system admin.

User four, five, six and seven: These users lacked any specific comments insofar as the application usage and content was concerned. One however proposed the addition of the logout alternative in this section of the portal.

User eight, nine, and ten: The three had a lot of difficulties navigating through the patients account page. However, they were later successful after being guided by the researcher.

User eleven: Did not make any notable suggestions.

FIG12: TEST RESULT OF REGISTRATION

FIG 13: REGISTERED PATIENTS DATA

Mhealth Admin Controller

Mhealth Staff management page:

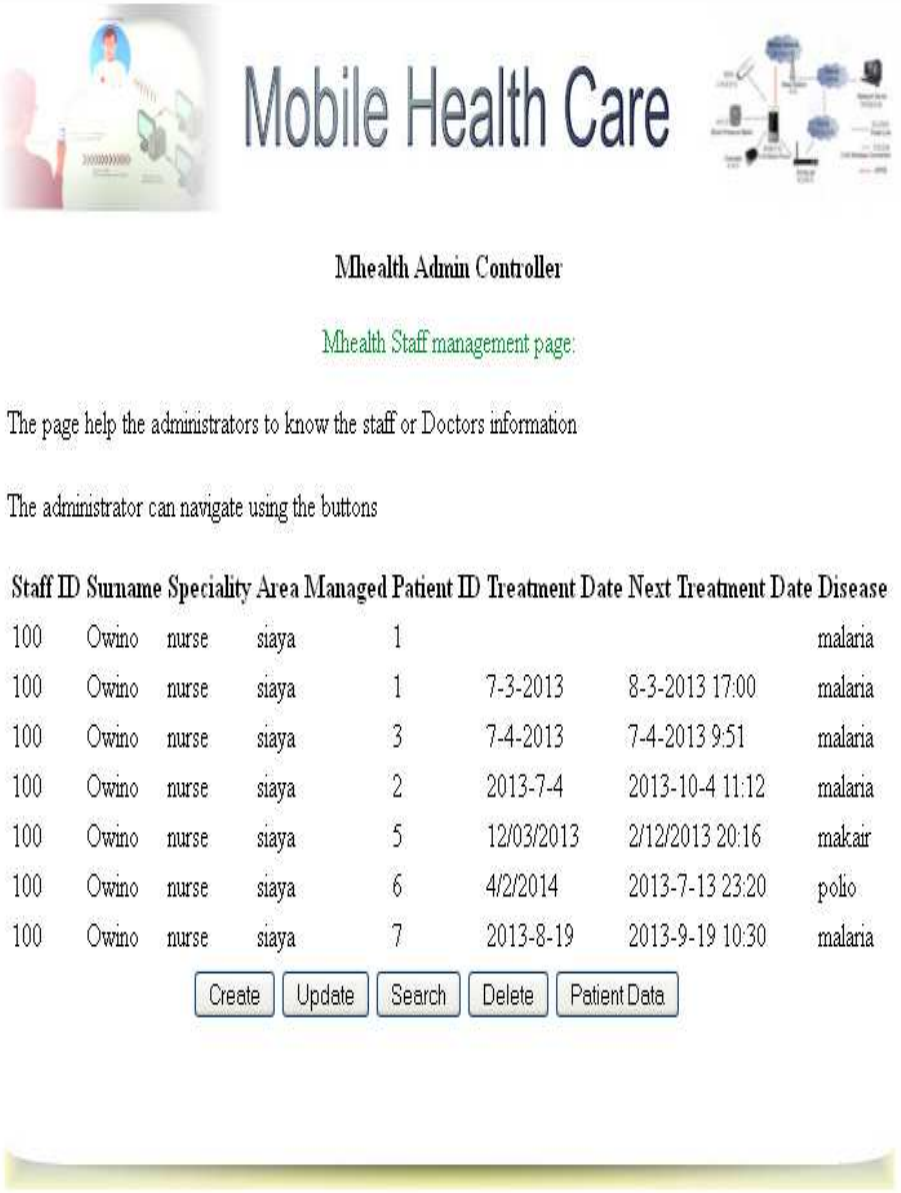
The page help the administrators to know the staff or Doctors and the patients they have treated.

The administrator can navigate using the buttons

Patient ID	Surname	Other Names	IDNO	Location	Phone Number	Disease	Symptoms	Treatment Date
1	Omondi	Edward Ochieng	25597704	Thika	0729362747	malaria	headache	
1	Omondi	Edward Ochieng	25597704	Thika	0729362747	malaria	aches	7-3-2013
3	Fadalus	Wanyama	14785632	Eastliegh	8965327	malaria	headache vbis	7-4-2013
2	Susan	Esther	456389	dandora	7865321	malaria	headache	2013-7-4
5	Thairu	Prof	582468173	iu	034876#1	makair	dg	12/03/2013
6	Agwata	Onyango	5609	dsndprs	2353	polio	bowed legs	4/2/2014
7	Edward	Kamau	12345567	Juja	0723654875	malaria	weak joints, headache	2013-8-19

Create | Update | Search | Delete | Staff Data

FIG14: STAFF MEMBERS DATA



CHAPTER 5: DISCUSSIONS OF FINDINGS

5.1 Discussions of Findings

A key finding was that the mobile app was well and finely received by the targeted population. One of the health workers said, “We shouldn’t call this a pilot because it is bringing very useful results and is now part of the system”. Some of the health workers were however concerned that they did not understand some of the applications modules especially on prescriptions. The implementer therefore suggested the need for training especially on the functionality of the application and what the elements mean.

Several members of the focus group were very much interested in an increase in the number of datasets collected mostly the addition of the whole complement on disease surveillance reports. Hence, the idea of rapidly adopting and accepting of the M-Health led to an early discussion by stakeholders at diverse levels so as to improve it. These improvements will therefore have to be made in phases as users continue to familiarise themselves with the system

To better customize mobile phones and applications for users, more research and innovation will be needed in design and development as well as selecting handsets types, features for use, and applications. For many older people, the biggest barrier to adoption of mobile phones is cost.

They were however concerned with the twin issues of privacy and security which featured prominently among the participants who were involved in the focus groups. Most participants were convinced by the security features integrated in the applications; however few of them were of the view that the issue of privacy of the patient’s data has to be taken seriously because of the sensitivity of the data collected by the application

5.2 Conclusions

It is apparent that even as mobile technologies evolve; evidence suggests that there is a wide range of benefits, advantages and efficiency brought about by mobile phones to patients and institutions involved in malaria management. This already grown body of evidence needs to be quickly transposed onto developing country context, where it is much needed.

However the various benefits that have been shown in various small-scale case scientific studies have already build a base of faltering evidence in some countries for the application of mobile communication strategies. These, has therefore provided a compelling need and indication that there are several benefits if mobile communication implementation in health is fully carried out by the various stakeholders

Seven major conclusions can be made when it comes to the usage of mobile communication in the health sector in general and malaria management in particular. These seven needs to be put in practice at all the different multi-sectorial levels. The complication of ensuring that they are put into practice is appears to be one of the major challenges and headaches experienced by the implementers in ensuring that the health system enjoys and benefits, and the group that makes use of the health system – the citizens and patients – benefit and their overall quality of health care improves.

- Ensure that information and communication technology is kept relevant, simple and local.
- Basically build on what is already there (and is currently in practice).
- Ensuring the involvement of users in the design (by demonstrating benefit).
- Work on strengthening capacity and ability to use ICTs
- Introduction of greater monitoring and evaluation of the technologies
- Include communication and information technologies in strategic design of ICT projects.

In conclusion therefore, it is imperative to note that in this study, the focal point was on mobile systems being used to collect, manage and transmit routine data by the health care workers especially in rural areas where the availability of resources is normally hindered to some central place where some analysis can be performed on it. In this scenario, datasets

from mostly rural and remote areas are transmitted to upper levels through the state to the central databases, with health information defining a whole range of data elements spanning from utilization data, child health data, mortalities, stock levels and disease surveillance data. In developing countries, the collection of such data has historically proven to be intractable.

5.3 Critical review and reflections

Malaria management in Kenya faces difficult challenges in terms of meeting the needs of both patients and health care workers. There is need to address inequalities in access to care and the increasing incidence of lack of proper information. To do all this, it will be critical for countries to start harnessing the power of M-Health

The healthcare sector in Kenya therefore needs to work with the mobile telecommunications industry and application developers to review the policies and regulations in order to enable new models of care that:

- Embrace technology especially M-Health systems
- Regulate technology (devices, systems and interfaces) in a way that lets it get to market quickly.

Healthcare service provision worldwide face difficult challenges in terms of meeting the needs and, where possible, the expectations of growing and ageing populations coupled with lack of resources. There is need to address inequalities in access to care and the increasing incidence of chronic illness. To do all this, it will be critical for countries to start harnessing the power of mHealth

The healthcare sector of different countries worldwide therefore needs to work with the mobile telecommunications industry to review their policies and regulations in order to enable new models of care that:

- empower patients
- reward outcomes
- regulate technology (devices, systems and interfaces) in a way that lets it get to market quickly.

5.4 Future

Many more stakeholders in the health care industry would like to employ M-Health services; however a good number of them are apprehensive about the twin issues of mobile phone device privacy and security and marvel at whether amplified dependence on this devices and applications will endanger the confidentiality and integrity of their medical information. These two issues of privacy and security of mobile applications will therefore have to be addressed by other researchers in the future

They fear the loss of a wireless communication device like a tablet, iphone or smart-phone that has some personal and private medical information and material and hence are concerned that their medical information might end up in the wrong hands for example employers or private individuals, thus encryption of data is very vital

Trust is also one of the key barriers when it comes to adoption of M-Health technologies since a decision to continue using or to dispose off an M-Health application is easily influenced in the first few moments of an individual's interaction with it. For the health care workers in the rural places especially, may not have as much exposure or comfort with mobile phone applications, the trust hurdle may be higher than average. M-Health solutions designed with this people in mind will likely have a better chance of success and continued use than those aimed at the general population.

Another very important point that must be emphasized is the idea of ergonomics. It plays an important role in individuals' decisions whether to continue use of a technology. Special attention is required when considering mHealth ergonomics, for example, which handsets are better geared for use by the health care workers in rural areas populations. Large screens and large buttons that are easy to see and touch are better for older individuals with impaired vision and hearing.

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