

MOBILE COMPUTING ENABLED KNOWLEDGE BASED MATERNITY CARE AND FOLLOW UP SYSTEM

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Degree of Master of Science in Software engineering

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Contents

ACKNOWLEDGEMENT	2
List of Figures	7
List of Tables	8
Abstract	9
CHAPTER ONE	10
INTRODUCTION	10
1.1. Background	10
1.2. Introduction to M-Health	12
1.3. Overview of Gandhi Hospital	13
1.4. Statement of the Problem	15
1.3 Research Questions	16
1.4 Objective of the Study	16
1.4.1 General Objective	16
1.4.2 Specific Objectives	16
1.5 Significance of Study	17
1.6. Scope and Limitations of the Study	17
1.6. Organization of the Thesis	18
CHAPTER 2	19
LITERATURE REVIEW	19
2.1. INTRODUCTION.....	19
2.2. THE MOBILE TELECOMMUNICATIONS SYSTEM	20
2.2.1. GSM (Global system for Mobile communication).....	21
2.2.2. GPRS (General Packet Radio Services)	22
2.2.3. CDMA (Code Division Multiple Access)	24
2.2.4. THIRD GENERATION MOBILE NETWORKS (3G)	25

2.2.5.	FOURTH GENERATION MOBILE TECHNOLOGY	26
2.3.	MOBILE COMPUTING.....	26
2.3.1.	M-Health initiatives globally.....	27
2.3.2.	Challenges and remedies to M-health	27
	Confidentiality of data	28
	Market volatility.....	28
	Innovation	28
	Integration with existing IT system	28
2.3.3.	“MOTECH” or “MOBILE MIDWIFERY”	28
2.3.4.	“WIRED MOTHER SOFTWARE”	29
2.3.5.	MAMI Care	29
2.3.6.	“VIRTUAL MATERNITY CARE”	30
2.3.7.	“MATERNITY-HEALTH”	30
2.3.8.	EVIDENCE BASED MATERNITY CARE.....	31
2.3.9.	IMPACT OF MOBILE PHONE ON MATERNAL HEALTH CARE.....	32
2.3.10.	MOBILE PHONE BASED PREGNANCY SUPPORT SYSTEM.....	33
2.4.	SUMMARY OF LITERATURE REVIEW	33
CHAPTER THREE		37
DESIGN AND METHODOLOGY		37
3.1.	Research Design and methodology	37
3.1.1.	Study Area	37
3.1.1.1.	Overview of Gandhi Hospital maternal information system	37
3.1.2.	Methodology of the study.....	38
3.1.3.	Study Population.....	39
3.1.4.	Data Collection Procedure.....	39
3.1.5.	Data Analysis Procedure	40

3.1.6. Validity and reliability of data.....	40
3.2. System design and methodology.....	41
3.2.1. Tools used for Simulation of the new system.....	41
3.2.1.1. Genymotion.....	41
3.2.1.2. WAMP server.....	42
3.2.2. Programming tools	44
3.2.2.1. Android application development	44
3.2.2.2. Java Development Kit (JDK)	44
CHAPTER FOUR.....	45
DATA ANALYSIS AND DISCUSSION	45
4.1. Introduction	45
4.2. Respondents' Data.....	45
4.3. Maternal Health and Information technology	47
4.4. Maternal Health Related Issues.....	49
4.5. Attitude towards the new system	55
CHAPTER 5	56
DESIGNING MOBILE ENABLED KNOWLEDGE BASED SYSTEM	56
5.1. Knowledge Acquisition.....	56
5.1.1. Current situation	56
5.1.2. Focused Antenatal care	57
5.1.3. Common symptoms and remedies.....	60
5.1.4. Danger Signs during Pregnancy	62
5.2.1. Decision tree structure for maternal follow up and treatment	63
5.3. Knowledge Representation	71
5.4. Overview of the new system.....	73
5.5. Sample output screen (<i>see sample code in annex-2</i>).....	76

CHAPTER SIX.....	77
CONCLUSION AND RECOMMENDATION.....	77
6.1. Summary and Conclusion	77
6.2. Future works.....	79
6.3. Recommendations	80
Reference	81
Annex-1- Questionnaire and interview	84
Part I- Personal information.....	85
Part II- Maternal health and information technology	85
Part III- Maternal Health related.....	85
Part IV –Current situation.....	87
Part V - Attitude towards the future system.....	87
Annex-2 Sample Code	88

List of Figures

Figure 1 Mobile phones in 1946-1980's.....	19
Figure 2 Simplified architecture of Mobile Telecommunication System (Cox, 2008)	20
Figure 3 GSM System Architecture.....	21
Figure 4 GPRS architecture	23
Figure 5 CDMA System	24
Figure 6 3G System Architecture	25
Figure 7 SMART Care System	37
Figure 8 Genymotion Android phone emulator.....	42
Figure 9 WAMP interface.....	43
Figure 10 PHP My admin Interface	43
Figure 11 Field of Specialization of respondents	46
Figure 12 If ever used IT devices	47
Figure 20 Classification of the major UN recommended four visits	64
Figure 21 first visit decision tree	65
Figure 22 Decision tree of second visit.....	67
Figure 23 Third visit decision tree	68
Figure 24 Decision tree for the type of delivery	69
Figure 25 Visit four decision tree	70
Figure 18 Mobile phone enabled maternal care and follow up system	75
Figure 26 Android Studio IDE.....	76
Figure 27 Week 1 Output Screen.....	76

List of Tables

Table 1 Summary of Literature Review.....	36
Table 2 Field of Specialization of the respondents.....	45
Table 3 If ever used IT devices for Maternal Service.....	47
Table 4 Why Respondents used IT tools	48
Table 5 Frequency of Symptoms	50
Table 6 Initial Registration form of maternal mothers	58
Table 7 Engagement of mothers in the follow up process before delivery	53
Table 8 Attitude toward the new system.....	55
Table 9 Attitude towards the knowledge base	55

Abstract

This study is about using a mobile phone of maternal mothers for communicating their daily status with maternal health professionals in health stations, health centers and hospitals. This study is an M-health system categorized under patient monitoring integrated with decision support system. The communication is established using a mobile phone containing checklists of every possible symptom which occur at a specific time in the prenatal and postnatal periods. Each pregnant mother sends and gets information specific to her status. Collection of these symptoms sent from the mother is used in health institution side for decision making supported by knowledge based system. The decisions include making appointments, going to the nearby health institution for vital signs check-up, an emergency message for a fast reaction, simple advices...etc. The process starts when a woman is identified to be pregnant and ends 2 years after delivery. This system is developed for android based mobile phones using Android Development Kit. Generally, there are two results after implementation of this study. The first one is minimizing the death of maternal mothers. The second one is minimizing lifelong health problems resulted from pregnancy.

CHAPTER ONE

INTRODUCTION

1.1. Background

People all over the world die of various causes. Among this, maternity has brought a great deal of attention by being a cause of death for maternal mothers. According to 1990 report, each year globally, about 2.5 million mothers die of complications arising from pregnancy. 380 mothers die out of 100,000 live births. This number is nearly equal to the total population living in an average city. Among this number, the largest portion belongs to sub-Saharan Africa. In 2013, there was a decline from 380 to 210 maternal deaths out of 100,000 live births. The sub-Saharan Africa has still the highest death rate which is 510 maternal deaths out of 100,000 live births. From this, Ethiopia accounts for 420 Maternal Mortality Ratio (MMR). Life time risk of maternity death in Ethiopia is 1 in 52 mothers. (Mekonen, 2012).

In a recent WHO, UNICEF, UNFPA, World Bank Group, and United Nations Population Division Maternal Mortality Estimation Inter-Agency Group the Maternal mortality ration in Ethiopia in 2015 is 352 deaths out of 100,000 lives. (WHO, UNICEF, UNFPA, World Bank Group, and United Nations Population Division, 2016)

The goal of the fifth Millennium Development Goal of United Nations is improving maternal health. One of the ten recommendations of the commission was specific to improving measurement of maternal and child deaths. This recommendation requires that “by 2015, all countries have taken significant steps to establish a system for registration of births, deaths and Causes of death, and have well-functioning **health information systems** that combine data from facilities, administrative sources and surveys”. (World Health Organization, 2014).

A good progress has been made in maternity health within the last 23 years globally. Global maternal mortality ratio (deaths per 100,000 live births) has decreased from 380 in 1990 to 210 in 2013. Since 1990, the maternal mortality ratio has declined by 45 per cent worldwide. The maternal mortality ratio declined by 49 per cent between 1990 and 2013 in sub-Saharan Africa.

Among the contributing factors for the progress made is, the proportion of pregnant women who received four or more **antenatal visits** increased from 50 per cent to 89 percent between 1990 and 2014 and Global **births attended by skilled health personnel** has increased from 59% in 1994 to 71% in 2013. Here, the difference between developed and underdeveloped countries is depicted as well. (United Nations, 2015)

Maternal mortality is not the only problem related to maternal health. The complications and lasting health problems resulted from pregnancy are very critical. Life time risk of maternity in Ethiopia is 1 in 52 mothers. (Mekonen, 2012)

50 million pregnant women per year suffer from pregnancy-related health problems during or after pregnancy, and childbirth, with 14% suffering serious or long term complications. As a consequence, 300 million women suffer from pregnancy related health problems and disabilities, including anaemia, uterine prolapsed, fistula, PID, and infertility. (Starrs, 1997)

Maternal mortality and related health problems happen before, during and after delivery. Lack of information (the right information at the right time) about the sign and symptoms during these periods, Absence or distance of Health infrastructure and inadequacy of skilled personnel are the major factors. (Abdella, 2010)

In an information age, the information gap between maternal mothers and stake holders should not continue to be the cause of these problems. Especially today, communications has been made very successful using mobile phones. Mobile phones have overridden the geographical barriers, cost, distance and content limitations of communication.

Before 1940, two way radios was the only wireless technology. In the late 1940s and early 1960s, a half-duplex Mobile telephone service (MTN) was introduced. 1964 to 1969 improved mobile phone service (IMPS) which allows multiple channels and multiple users started. 1970 to 1983, mobile services became duplex, both send and receive simultaneously. Metropolitan Statistical areas and rural service areas defined by US Federal Communications Services collectively called Advanced Mobile Phone Services. 1991 to 1994 is the birth of second generation cell technology. This time, the technology migrated from analogue to digital.

1995 to 2008, third generation technology emerged which allowed SMS messaging and internet browsing. From 2008 to today, fourth generation technology started. Technology of 100 Mb Broadband (while moving) Technology of 1 GB Broadband (stationary) On Demand, High Quality Audio and Video emerged. (Federal Law enforcement Training Center, 2010)

As of 2012, Ethiopian government owned telecom service provider (Ethio-Telecom), the only service provider in Ethiopia, had 20,524,000 cellular phone subscribers. It launched the fourth Generation Long-term Evolution Service in March 21st, 2015. (A & M, 2015)

Currently there are 40 million mobile subscribers and 10 million internet subscribers. There is a plan to increase mobile subscribers to 64 million and internet subscribers to 46 million in 2020. (Ethiopian News Agency, 2015)

1.2. Introduction to M-Health

According to (World Health Organization, 2011) M-Health is defined as a component of eHealth in which medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices. mHealth involves the use and capitalization on a mobile phone's core utility of voice and short messaging service (SMS) as well as more complex functionalities and applications including general packet radio service (GPRS), third and fourth generation mobile telecommunications (3G and 4G systems), global positioning system (GPS), and Bluetooth technology.

mHealth helps to narrow the gap between access to services in urban versus rural areas attributed to the fact that health care providers are more likely to be located in densely populated cities where hospitals and clinics are more available. For this reason, mHealth not only compensates for poor or inconsistent access to health services in rural areas, it can also help in delivering faster and better quality care. This highlights how mHealth allows people to overcome geographical limitations in health care. mHealth can also address the chronic shortage of healthcare workers Africa. (Leveille, 2016)

Although the level of mHealth activity is growing in countries, evaluation of those activities by Member States is very low (12%). Evaluation will need to be incorporated into the project management life-cycle to ensure better quality results. Data security and citizen privacy are areas that require legal and policy attention to ensure that mHealth users' data are properly protected. Member States will progress further in implementing mHealth if they share global ICT standards and architecture. Cooperation in the development of best practices enterprise architecture will ensure that data can move more effectively between systems and applications.

The report of (World Health Organization, 2011) shows that Rather than strategic implementation, the emergence of mHealth is occurring in many Member States through experimentation with technologies in many health settings.

1.3. Overview of Gandhi Hospital

Gandhi Memorial hospital is a governmental hospital which specializes in maternity services. The hospital was established in 1954 E.C. with the collaboration of an Indian community that lived in Ethiopia and took its name from the famous Indian leader 'Mahatma Gandhi'. Starting from its establishment the hospital has been providing maternity services (Gandhi Hospital Planning and monitoring supportive core process, 2015).

The hospital serves as a teaching centre for Addis Ababa University students who specialize in gynaecology and obstetrics and other under graduate medical students with signed memorandum of understanding with the university and the hospital. This has resulted in a good opportunity for the hospital in providing a better service and in fulfilling the physicians demand; 75- 80 % of the physicians work is covered by these staffs. This shows that the hospital by itself has not adequate human power.

The hospital daily manages 25 -30 delivery cases of pregnant mothers who come from various corners of Addis Ababa and nearby towns. By doing so the hospital's original capacity becomes unable to fulfil the growing demand of mothers who come for this service. The main reason is the in proportionate number of delivery beds with labouring mothers.

Out of all mothers who come for delivery service, only 92% get the service the rest 8% are referred to other hospitals. This is one of the shortcomings the hospital management and staff face despite the trials to provide better service.

According to the BPR structure, the services provided in the hospital are divided in to two core processes, preventive and rehabilitative core process and curative core process.

❖ Preventive and rehabilitative core process contains the following sub processes

- Delivery service
- Antenatal service
- Family planning and vaccination
- Prevention of mother to child transmission of HIV(PMTCT)
- ART and VCT service

❖ Curative core process which consists of the following sub processes

- Emergency service
- Sexual assault management centre
- Abortion care
- Gynecological service
- Surgical service
- In patient service
- Diagnostic and pharmacy services

Gandi Hospital aspires to be the model hospital in maternal and child health care service by 2012 E.C. The mission of Gandi Hospital is to decrease prenatal and maternal morbidity and mortality rate through full package of preventive, promotive, rehabilitative and curative reproductive health care service via integrated collaboration with all stakeholders.

This research is directly related with the vision and mission of Gandi Hospital, in that it focuses in preventive and curative tasks through the mobile based follow up system and the knowledge base.

1.4. Statement of the Problem

There was a progress made between 1990 and 2013 regarding maternity health. The increase in **Antenatal visits** and **births attended by skilled health personnel** had great contribution. Just half of pregnant women in the developing regions receive the recommended minimum of four antenatal care visits. Lack of adequate antenatal visits is related to poor delivery outcome, resulting in need for skilled health personnel attendant and this is not sufficiently available. This study is motivated by the fact derived from the United Nation's report of 23 years maternal mortality progress. The report clearly indicated that more maternal visits and skilled health professionals' involvement in maternal health play the major role. This study helps to create more maternal visits and skills to health professionals through non-physical visit to women through mobile phone and knowledge base system support to decision makers. (World Health Organization, 2014). Previous studies do not make use of the fact in the 23 years old mature progress report of the United Nations, which is increasing maternal visit. More maternal visits results in less complications and less mortality. More knowledge to health professionals fills the gap for highly qualified professionals.

In technologically advanced countries like Israel, Estimates of maternal mortality ratio (MMR, maternal deaths per 100 000 live births), in 2013 is 2 and in Ethiopia it is 420. There is a visible difference between developed and developing countries in this regard. We should not wait until we reach the developed countries to make a significant change in maternity health.

It should be possible for maternal women to get in touch with health professionals for every signs and symptoms they face. The health infrastructure is one of the barriers towards achieving success in maternal health. Developing countries like Ethiopia cannot afford to avail every modern health facility in all Hospitals, Health centres or health posts.

Maternal health should not be compromised until we get these facilities. The United Nations has recommended well-functioning health information systems that combine data from facilities, administrative sources and surveys”. Data directly collected from maternal mothers should be included, the data collection mechanism should be automated and the data should be formed ready for more researches are made.

1.3 Research Questions

This study attempts to answer the following questions:

1. How to integrate mobile computing with knowledge base to provide an intelligent care, follow up and visit to women?
2. How to use the real fact about the maternal mortality problems input for studies in software engineering?
3. What is the one of the possible approaches to mobile computing enabled maternity care and follow up to fill the gap to lack of more maternal visits and skilled health professionals?

1.4 Objective of the Study

1.4.1 General Objective

- The general objective of this study is enabling mobile phones to support maternity care, follow up and treatment and contributes in the reduction of maternal death and related health problems.

1.4.2 Specific Objectives

- Collecting, organizing and analyzing data concerning maternity from literature and knowledge experts.
- Analyzing the available and relevant mobile computing technologies and methodologies to choose the best one.
- Modeling and representing the knowledge base system
- Experimenting on the data and methodologies and comparing results with similar studies.
- To develop prototype Mobile based maternity care, follow up and treatment system
- To test and validate the performance of the maternity care and follow up system.

1.5 Significance of Study

- Contributes in reducing the death of maternal mothers
- Improves the consistency of decision making between maternal health professionals through the use of knowledge base
- Minimizes the socio economic impact on females
- Minimizes the cost of health infrastructure and facility
- Paves the way for further research in the field of maternal health
- Minimizes the lifelong health problems maternal mothers face as a result of pregnancy
- Fills the gap for more skilled health professional by increasing the number of antenatal visits. Because, inadequate antenatal care results in poor pregnancy output, hence more skilled health personnel.

1.6. Scope and Limitations of the Study

This study addresses problems of information gap between maternal mothers and maternity health related professionals and also the knowledge gap and inconsistency among health professionals.

The source of the data for this study originates from health professionals in Gandhi hospital. The data is about the sign and symptoms maternal women face during and after pregnancy. These data are separated in 50 weeks of maternity, divided in to 37 weeks before delivery and 13 weeks after delivery. This information is used to follow up and care for maternal mothers before, during and after delivery. This information is collected from each mother using check list of each week sent in her mobile phone. The exact week of the mother is derived from the table of the first day registration. A rule based knowledge base modelled using decision tree is the approach for recommending possible care options and to categorize and group problems and solutions.

Collecting data for this purpose was the difficult task in this study. Health professionals, especially those who are high qualified are so busy to take time for discussion. Some of the health professionals are not aware of such systems and it was not an easy task to introduce them with. The time and budget constraints were also challenges faced during this study.

1.6. Organization of the Thesis

This thesis is organized into six chapters. Chapter one introduces the background of the study, problem of the study areas, significance of the study, the research objectives, research questions and scope and limitations of the study. Chapter two covers the review of the related literature that includes a conceptual explanation on how mobile phone technology is used to solve problems. Chapter three presents the research design and methodology that is used to carry out this research. Chapter four presents the study findings, and presentation of the results. Chapter five presents the new system design. Finally, Chapter six comprises summary, conclusions, future works and recommendations of the findings.

CHAPTER 2

LITERATURE REVIEW

2.1. INTRODUCTION

The word mobile comes from the Latin word “*mobilis*” and the meaning is “*to be able to move freely or easily*”. A mobile device (also known as a handheld device, handheld computer or simply handheld) is a small, hand-held computing device, typically having a display screen with touch input and/or a miniature keyboard and weighing less than 2 pounds. This includes Cell phones, Personal digital assistants, smart phones, tablet computers, notebook computers. (Kaur, 2013). Early mobile phones those existed before 1980’s (see Figure 1) were expensive, attached to trucks and briefcases and transmit only voice data. The introduction of GSM, GPRS, IDEN and CDMA has brought a revolution to the mobile technology. Nowadays. there are billions of mobile phones in the world, which is far greater amount than any type of electronic devices. (Sharon, 2008)



Figure 1 Mobile phones in 1946-1980’s.

2.2. THE MOBILE TELECOMMUNICATIONS SYSTEM

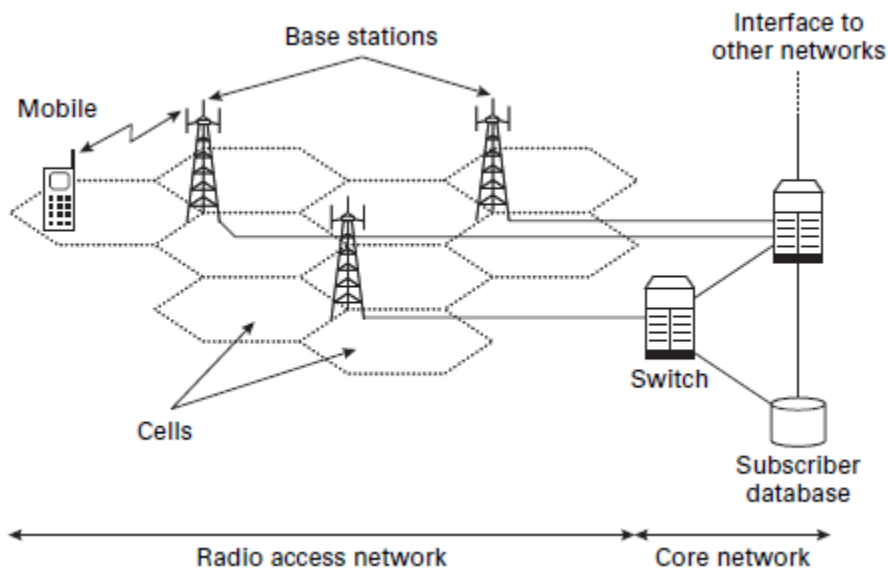


Figure 2 Simplified architecture of Mobile Telecommunication System (Cox, 2008)

The **core network** of mobile network has a similar role to a traditional fixed line telephone network. It sends information like voice calls or text messages from one phone to another using component that is known as switch. It also maintains a database containing information about the network operators, subscribers, and uses the database for tasks like preparing and distributing bills. Finally, it has a number of functions that are not required in a fixed line network; for example, it monitors the locations of the mobile phones, so that it can continue sending information to them as they move around. The radio access network handles the radio communications between the core network and the mobile phone. It contains a large number of base stations, each of which transmits and receives radio signals to and from the mobile phones in the surrounding area. The area around a base station is often divided into multiple sectors by equipping the base station with multiple directional antennas, each of which communicates with the mobile phones in the corresponding sector. (Cox, 2008)

2.2.1. GSM (Global system for Mobile communication)

GSM is a second Generation Mobile network. Global System for Mobile Communications was introduced in the mid-1980s. Today, GSM is the most popular mobile radio standard in the world and it operates in the 900MHz and 1.8 GHz bands throughout the world with the exception of the Americas where they operate in the 1.9 GHz band. Within Europe, the GSM technology made possible the seamless roaming across all countries. A boom is underway, such that many GSM users find life without their phone practically in conceivable. (Kahabka, 2004)

In Ethiopia, a 2G technology is still working and 3G and 4G are also in place recently. In 2G, it is possible to open websites. Therefore, mobile phone enabled web based system can be applicable in Ethiopia.

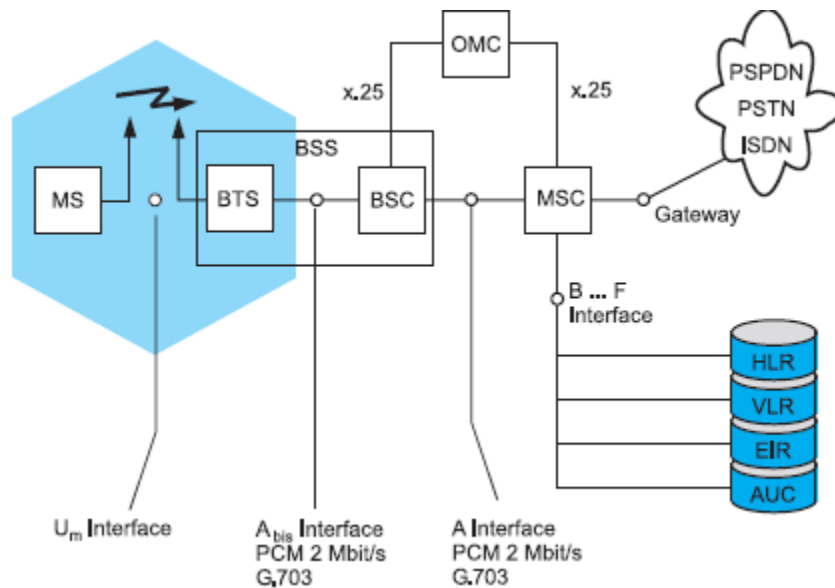


Figure 3 GSM System Architecture

As shown in the above Figure 3, GSM has three parts: The mobile station, the base station subsystem and the network subsystem. A **mobile station** may be referred to as a handset, a mobile, a portable terminal or mobile equipment ME. It also includes a subscriber identity module (**SIM**) that is normally removable and comes in two sizes. Each SIM card has a unique identification number called IMSI (international mobile subscriber identity).

In addition, each MS is assigned unique hardware identification called IMEI (international mobile equipment identity).

The protocol on the air interface contains the Radio Resource management, the mobility management and connection management. The connection management used to set, maintain and take down calls connection comprised of three subgroups. Call Control, which manages all connections, Supplementary Service Support, which handles special services and short message service support, which transfers brief texts. (Kahabka, 2004)

2.2.2. GPRS (General Packet Radio Services)

A mobile data service for use on GSM networks called GPRS (General Packet Radio Service) is a packet based communication service for mobile devices that allows data to be sent and received across a mobile telephone network. GPRS is a step towards 3G; it is why it is So-called '2.5G' system. GPRS recently introduced to enhance the data capacity of GSM and mitigate some of its limitations. These systems add packet data capability to GSM networks. A similar technology called WAP (Wireless Application Protocol) defines how Web pages and similar data can be passed over limited bandwidth wireless channels to small screens being built into new mobile telephones. At the next lower layer, GPRS defines how to add IP support to the existing GSM infrastructure. GPRS provides both a means to aggregate radio channels for higher data bandwidth and the additional servers required to off-load packet traffic from existing GSM circuits. It supplements today's Circuit Switched Data and Short Message Service. GPRS is not related to GPS (the Global Positioning System), a similar acronym that is often used in mobile contexts. Theoretical maximum speeds of up to 171.2 kilobits per second (kbps) are achievable with GPRS using all eight timeslots at the same time. This is about ten times as fast as current Circuit Switched Data services on GSM networks. However, it should be noted that it is unlikely that a network operator will allow all time slots to be used by a single GPRS user. Additionally, the initial GPRS terminals (phones or modems) are only supporting only one to four timeslots. The bandwidth available to a GPRS user will therefore be limited. There exist phones which support only GPRS. Here we have to make clear that the more lately the technology, the more better mobile phone enabled system will be built up on. Therefore, mobile phones having ability to support 3G get more advantage from this system.

All 2G wireless systems are voice-centric. GSM includes short message service (SMS), enabling text messages of up to 160 characters to be sent, received and viewed on the handset.

Most 2G systems also support some data over their voice paths, but at painfully slow speeds usually 9.6 Kb/s or 14.4 Kb/s.

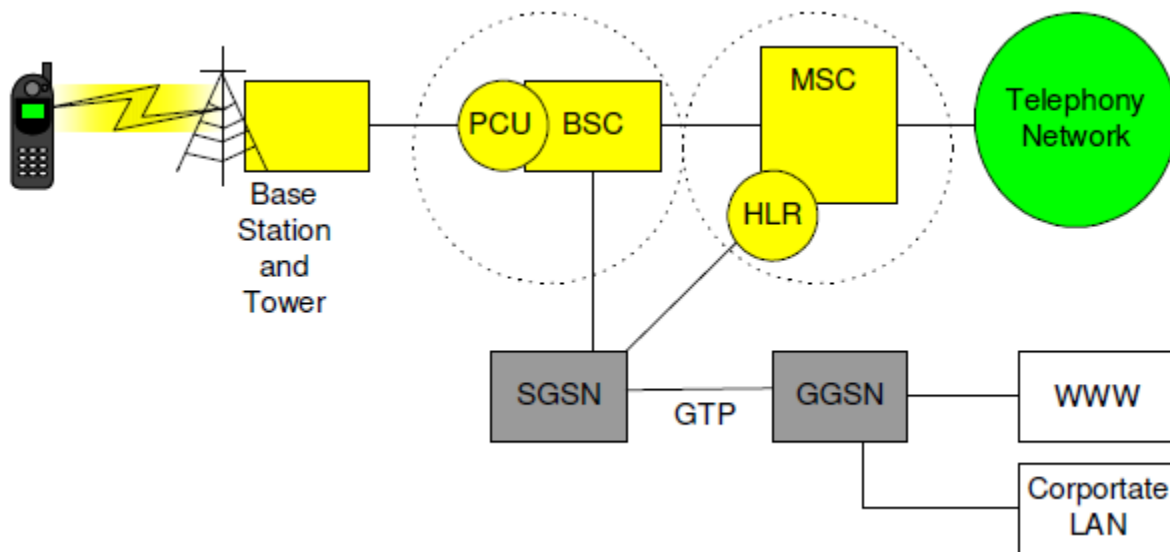


Figure 4 GPRS architecture

In practice, GSM and GPRS are working in parallel. In any GSM network there will be several BSC's (Base Station Controllers). When implementing GPRS, a software and hardware upgrade of this unit is required. The hardware upgrades consists of adding a Packet Control Unit (PCU). This extra piece of hardware differentiates data destined for the standard GSM network and data destined for the GPRS network.

The HLR or Home Location Register is a database that contains subscriber information, when a device connects to the network their MSISDN number is associated with services, account status information, preferences and sometimes IP addresses.

The Serving GPRS Support Node, or SGSN for short, takes care of some important tasks, including routing, handover and IP address assignment. The Gateway GPRS Support Node is the "last port of call" in the GPRS network before a connection between an ISP or corporate network's router occurs. The GGSN is basically a gateway, router and firewall rolled into one. It also confirms user details with RADIUS servers for security, which are usually situated in the IP network and outside of the GPRS network. The connection between the two GPRS Support Nodes is made with a protocol called GPRS Tunnelling Protocol (GTP). GTP sits on top of TCP/IP and is also responsible for the collection of mediation and billing information. GPRS is billed on per megabyte basis unlike GSM.

A mobile device is programmed with one or more Access Point Names consist of a fully qualified DNS name. When a GPRS device wants to talk to the APN network, the SGSN does a DNS lookup and resolves the name to the correct GGSN. (MorganDoyle Limited, 2004)

GPRS in general has problems in Connection speeds.

2.2.3. CDMA (Code Division Multiple Access)

Code Division Multiple Access (CDMA) is a digital cellular technology used for mobile communication. In CDMA, every channel uses the full available spectrum. CDMA consistently provides better capacity for voice and data communications, allowing more subscribers to connect at any given time. CDMA is the common platform on which 3G technologies are built. CDMA technology are recognized as providing clearer voice quality with less background noise, fewer dropped calls, enhanced security, greater reliability and greater network capacity. These days, CDMA technology is going out of service and being replaced by 3G.

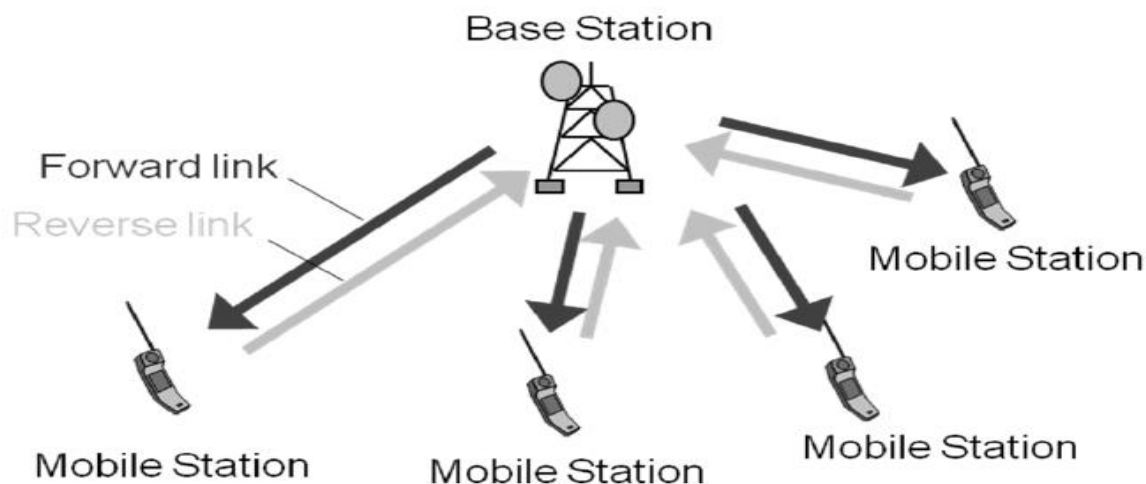


Figure 5 CDMA System

In radio CDMA, each group of users is given a shared code. Many codes occupy the same channel, but only those users associated with a particular code can communicate. The Forward channel is the direction of the communication or mobile-to-cell downlink path.

The Reverse channel is the mobile-to-cell direction of communication or the uplink path. (Tutorials Point (I) Pvt. Ltd., 2015)

2.2.4. THIRD GENERATION MOBILE NETWORKS (3G)

As personal wireless handsets become more common than fixed telephones, it is clear that personal wireless Internet access will follow and users will want broadband Internet access wherever they go.

Today's 3G specifications call for 144 Kb/s while the user is on the move in an automobile or train, 384 Kb/s for pedestrians, and up to 2 Mb/s for stationary users. That is a big step up from 2G bandwidth using 8 to 13 Kb/s per channel.

The second key issue for 3G wireless is that users will want to roam worldwide and stay connected. Today, GSM leads in global roaming. Because of the pervasiveness of GSM, users can get comprehensive coverage in Europe, parts of Asia and some U.S. coverage. A key goal of 3G is to make this roaming capacity universal.

A third issue for 3G systems is capacity. As wireless usage continues to expand, existing systems are reaching limits. Cells can be made smaller, permitting frequency reuse, but only to a point. The next step is new technology and new bandwidth. (Pereira, 2004)

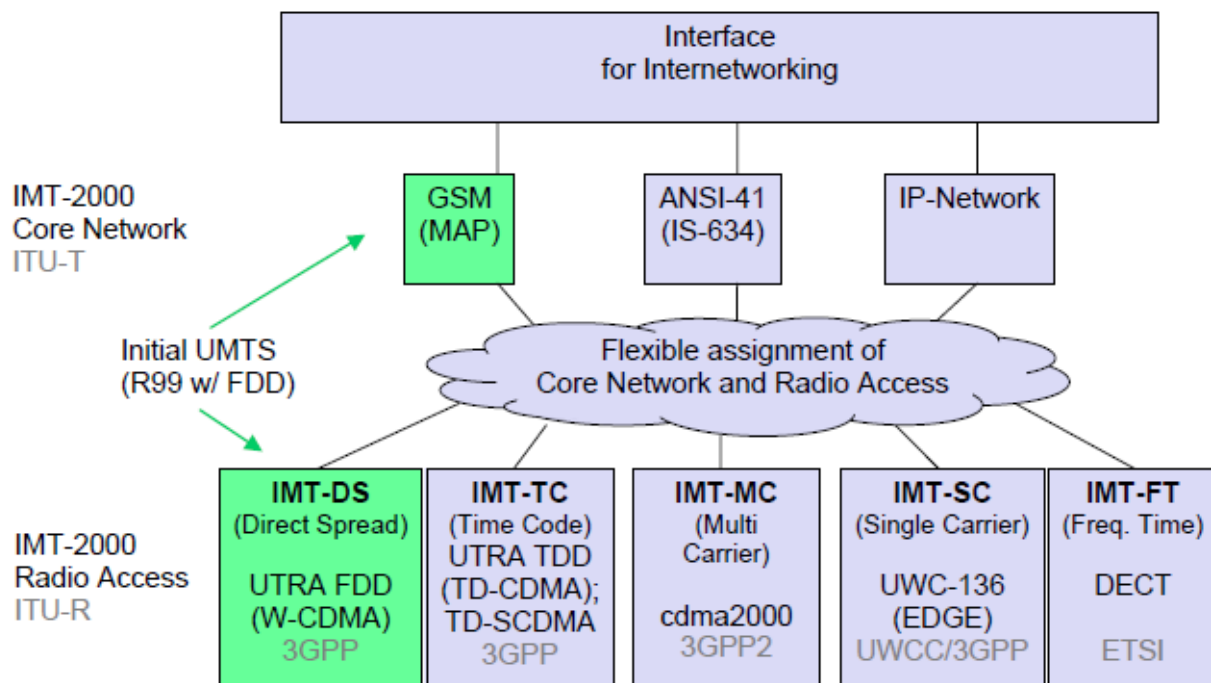


Figure 6 3G System Architecture

2.2.5. FOURTH GENERATION MOBILE TECHNOLOGY

The objective of the 3G was to develop a new protocol and new technologies to further enhance the mobile experience.

In contrast, the new 4G framework to be established will try to accomplish new levels of user experience and multi-service capacity by also integrating all the mobile technologies that exist (e.g. GSM - Global System for Mobile Communications, GPRS - General Packet Radio Service, IMT-2000 - International Mobile Communications, and Wi-Fi - Wireless Fidelity, and Bluetooth).

In spite of different approaches, each resulting from different visions of the future platform currently under investigation, the main objectives of 4G networks can be stated in the following properties:

Ubiquity means that this new mobile networks must be available to the user, anytime, anywhere. To accomplish this objective services and technologies must be standardized in a worldwide scale.

A **multi-service platform** is an essential property of the new mobile generation, not only because it is the main reason for user transition, but also because it will give telecommunication operators access to new levels of traffic. Voice will lose its weight in the overall user bill with the raise of more and more data services.

Low-bit cost is an essential requirement in a scenario where high volumes of data are being transmitted over the mobile network. With the actual price per bit, the market for the new high demanding applications, which transmit high volumes of data (e.g. video), is not possible to be established.

2.3. MOBILE COMPUTING

Mobile Computing is a technology that allows transmission of data, via a computer, without having to be connected to a fixed physical link. The term "Mobile computing" is used to describe the use of computing devices, which usually interact in some fashion with a central information system--while away from the normal, fixed workplace. Mobile computing services can be provided for the specific purposes and its cost varies from company to company.

Additionally, there are customized mobile computing solutions that are designed for the different commercial fields like health care, business, education, pharmaceutical, IT and service providers. Mobile systems Facilitate business operations such as marketing, sales, provision of information and services, organizational procedures and processes and transaction of money. On a case study made on economic and social impacts of mobile phone in Bangladesh, the following are found. (Barney, Susan, David, Josie, Ioanna, 2006)

- Almost a quarter of a million Bangladeshi depend on the mobile industry, directly and indirectly.
- Mobile services contribute US\$650 million to the economy every year.
- Mobile services are good value for money when compared with other countries.
- Mobile communications allow businesses to operate with greater efficiency.
- For every additional 10 percentage points of mobile penetration, the annual GDP growth rate is increased by approximately 0.6%.
- Higher mobile penetration will assist Foreign Direct Investment (FDI). Increasing penetration by 1% increases FDI as a proportion of GDP by 0.5%.
- The poorest citizens benefit most from mobile services.
- Mobile services improve social cohesion, assist in reducing the digital divide, improve access to healthcare and can help improve users' quality of life.

2.3.1. M-Health initiatives globally

WHO (World Health Organization) has 112 members globally. From these, 83% reported at least one health care initiative in their country. Africa, which accounts about 70%, has the lowest initiative. The most frequently reported types of mHealth initiatives globally were health call centres (59%), emergency toll free telephone services (55%), emergencies (54%), mobile telemedicine (49%), health survey (26%), surveillance (26%), awareness raising (23%) and decision support (19%). (World Health Organization, 2011)

2.3.2. Challenges and remedies to M-health

Although M-health has a growing demand, the solutions come with their own advantage. Some of the challenges to M-health are summarized as follows. (Modi, 2015)

Confidentiality of data

Security and safeguarding of personal are obvious concerns of health care industry. Poorly developed applications, compliance with health insurance portability and accountability, proper regulation, definite rules and policies to ensure protected Health information data (PHI) is handed correctly.

Market volatility

The rapid evolvement nature of market and consumer habits, the demand of users can be on unpredictable base on latest trends. So, it is critical to stay current and refresh apps often.

Innovation

While mobile devices offer many ways for healthcare players to interact with consumers, such innovations are sometimes exploited. Innovative ideas demand wider participation and appreciation.

Integration with existing IT system

Latest M-Health technologies need to be properly researched and all the gaps during integration need to be addressed.

2.3.3. “MOTECH” or “MOBILE MIDWIFERY”

“MOTECH” or “MOBILE MIDWIFERY” (Wood, 2012) is a mobile based application developed in Ghana which sends both SMS and voice messages to pregnant women and their families about prenatal treatment and breastfeeding songs. It sends information specific to the women, alerts and reminds about treatments like appointment, Vaccination ...etc. At first it registers each woman in person, provides a toll free MOTECH ID and once the client sends a confirmation and the communication is established, a message sending continues. A message is also sent to the nurses about the appointments their clients have at the beginning of the week. A monthly report can also be generated automatically. Clients make a missed call to a toll free number and a call will be returned to them.

Generally, this system is very helpful in handling cases related to maternal mothers. However, there is no way to handle multiple calls, when the number of clients gets a larger number.

It is not possible to identify which missed call is prioritized as more emergency than the other one. The information flow is from the system to clients and not from clients to system.

2.3.4. “WIRED MOTHER SOFTWARE”

A “WIRED MOTHER SOFTWARE” (Lund, 2014) was developed in Zanzibar to automatically generate and send text messages to registered phone numbers throughout the pregnancy to until six weeks after delivery. At first a physical visit to each pregnant mother is made and every information is manually collected and communication is established. The content of the messages were developed by a team of international researchers and local partners from the Ministry of Health in Zanzibar.

Message content was standardized with neutral phrasing and provided as simple text in the local language of Swahili. In addition, primary health care facilities randomized for intervention and hospitals were provided with a mobile phone to improve timely referrals between different levels of the health system and to enable health workers in the periphery of the health system to consult patients with higher levels of care.

To further improve access to emergency obstetric care, communication and referral links wired mothers were given a phone voucher with modest credit and a card with the phone number of her local primary health care provider allowing all wired mothers to communicate directly with primary health care providers.

In this system, the literacy level of the mothers is not considered. Some communications are expected to be made by the mother using the mobile phone. A call made to local primary health worker is made manually.

When the number of mothers increases it may be difficult to get sufficient number of health worker unless a priority system is pre-established. There is no mechanism to minimize emergency situations until the mother make a call.

2.3.5. MAMI Care

MAMI Care System is developed for the rural area of Mexico. (Lavariega, 2013). It is connected to simple mobile devices such as stethoscope, Doppler, Oximeter, Glucometer, and ECG, which are used to collect vital signs of a pregnant mother by a social worker and registered in a tablet computer locally. On the other side, the physician gets a summary of this report remotely and makes decisions accordingly.

Some of the environments included in this system are: Android, Wi-Fi, 3G or 4G, Tablet computer, vital sign registration devices.

This system has a major contribution in avoiding the leading causes of maternal death associated with hypertension, haemorrhages, and other complications of delivery. More reliable data is transferred from Home to Health stations. However, most of the requirements of this system are not easily affordable for the majority of the people.

2.3.6. “VIRTUAL MATERNITY CARE”

“VIRTUAL MATERNITY CARE” (M.Gill, 2011) developed by Cisco Internet Business solutions Group (IBSG) after evaluating experiences of several leading organizations around the world who already have begun to move components of their maternity services online such as, text4baby (U.S.), NHS Choices (U.K.), Remote video (Australia and U.S.), Baby Mobile (Netherlands) and Net Clinic (Finland).

This study considers provision of maternity services for many people who are familiar with the Internet, email, texting, Face book, Twitter, and other online means of communication. In Ethiopia, there are of course about 4 million Face book users from the total of about 99 million people (The internet Coaching Library, 2015). Most of these services are delivered and integrated with other similar services online. This kind of systems is well suited for developed countries. In Ethiopia, we need a different system.

2.3.7. “MATERNITY-HEALTH”

“Maternity-Health” (Wikedzi, 2014) is a system analysis and design case study of Maternal Health M-Service in Tanzania. This Study raises two contrasts. The first one: Mobile phones are less inhibited by traditional access barriers that hinder the widespread use of many other communications technologies including geography, socioeconomic status, infrastructure such as electricity and literacy.

The second thing, Despite the fact that Mobile Service projects have proven to be a potential way for disseminating information to people, they are challenged by cost of service which is directly affecting sustainability of such services. As a solution, non commercial Mobile-Service, which integrates advertising functionality as a tool for subsidizing the cost of operating Mobile-Services is presented. A prototype of Maternity-Health is used for the study.

The question of financial sustainability and ultimately “Who pays?” poses persistent challenges and barriers to scale and investment in such projects.

MAMA Project in Tanzania was a similar project which has been reported to be failed. A report by maternity Health Alliance on usage of mobile phone applications for disseminating information indicated that, at present, the majority of M-Services, particularly in low and middle-income countries are dependent on donor funding. Therefore, the solution presented in this article is better approach in minimizing the chance of failure of such projects. USSD (Unstructured Supplementary Service Data) is the approach chosen. The limitation USSD has in listing all possible questions mothers could have at different maternal periods, is one of the gaps observed in this study.

Pregnant mother should be followed for every symptom she feels each day. No symptom should be ignored without the knowledge of maternal health professionals. To list all possible symptoms, we need a better way.

Advertisement messages followed by every single question make the system difficult. Through time, every advertisement sent may be ignored by the end users. The sponsors will get demotivated and the cost of operation will still fall into question. How many mothers send how many questions each day? And how many doctors respond to this? How emergency questions are addressed? Without an intelligent system intervention this will not be feasible especially in Africa. (Wikedzi, 2014)

2.3.8. EVIDENCE BASED MATERNITY CARE

Evidence based maternity care (Sakara & P.Corry, 2008) uses the best available research on the safety and effectiveness of specific practices to help guide maternity care decisions and to facilitate optimal outcomes in mothers and newborns. Although the field of pregnancy and childbirth pioneered evidence based practice, resulting in a wealth of clear guidance for evidence based maternity care, there remains a widespread and continuing underuse of beneficial practices, overuse of harmful or ineffective practices and uncertainty about effects of inadequately assessed practices.

Evidence based maternity care gives priority to care paths and practices that are effective and least invasive, with limited or no known harms whenever possible. Evidence based maternity care are especially important in consideration of the sensitive prenatal development period, the potential for long-term beneficial and adverse health effects and unintended consequences of possible exposure.

To implement these principles and to help guide maternity care decisions, decision makers need access to evidence about the safety and effectiveness of procedures, medications and other interventions.

2.3.9. IMPACT OF MOBILE PHONE ON MATERNAL HEALTH CARE

According to this study done by *A case of Njoro Division* which sought to establish whether use of mobile technology can increase antenatal service utilization and hospital deliveries in two health facilities in Njoro Division, Nakuru County in Kenya, Physical Access to maternal care is limited due to cost, poor roads, distance, and lack of proper information, inadequate staff and supplies among others (Fedha, 2014).

The emergence of mobile telephone technology has improved service delivery, information transfer, businesses, banking and changed ways people communicate in the world.

The most common activity is creation of call centres which respond to patient inquiries, and later there are Short Message Texts (SMS) which advise and alert clients on appointments, when to take medications and assessing treatment compliance etc. This study shows a high percentage of women attending antenatal clinic have mobile phone.

There was a positive correlation between women in study group and the number of antenatal visits before delivery is 96.4%, provision of counselling services in HIV 95.3%, diet counselling 95.3%, place of delivery 75.9 those who received tetanus 100% iron 91.6% vitamin supplements 39.8% anti-heliantus 74.3%.

Generally, the number of women who had been followed up that delivered in hospital was significantly higher than those who did not receive mobile telephone support *i.e.* 88.0% and 72.8% respectively. But once we decided to use mobile phone to support the follow up and treatment process of maternal mothers, we could see more result than this.

2.3.10. MOBILE PHONE BASED PREGNANCY SUPPORT SYSTEM

This paper presented the framework and prototype of mobile phone based pregnancy system based on preliminary study conducted among the pregnant mothers and their spouses in a local private hospital and few maternity clinics (JAYANTHY MANIAM, 2012). This study provided the basis for the personalized and localized content development for mobile phone on the health care for pregnant mothers, due date calculation, calendar, and growth of fetes, complications, medication, drug and health alerts.

Mobile phone based pregnancy support can position itself as a major breakthrough approach to educate women on pregnancy, monitor their own and child's progress, follow up with medical checkups, critical updates and post-delivery support through mobile phone. This will reduce the anxiety and stress among pregnant mothers. Women in rural area can benefit through this system greatly by preparing for childbirth and post-delivery.

2.4. SUMMARY OF LITERATURE REVIEW

NO.	Author	TYPE OF LITERATURE	THE MAIN IDEA OF THE LITERATURE
1.	(Cox, 2008)	Mobile Telecommunication system	• Core network contains switches, which send information from one phone to another. It contains database of subscribers and bills, It also monitors locations of mobile phones • The radio access network handles the communication between core network and the mobile phone. It contains large base stations each of which transmits and receives radio signals
2.	(Kahabka, 2004)	Global system for mobile communications	• Contains Mobile station, base station and network subsystem • Mobile station is handset containing Subscriber Identity Module
3.	(MorganDoyle Limited, 2004)	General Packet Radio Services	• Mobile data over GSM, which is a step towards 3G
4.	(Tutorials Point (I) Pvt. Ltd., 2015)	CDMA (Code division Multiple Access)	• Better capacity for voice and data communication

5.	(Pereira, 2004)	Third mobile generation networks (3G)	• High speed over 2G • Roaming worldwide connection • High capacity
6.	(Pereira, 2004)	Fourth mobile generation technology	• Ubiquity (anytime, anywhere), multi-service platform, Low-bit cost
7.	(Barney, Susan, David, Josie, Ioanna, 2006)	Mobile computing	• Facilitate business, marketing, sales, information, services
8.	(World Health Organization, 2011)	M-Health initiatives globally	The most frequently reported types of mHealth initiatives globally were • health call centers; • emergency toll free telephone services, • emergencies, • mobile telemedicine, • health survey, • surveillance, • awareness raising and • decision support
9.	(Modi, 2015)	Challenges and remedies to M-health	Challenges are confidentiality of data, market volatility, innovation, integration with existing systems and we should take in to account in any M-health development
10.	(Wood, 2012)	Mobile Midwifery	• Sends specific SMS, voice and breastfeeding songs to pregnant women and nurses and reminds appointment, vaccination • Accepts toll free missed calls • There is no way to handle multiple calls, when the number of clients gets a larger number. • <i>No priority system</i> • <i>Very less interactive</i> • <i>No intelligent system</i>

11.	(Lund, 2014)	Wired mother software	• Automatically generate and send text messages in local language • <i>A call to local primary health care is made manually, not automatically</i> • <i>No priority system</i> • <i>No intelligent system</i>
12.	(Lavariega, 2013)	MAMI Care	• Under construction to be developed for Rural area in Mexico • Mobile medical home equipments to collect vital signs working in Android, Wi-Fi, 3G, Tablet • Not available and not affordable by low income people
13.	(M.Gill, 2011)	Virtual Maternity Care	• Integration of advanced mobile phone based systems • To be used by people who are familiar with email, texting, face book, twitter • This kind of system are well suited for developed countries
14.	(Wikedzi, 2014)	Maternity Health	• USSD based system to better use the mobile phone opportunity to maternal mothers with advertisement enabled system to cover cost of operation by sponsors • All limitations of USSD in following every major symptom a mother feels lacks here and every possible question a mother could have can't be sent • No intelligent system intervention exist
15.	(Sakara & P.Corry, 2008)	Evidence based maternity Care	• Uses best available researches on safety and effectiveness of specific practices to help guide maternity care decisions
16.	(Fedha, 2014)	Impact of mobile phone on Maternal health	• This is a study in Kenya to make sure if mobile phone has improved antenatal service and hospital delivery • Most women do have mobile phone and using phone for maternity care has a positive correlation

17.	(JAYANTHY MANIAM, 2012)	Mobile phone based pregnancy support system	• This system provided basis for pregnant mothers due date calculation, calendar, and growth of fetus, complications, drug and health alerts • This is just a standalone education application
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Table 1 Summary of Literature Review

CHAPTER THREE

DESIGN AND METHODOLOGY

3.1. Research Design and methodology

3.1.1. Study Area

3.1.1.1. Overview of Gandhi Hospital maternal information system

Data Flow Diagram of Smart Care system of Gandhi Hospital

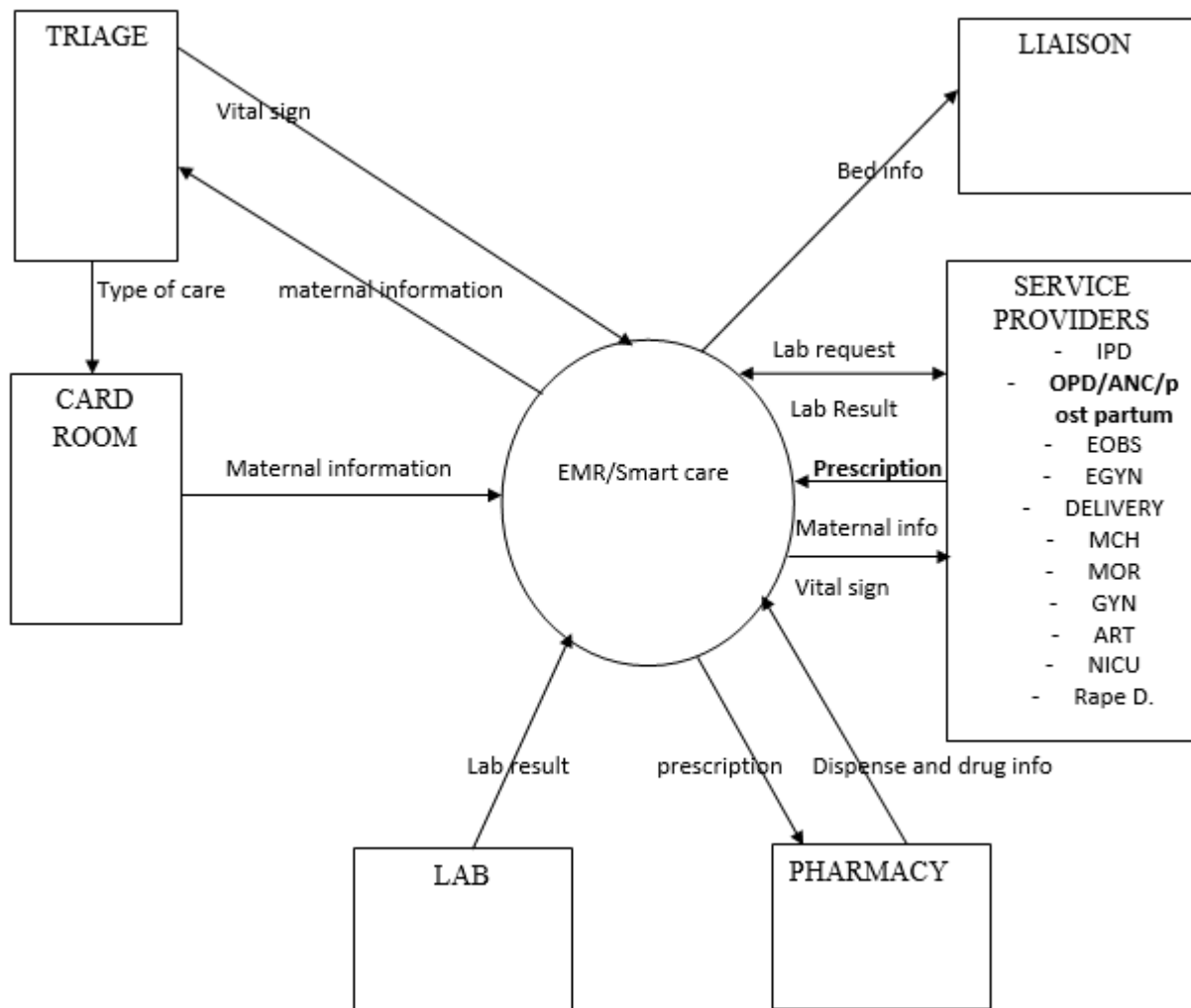


Figure 7 SMART Care System

The process of maternal mother treatment and follow up at Gandhi hospital starts from TRIAGE. At this place the type of case to be taken is identified. Cases include follow up, emergency, delivery, etc. Mother is given a small card from triage containing the department she should head to. They take the small card with them to the card Room, a place where full maternal and personal information about mothers is taken and filled in to the Smart care system. The information contained in the smart care system again goes to the triage room for further vital sign checkup. The vital signs taken from the mother is fed in to the system.

This information waits a Queue to the department at the service providers the mother is assigned to. As part of the diagnosis process, the department undergoing the treatment of the mother may send blood and other tests to Laboratory using the smart care system. The test results are also sent back to the department using the system. After all the diagnosis is done, the department writes prescription for Pharmacy from which the mother buys her medicine or the department sends an information to the In Patient department from which the Liaison takes bed information for the mother.

3.1.2. Methodology of the study

This research used applied research methodology. According to (Rajasekar, Philominathan, & Chinnathambi, 2013), in an applied research one solves certain problems employing well known and accepted theories and principles. Most of the experimental research, case studies and interdisciplinary research are essentially applied research. Applied research is helpful for basic research. A research, the outcome of which has immediate application is also termed as applied research. Such a research is of practical use to current activity. For example, research on social problems has immediate use. Applied research is concerned with actual life research.

In this research the researcher uses existing computing technology in order to solve practical problem. Mobile computing is well known wireless technology used in different sectors for different purposes. Mobile computing enabled maternity care and follow up system is one of the applications this research is concerned to solve a practical social problem of the society. Maternal health is a national as well as a global problem which needs to be addressed by all stake holders.

3.1.3. Study Population

The organization selected for this study is Gandhi Memorial Hospital which is one of the Hospitals controlled by the Federal Ministry of Health of Ethiopia. Gandhi is chosen for this research because it is the only fully engaged governmental Maternity hospital in Ethiopia.

Based on Gandhi's organizational structure, the total number of health professionals in the hospital is 199.

From these, Midwives are 25. Midwives are fully engaged in the follow up process of maternal mothers. All the midwives are asked the questionnaire. Midwives will remain the focus of this research.

For this research, the researcher has used purposive sampling. According to (Palys, 2008) from the type of purposive sampling methods, Typical case sampling is chosen. In this type of sampling, population directly related with the research case are selected. Since the research is about making sure mobile based maternity follow up and intelligent treatment system works in Gandhi hospital, all the midwives are target groups of the questionnaire. And one sample from each health professionals other than midwives is selected.

3.1.4. Data Collection Procedure

Firstly, the researcher observed the existing system at Gandhi. Then interview sessions were conducted with ICT staff of the Hospital about the existing system and their expectations from the new mobile system. The interview also used as an input for the development of questionnaire. Finally, a questionnaire survey was conducted. The questionnaire contains choices, open-ended and close-ended questions.

The purpose of the questionnaire was:

- To have a knowledge of Gandhi staff's experience in treatment and care of maternal cases with and without using the information technology tool
- To identify where to start and how to start this research
- To understand Gandhi staff's opinion towards the system recommended in this research.

The questionnaire is divided in to five parts. The first part is about field of the staffs and the professional experience they have. The second part is about maternal health and information technology. In this part, the experience of the staff with information technology and if they in case have ever used information technology tool for medical purpose is assessed. The third part is maternal health related. All information related to maternal mothers before and after delivery which will be input to knowledge base is collected from experts. The fourth part is about the current situation of maternal mothers in Gandhi Hospital.

This includes follow up habit of mothers. The last and the fifth part is about the attitude of the Gandhi staffs about the future of the system.

Another official document used by Gandhi hospital which has been input to this research is, “*management protocol on selected obstetrics topics*” which is provided by the Federal Democratic Republic of Ethiopia Ministry of Health.

3.1.5. Data Analysis Procedure

In this section, the findings from the observation, interview, documents and questionnaire survey are systematically analysed. The quantitative data collected mainly through questionnaire from the users answer were fed in to Statistical Package for Social Scientists (SPSS) for analysis. Analysis was made for categorical data and Interval data. Graphs were used for further analysis. Simple descriptive statistical tools such as percentage, frequency, mean and standard deviation were used to analyse the survey data.

Qualitative data were analysed manually. Most of the qualitative data are input to the knowledge base and are compared with each other and answers from highly qualified and more experienced health professionals are taken as bases for all other answers.

3.1.6. Validity and reliability of data

In order to make sure the reliability and validity of data, the steps followed include;

- The consistency of data collected in different methods,
- Accurate representation of the total population in Gandhi Hospital,

- Making sure the questionnaire to be collected with the presence of ICT staffs of the Hospital, who already have introduced with the concept of the new system and the researcher himself to make the questions more clear.

Depending on the organizational structure of Gandhi Hospital, all medical staffs of each department have been represented. This includes Health assistants, Clinical Nurses, Midwives, Health officers, General Practitioner Doctors, Gynaecologists. Accordingly, data collected from different fields of each department has shown high level of consistency.

On the other hand, to make the medical staffs give more attention when they fill in the questionnaire, the ICT department of the Hospital were participating in person with the medical staff during the questionnaire is filled.

3.2. System design and methodology

3.2.1. Tools used for Simulation of the new system

3.2.1.1. Genymotion

Genymotion is an Android emulator which comprises a complete set of sensors and features in order to interact with a virtual Android environment. Genymotion helps to test Android applications on a wide range of virtual devices for development, test and demonstration purposes. Genymotion is fast, simple to install and powerful thanks to user-friendly sensor widgets and interaction features. It is available for Windows, Mac OS X and Linux operating systems.

To run this virtual device, the researcher used Oracle VM Virtual Box 5.0.4. For installation, updates and services provided by the Genymotion website, the researcher has used Google chrome web browser.

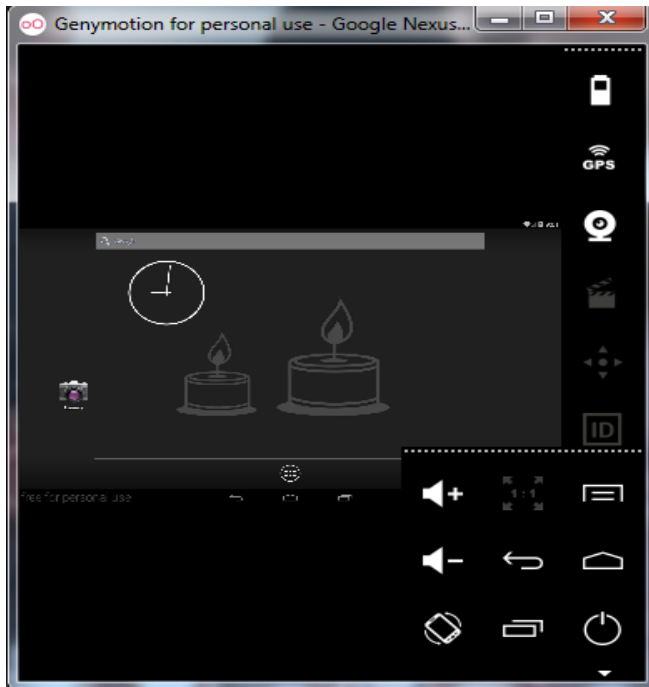


Figure 8 Genymotion Android phone emulator

3.2.1.2. WAMP server

WAMP server is a Windows based web application development environment. It allows creating web applications with Apache, PHP and MySQL data base. WAMP server automatically installs the essential elements used to develop web based application. For this research, the researcher has used this Server.

The benefit of WAMP server is being able to develop and test scripts locally. WAMP stands for **W**indows **O**perating system, **A**pache, **M**ySQL and **P**HP. WAMP server is Open Source and free to use, which is very nice opportunity for this experiment. WAMP server even includes great graphical tool, phpMyAdmin, which helps handle the administration of MySQL. (Bragg, 2012)

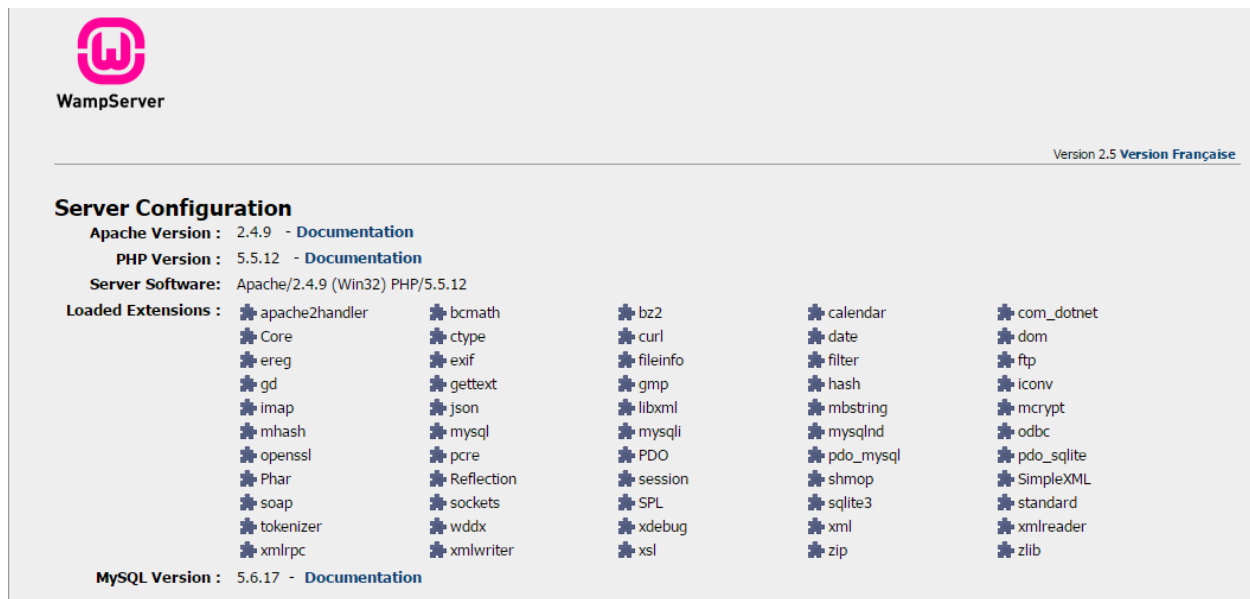


Figure 9 WAMP interface

PhpMyAdmin is a free software tool written in PHP, intended to handle the administration of MySQL over the Web. PhpMyAdmin supports a wide range of operations on MySQL over the web. PhpMyAdmin supports a wide range of operations on MySQL and MariaDB. Frequently used operations (managing databases, tables, columns, relations, indexes, users, permissions, etc.) can be performed via the user interface, while having the ability to directly execute any SQL statement. (Contributers, 2003-2016)

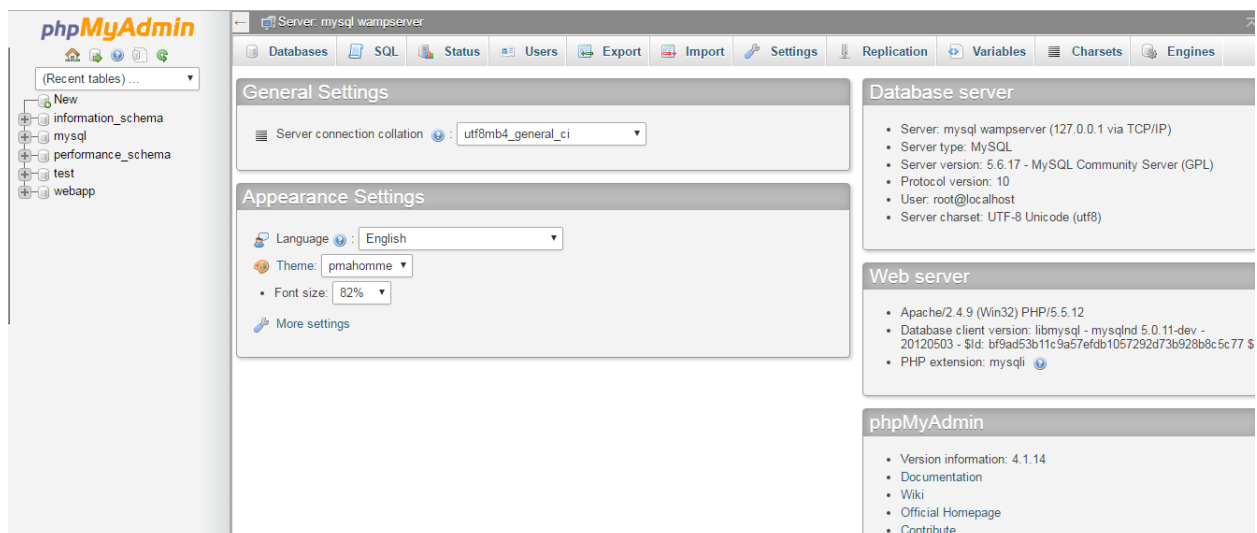


Figure 10 PHP My admin Interface

3.2.2. Programming tools

3.2.2.1. Android application development

Android is a mobile operating system that is based on a modified version of Linux. It was originally developed by a startup of the same name, Android, Inc. In 2005, as part of its strategy to enter the mobile space, Google purchased Android and took over its development work (as well as its development team). Google wanted Android to be open and free; hence, most of the Android code was released under the open-source Apache License, which means that anyone who wants to use Android can do so by downloading the full Android source code. Moreover, vendors (typically hardware manufacturers) can add their own proprietary extensions to Android and customize Android to differentiate their products from others. This simple development model makes Android very attractive and has thus piqued the interest of many vendors. This has been especially true for companies affected by the phenomenon of Apple's iPhone, a hugely successful product that revolutionized the smart phone industry. Such companies include Motorola and Sony Ericsson, which for many years have been developing their own mobile operating systems. When the iPhone was launched, many of these manufacturers had to scramble to find new ways of revitalizing their products. These manufacturers see Android as a solution — they will continue to design their own hardware and use Android as the operating system that powers it. The main advantage of adopting Android is that it offers a unified approach to application development.

Developers need only develop for Android, and their applications should be able to run on numerous different devices, as long as the devices are powered using Android. In the world of smart phones, applications are the most important part of the success chain. Device manufacturers therefore see Android as their best hope to challenge the onslaught of the iPhone, which already commands a large base of applications. Due to these and other advantages, the researcher has used Android for the experiment of the system.

3.2.2.2. Java Development Kit (JDK)

A java development kit is a program development environment for writing java applets and applications. It consists of a runtime environment that sits on top of the operating system layer as well as the tools and programming that developers need to compile, debug, and run applets and applications written in the java language.

CHAPTER FOUR

DATA ANALYSIS AND DISCUSSION

4.1. Introduction

In this section, the responses to the questionnaires that were handed out to Health professionals at Gandhi Hospital are organized, compiled, analysed and interpreted. As well as used as input to the design and view of the new system. Most of the Questionnaires were gathered in the presence of the researcher. This guarantees validity. Therefore, interviews were also conducted alongside the questionnaire. This report therefore includes the interview. Some report and performance documents are also analysed.

4.2. Respondents' Data

A total number of 24 responses (100 % response rate) from the health professionals of Gandhi Hospital and few from Entoto Health centre were found valid and included in the analysis. The average work experience of the respondents is 7.21. This means we do have enough work experience to accept the answers.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Clinical Nurse	10	41.7	41.7	41.7
	Doctor	2	8.3	8.3	50.0
	Gynaecologist	1	4.2	4.2	54.2
	Health Officer	2	8.3	8.3	62.5
	Midwifery	9	37.5	37.5	100.0
	Total	24	100.0	100.0	

Table 2 Field of Specialization of the respondents

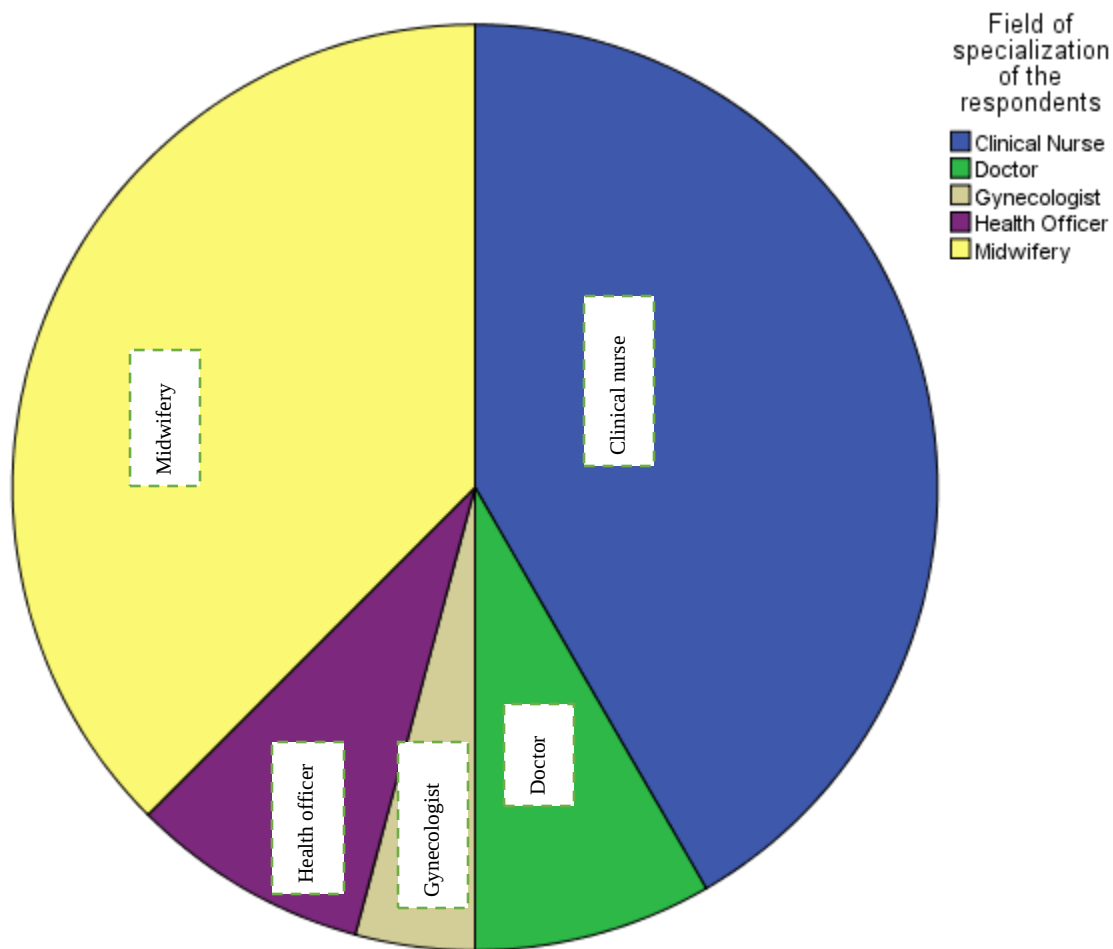


Figure 11 Field of Specialization of respondents

According to the above table, most of the respondents are Clinical Nurses and Midwives. This is because the case of this research is related to follow up and treatment of maternal mothers in which these two professions are more responsible for.

According the observation of the researcher and the interview conducted in the Antenatal Care section of Gandhi Hospital, maternal mothers come to visit their midwives and clinical nurses on the appointment date they received in the previous visit and take an appointment for the next visit. During this process, the responsible health professionals check the status of the mothers according to sign and symptoms and they provide advice.

4.3. Maternal Health and Information technology

If Ever used IT devices for maternal service

	Frequency	Percent	Valid Percent	Cumulative Percent
Both	1	4.2	4.2	4.2
Computer	5	20.8	20.8	25.0
Valid Mobile	1	4.2	4.2	29.2
None	17	70.8	70.8	100.0
Total	24	100.0	100.0	

Table 3 If ever used IT devices for Maternal Service

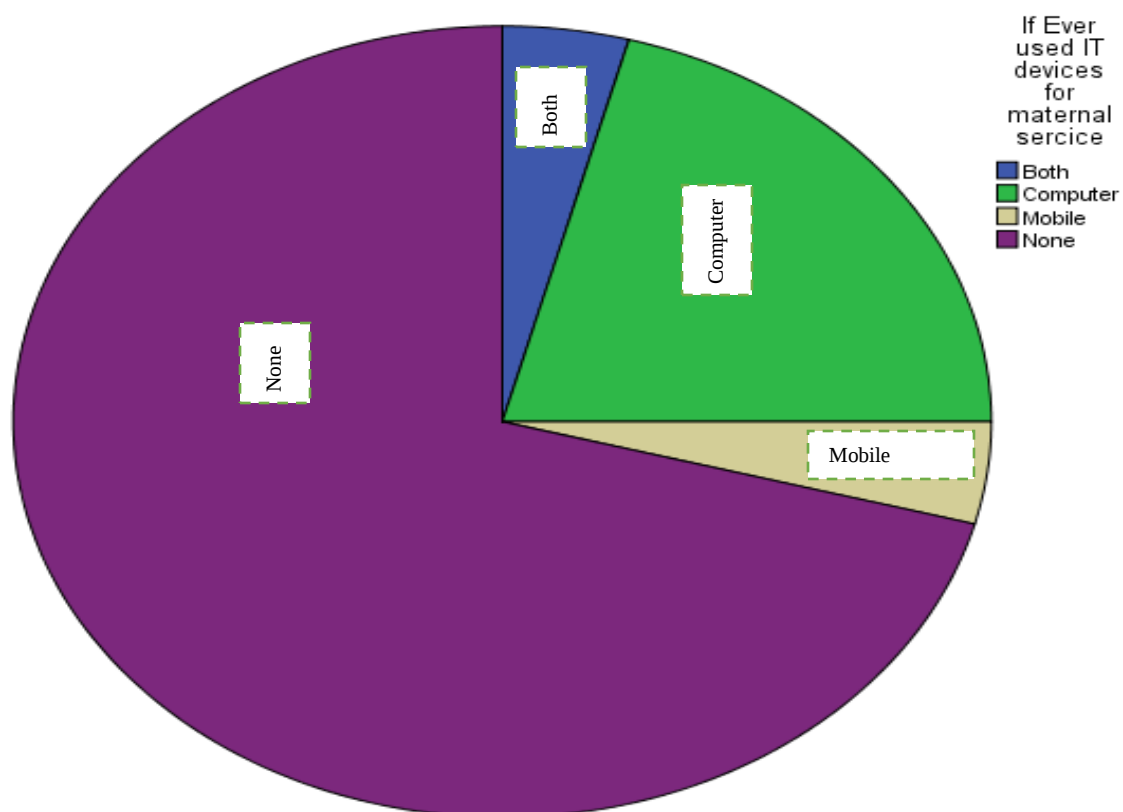


Figure 12 If ever used IT devices

Figure 13 shows that most of the respondents, about 71%, haven't ever used their computer and mobile phones for maternal service provision. Therefore, these technology resources are less used while being more powerful tools. Only 4% of the respondents used mobile phone in relation to maternal service. The only time mobile phone was used is during a pilot project implemented in Entoto Health centre which was started and not working now. The concept of the project was to send messages for maternal mothers about their status using their mobile phone. The smart care system used by all the health professional staffs of the Hospital is not used for direct communication with maternal mothers. The daily status of maternal mothers is not communicated with the hospital using the existing technology.

Mothers speak their status to their respective Ante Natal Care department 4 times before birth and sometimes only when they feel strange symptoms. The number of visit and the type of care depends after the focused ante natal care form is filled by the triage room.

Even though few respondents use technology in the process of maternal care process, most of the respondents still are not using it to advice, follow up and knowledge reference related to maternal mothers.

Why respondents used the tools or devices

	Frequency	Percent	Valid Percent	Cumulative Percent
Advice	1	4.2	4.2	4.2
Follow sup	5	20.8	20.8	25.0
Valid Knowledge reference	1	4.2	4.2	29.2
None	17	70.8	70.8	100.0
Total	24	100.0	100.0	

Table 4 Why Respondents used IT tools

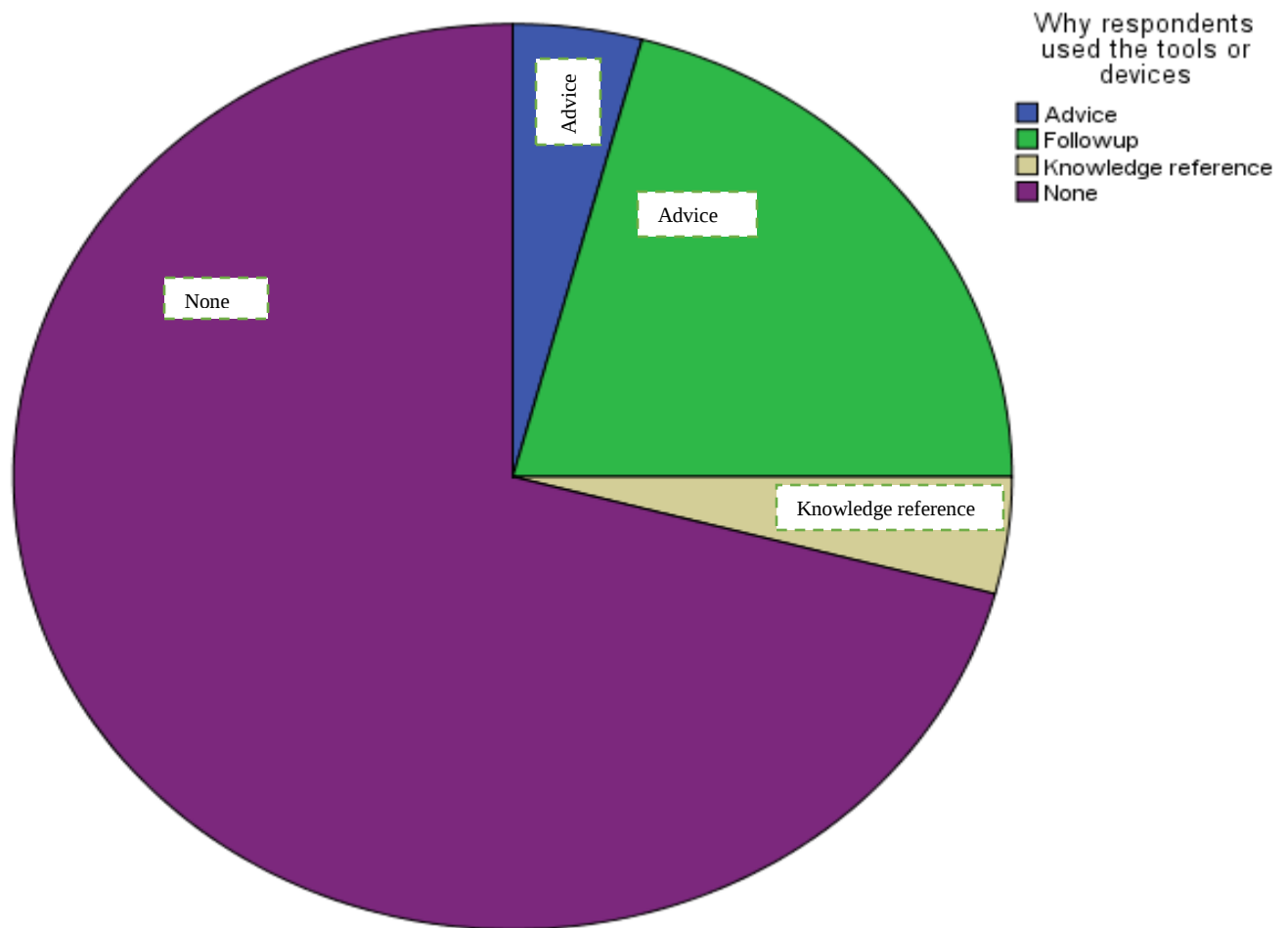


Figure 13 The reason respondents used tools or devices

According to the above table and figure 13, about 71% of the respondents are not using their mobile phone and computer to follow up, advice or knowledge reference purposes. They have used their devices for other simple tasks such as, Calculating Expected Delivery Date, allocating TRIAGE section for patients. This is because Health professionals in Gandi have not experienced use of these tools for maternity. M-health doesn't exist in Gandi hospital.

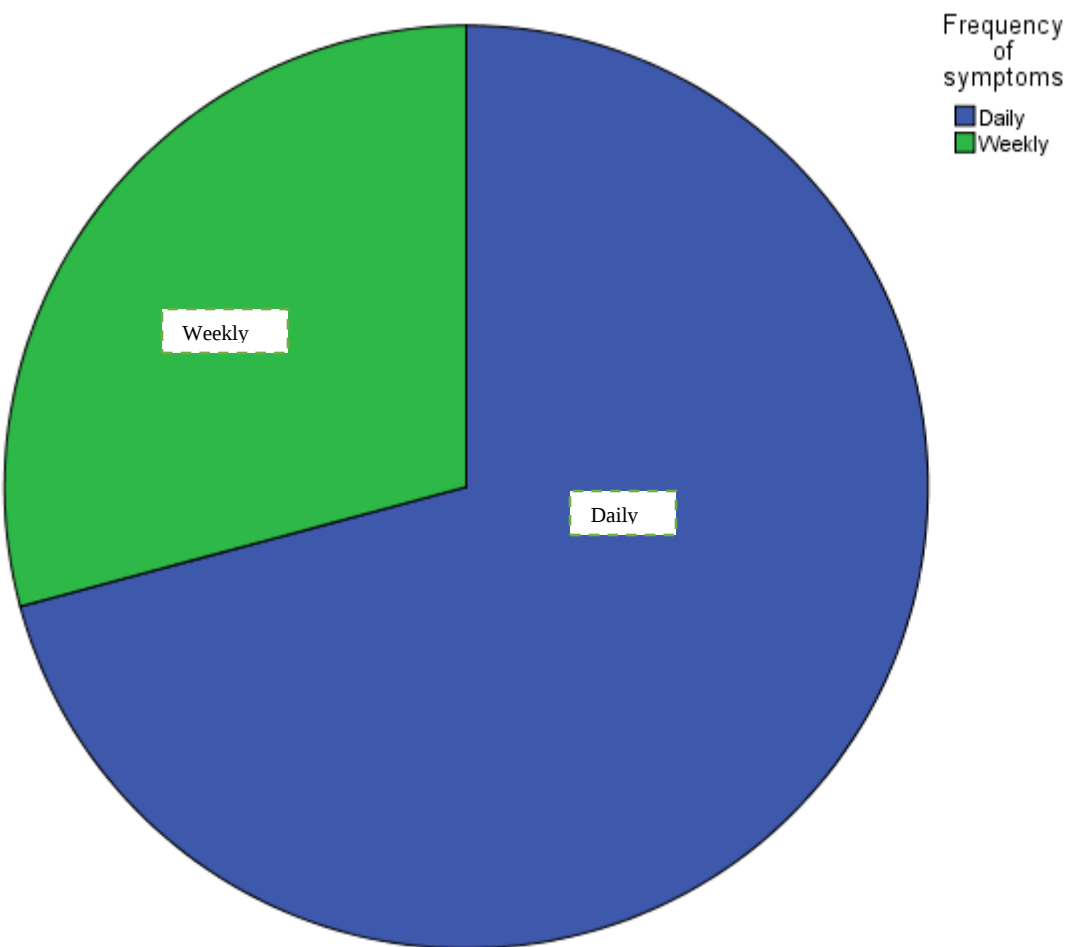
4.4. Maternal Health Related Issues

What is the frequency of maternal symptoms observed by maternal mothers before and after delivery? If this experiment becomes successful, how often should maternal mothers send the symptoms they feel before and after delivery to the central server? As shown in the following table, most of the health professionals recommend if the mother reports her symptoms in daily basis.

Frequency of symptoms

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Daily	17	70.8	70.8
	Weekly	7	29.2	100.0
	Total	24	100.0	

Table 5 Frequency of Symptoms



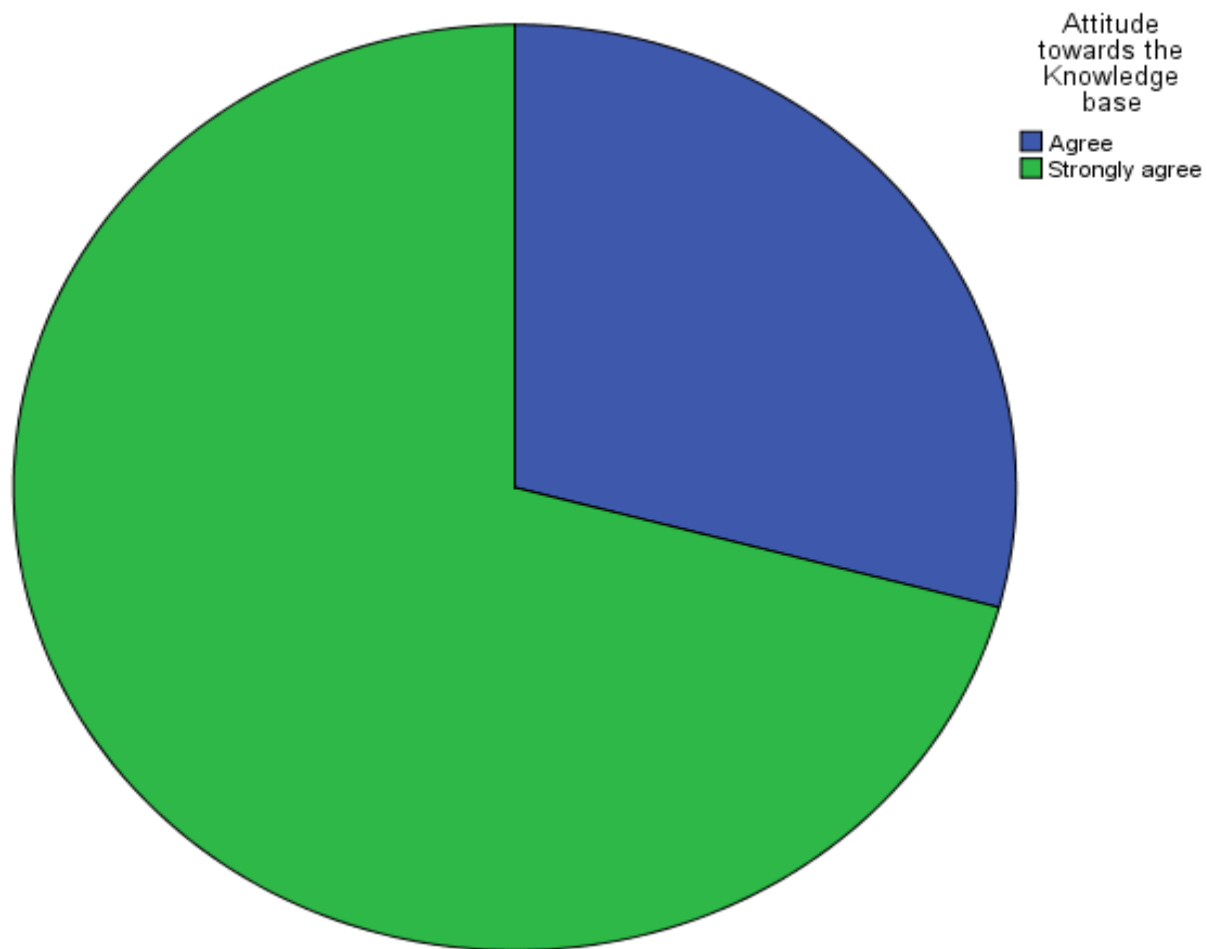
Among the respondents who recommended a weekly follow up, most of them responded that the number or frequency of maternal visit depends on the situation of the maternal mother.

66.7 percent of most experienced respondents, whose work experience is more than 20 years, recommended daily follow up of maternal mother, is very necessary. To make a daily follow up, we should necessarily need and M-health intervention.

On the other hand, 77.8% of Midwives, whose basic job is to follow up and care for maternal mothers, recommended daily follow up of maternal mothers, is necessary. Even though weekly follow up is needed we still need M-Health intervention.

This case clearly shows difference between respondents in the same hospital. In other words, there is inconsistency among the staffs of the hospital during maternity care and follow up before and after delivery. To address this situation, one of the approaches pre stated in the proposal of this research is intelligence. An artificial intelligence system called Knowledge base system should be shared and referred by all the staff during follow up and care service. This knowledge base system provides consistent recommendation and advice to all the staff. When the mother submits her situation using her mobile phone, the sum total of all symptoms needs diagnosis to be made by the health professionals. When the number of mothers and the amount of symptoms increase, decisions may fall in short of accuracy. Poor decisions result in dangerous outcome. This can be easily solved by knowledge base system. In knowledge base system, poor decision will not exist because of the knowledge provided by the knowledge base is shared by all health professionals in the hospital.

In this study respondents are also asked the attitude they have towards knowledge based system. Accordingly figure 14, presents the attitude of respondents for the knowledge based system. As shown in the figure, no one disagrees about the benefits of knowledge base system in maternity issues.



The other thing is the knowledge gap between more experienced and highly educated health professionals. The more experienced and highly qualified professionals make better decisions than the others. However, a Knowledge base system helps to improve this situation by providing consistent information among all health professionals.

Alongside the responses, interviews were also conducted about this issue. The interview includes why the respondents recommended daily follow up. The main reason is all symptoms may not be seen simply or ignored without the knowledge of health professionals. Any decision should not be made by maternal mothers. Some ignored symptoms such as; bleeding or leaking fluid from vagina; sudden or severe swelling in the face, hands or fingers; severe or long-lasting headaches; discomfort in the lower abdomen; may result in serious complications unless they get early knowledge of health professionals.

The same is true for health situations after delivery. The respondents who recommended daily approach before delivery also gave the same answer to the follow up approach that should be taken after delivery. Symptoms such as heavy bleeding that lasts more than few hours, large blood clots, fever, nausea, vomiting and sharp chest pain need great attention after delivery.

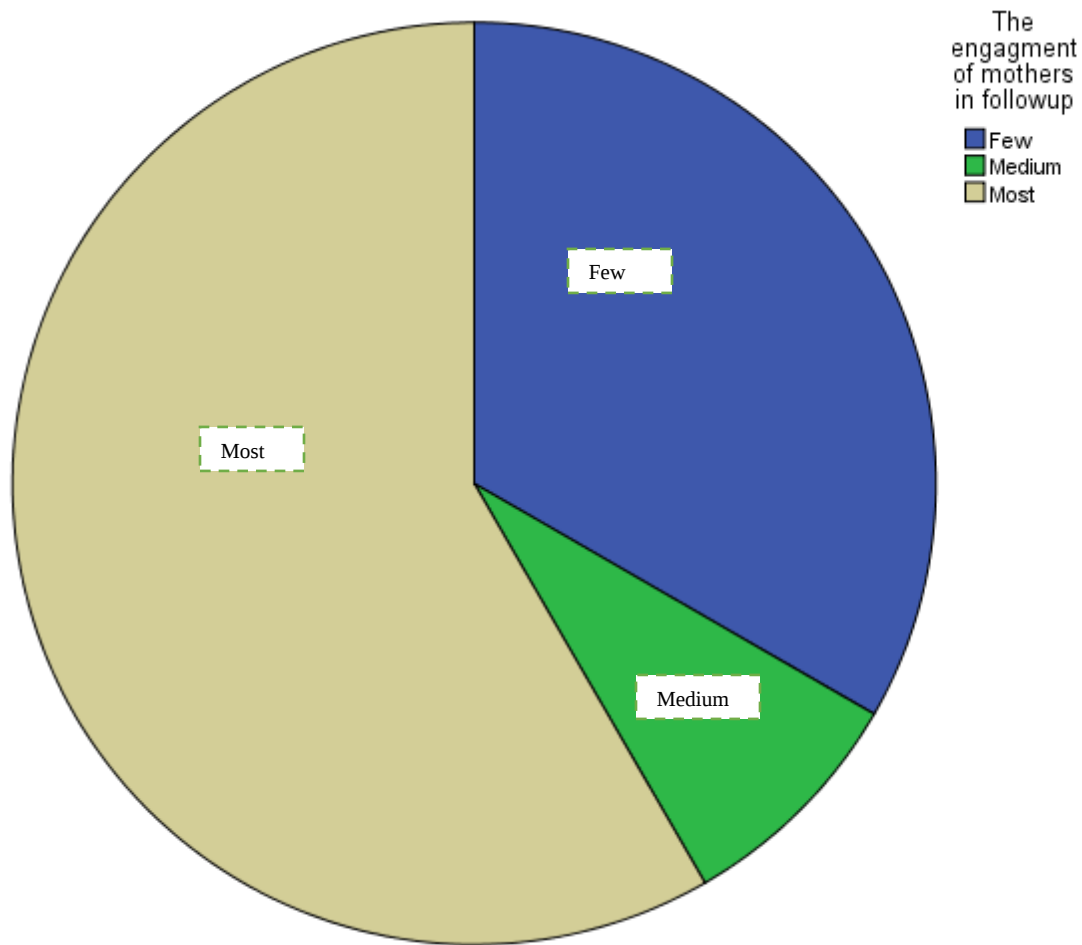
The question that comes with this kind of approach is the enormous amount of data that will be submitted by the mother which creates overload on the health professionals responsible to see the status. Even though there are serious symptoms which need better attention, there are also very normal symptoms which do not need much attention. Therefore whenever the data from the mother is sent to the central system, priorities will be sorted according to the level of danger the symptom has and the responsible health professionals are notified accordingly.

Concerning the motivation and awareness of mothers to attend the Maternity Care and Follow up process, more than 58% of the mothers are more engaged.

The engagement of mothers in follow up process before delivery

	Frequency	Percent	Valid Percent	Cumulative Percent
Few	8	33.3	33.3	33.3
Medium	2	8.3	8.3	41.7
Most	14	58.3	58.3	100.0
Total	24	100.0	100.0	

Table 6 Engagement of mothers in the follow up process before delivery



During the interview sessioin held with the respondents, they expressed that some of the maternal mothers even come for very minor things before the date of the shcheduled appointment. If they have had this new system at their home, they get optimum assistance from it.

Being the only fully engaged maternity Hospital in Addis Abeba City, and having 1 health professional to about 58 mothers ratio, the intervention of mobile phone enabled Ante Natal Care and Post Natal Care boosts the number of visits and the number of mothers to a significant amount.

4.5. Attitude towards the new system

Information technology will not be successful without the engagement of the stake holders. The engagement of the stakeholders is important because they most likely know the procedure of the system. They also recognize if the system really benefits mothers and the hospital. On the other hand, it is very important to make them feel the ownership of the system. In this case, the stake holders of this system are health professionals. After clearly understanding the roles of this system in the process of maternity care and follow up, as explained by the researcher, the responses of the respondents are shown in the following table.

Attitude towards the mobile system					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	24	100.0	100.0	100.0

Table 7 Attitude toward the new system

As clearly seen in the above table 8, all the stake holders of this system recognize that the mobile system is very supportive.

Concerning the knowledge base system, the respondents have the following say. The knowledge base system, after receiving the symptoms from mobile phone, performs clinical diagnosis and provides more information alongside the details of the mother.

Attitude towards the Knowledge base					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	7	29.2	29.2	29.2
	Strongly agree	17	70.8	70.8	100.0
	Total	24	100.0	100.0	

Table 8 Attitude towards the knowledge base

Figure 14 Attitude towards the knowledge base

As shown in the above table, most of the respondents strongly agree that the knowledge base system is very supportive. Some respondents respond that they agree. No one responded disagreement.

CHAPTER 5

DESIGNING MOBILE ENABLED KNOWLEDGE BASED SYSTEM

5.1. Knowledge Acquisition

The knowledge for this study is acquired from the health professional in Gandhi hospital through interview and a document from Ministry of Health which is used as a guideline for care and follow-up of maternity.

5.1.1. Current situation

Ante Natal Care, Post Natal Care and Delivery service are some of the major services provided by Gandhi Memorial Hospital.

- In the 9 months of the year 2008 E.C, the hospital planned to address 10, 458 **Ante Natal Care** and performed 11,695, which is 111% of the plan.
- The hospital planned to provide **Delivery** service for 5400 mothers and provided to 5336 mothers, which is 99% of the plan.
- The hospital planned to provide **Post Natal Care** for 2100 mothers and provided to 2270 mothers, which is 108% of the plan.
- From a total of 3,122,000 people living in Addis Ababa City, 1,080,212 are in an age range between 15-49 years, which is a range who can give birth.
- From this, number of expected pregnancy in Addis Ababa in 2013 was 72,743 (Federal Ministry of Health, 2013).
- Comparing this year's 9 months report of Gandhi Hospital with the data in 2013, the hospital has taken about 16% share of the total ANC in Addis Ababa.
- Comparing this year's delivery at Gandhi Hospital with the Skilled delivery attended in 2013, the Hospital takes about 10% of the total deliveries in Addis Ababa.
- Comparing this year's 9 months report of Gandhi hospital Post Natal Care report with 2013 report of Addis Ababa City, the hospital has 6% share of the Post Natal Care contribution.

The hospital has achieved very substantial success in its plans towards Ante Natal Care, Delivery and Post Natal Care services. From the data listed above, the number of Post Natal Care is only 19% of the total Delivery service provided. From this, we can conclude that most of the mothers who get delivery service from the Hospital stop their connection to the Post Natal Care services. Post Partum Bleeding and Post Partum infections contribute 15% and 8% respectively of maternal mortality (Wikipedia, 2016). Therefore, losing the connection with Delivered mothers has dangerous consequences. Mobile based system helps in extending the connection with mothers possible.

5.1.2. Focused Antenatal care

Concerning the sign and symptoms, the Ethiopian Ministry of Health has provided a Guiding protocol document. (Federal Ministry of Health, 2010). The purpose of antenatal care is to prevent, identify and treat conditions as well as help a woman approach pregnancy and birth as a positive experience. ANC is an opportunity to advise women and their families on how to prepare for birth and potential complications. During this time, the pregnant woman has the right to information about her health, discuss her concerns and thought, privacy confidentiality. (Federal Ministry of Health, 2010).

According to the document prepared by Federal Ministry of Health, pregnant women has the right to get information about her health, discuss her concerns, and know planned procedures in advance.

After the initial registration of the first care card, basic things about the mother will be available at the server side in the hospital.

The details of the first registration are shown in the following Table 6. If any one of the 19 questions responded “YES” means that the woman requires closer follow up or referral to specialty care and frequent visits.

The four more focused visits are clearly stated in the document. In each visit, details of every care and treatment are explained step by step. Objectives of the visit, Special Notes on the visit, Personal History, Medical History, Obstetric History, Physical examination, Laboratory tests, and Medical interventions, Advices, Questions, Answers and Schedule of the next visit and maintaining complete records are included.

The mobile based follow up system intervenes in this system by collecting daily or weekly clinical history of the maternal mother.

Whenever the mother goes to hospital for visit, her clinical history will already be well known by the health professionals. If the mother in case face unexpected health situation, the mobile system will already be in place to analyze dangerous signs using the knowledge base and alert to the responsible health professionals.

OBSTETRIC HISTORY	No	Yes
1. Previous stillbirth or neonatal loss?	☐	☒
2. History of 3 or more consecutive spontaneous abortions?	☐	☒
3. Birth weight of last baby < 2500g	☐	☒
4. Birth weight of last baby > 4000g	☐	☒
5. Last pregnancy: hospital admission for hypertension or pre-eclampsia/eclampsia?	☐	☒
6. Previous surgery on reproductive tract?(Myomectomy, removal of septum, fistula repair, cone biopsy, CS, repaired rapture, cervical circlage)	☐	☒
CURRENT PREGNANCY	No	Yes
7. Diagnosed or suspected multiple pregnancy?	☐	☒
8. Age less than 16 years?	☐	☒
9. Age more than 40 years?	☐	☒
10. Isoimmunization Rh (-) in current or in previous pregnancy	☐	☒
11. Vaginal bleeding	☐	☒
12. Pelvic mass	☐	☒
13. Diastolic blood pressure 90mm Hg or more at booking?	☐	☒
GENERAL MEDICAL	No	Yes
14. Diabetes mellitus	☐	☒
15. Renal disease	☐	☒
16. Cardiac disease	☐	☒
17. Chronic Hypertension	☐	☒
18. Known 'substance' abuse (including heavy alcohol drinking, Smoking)	☐	☒
19. Any other severe medical disease or condition TB, HIV, Ca, DVT..	☐	☒
A "Yes" to any ONE of the above questions (i.e. ONE shaded box marked with a cross) means that the woman is not eligible for the basic component of the new antenatal care mode and require more close follow up or referral to specialty care.If she needs more frequent ANC visits use and attach additional recording sheets		

Table 9 Initial Registration form of maternal mothers

Forexample:

If a mother sees one or all of the following symptoms mentioned on figure 15, a high level alert will be made to the server side, nearby health station or Ambulance service. Because, one of the symptoms indicates a readiness to delivery and staying longer in this situation leaves the baby and the mother at high risk.

Week 39	
✓	Leaking from Vagina
✓	Blood from vagina
✓	1 minute long contraction
	Back ache
	Head ache
Submit	

Figure 15 Look of the mobile interface

As the mother clicks the submit button, the information directly goes to the hospital server on which the mother first registered for maternity follow up. The information reaches the server as a complaint and for each complains, what to tell for the mother is already found in the knowledge base. Additionally, more information will be kept for the health professional responsible for the follow up of the woman in the form of management to be provided. This additional information helps the professional to make his own decision and send the woman a custom message or make calls depending on the urgency of the situation.

5.1.3. Common symptoms and remedies

Complaint	What to Tell the Client	Management Provided
Constipation	• Increase your water intake (8 glasses); • Eat high-fiber foods, and take daily exercise. • Use mild laxatives as a last resort	• Counsel the client on diet • Suggest mild laxatives only if the other measures have failed.
Headache	• Take mild pain relievers; <i>e.g.</i>, paracetamol. Avoid aspirin. • Inform provider if pain becomes severe. She should attend the health facility	• Determine that the headache is not a <i>Danger Sign</i> • Offer paracetamol (Panadol,) 300 mg every 3-4 hours. • For severe headache or migraine, offer codeine or other related narcotic might be used. • Remember headache can be associated with hypertension.
Backache	• Avoid excessive bending, lifting, or walking without a rest period. • Rock pelvic periodically during the day for relief. • Wear supportive, low-heeled shoes. • If severe, wear a maternity girdle for additional support. • Heat or ice to back for relief, whichever is more comforting.	• Counsel regarding comfort measures. • Remember: the Symptoms of UTI and onset of labor include backache.

Nausea and vomiting	• Eat small, meals frequently. Keep crackers at bedside and eat before getting out of bed. Eat fruit or drink fruit juice before going to sleep. • Avoid oily, spicy foods. • Get out of bed slowly. • Symptoms should not extend beyond the first three months; if severe and persistent; see your health care provider.	• Counsel about comfort measures. • Provide Vitamin B6, 50 mg, twice daily. • If symptoms are severe, refer for possible hospitalization and intravenous fluids. • Medications for management may include: - promethazine (Phenergan) - Diphenhydramine (Benadryl) –Other antihistamines • Birth defects have not been associated with the use of these drugs.
Varicosities	• Elevate legs periodically during the day. • Wear support hose (elevate legs before putting on hose for maximum support).	• Prescribe support hose, as necessary. • Refer if varicosities are severe and painful.
Vaginal discharge	• Cleanse genitalia daily. Wear cotton underwear. • Use light sanitary pads if discharge is heavy. • Avoid vaginal douching. • If discharge develops with itching, irritation or unpleasant odor, see the provider as soon as possible for treatment.	• If not infection, counsel for genital hygiene. • With symptoms of infection, treat according to guidelines or refer for treatment.

Leg cramps

- During cramping, straighten leg slowly with the heel pointing and the toes upward or push the heel of the foot against the footboard of the bed or floor, if standing.
- Exercise daily to enhance circulation.
- Elevate legs periodically throughout the day.
- Take calcium tablets daily. Eat calcium rich foods such as dairy and dark green leafy vegetables.
- Prescribe calcium carbonate or calcium lactate tablets.

5.1.4. Danger Signs during Pregnancy

According to the information found from the interview with experts in the hospital and the referenced document, the following conditions are dangerous signs which have to be reported for immediate attention:

1. Vaginal bleeding
2. Sudden gush of fluid or leaking of fluid from vagina
3. Severe headache not relieved by simple analgesics
4. Dizziness and blurring of vision
5. Sustained vomiting
6. Swelling (hands, face, etc.)
7. Loss of fetal movements
8. Convulsions
9. Premature onset of contractions (before 37 weeks)
10. Severe or unusual abdominal pain
11. Chills or fever

5.2. Knowledge base Conceptual Modeling

Conceptual modelling is a technique that helps to clarify the structure of a knowledge-intensive business task. Knowledge model specifies the knowledge and reasoning requirements of the prospective system; the communication model specifies the needs and desires with respect to the interfaces with other agents: i.e., a user interface and/or interfaces with other software systems. Together, the knowledge model and the communication model form the input for system design and implementation. Input for the conceptual-modelling process is a certain task identified during business modelling. (Speel, Schreiber, Joolingen, Heijst, & Beijer, 1999)

5.2.1. Decision tree structure for maternal follow up and treatment

Maternity health is achieved through maternal follow up and treatment. Maternal follow up is performed in Ethiopia at least four times before birth depending on the recommended follow up by World Health Organization. In each of the four visits, check up as well as treatment and advice is performed. This decision tree model of the knowledge base which helps to make decision during the follow up and treatment is structured in all the four visits. Each visit contains personal, medical and obstetric history; physical examination and laboratory tests; and medical interventions.

Visits are separated in trimesters. Trimesters are three subdivisions in the total time which takes a woman to give birth, usually 37 to 42 weeks. First trimester is from start to 16 weeks. Second trimester is from 17 to 28 weeks. The third trimester is from 29 to 37 weeks. As a woman appear before a health professional, prior making any check up or treatment, the week of the pregnancy should be known. There are some women who come to the visit in the second or third trimester without attending the first or the second trimester. In such cases, knowing the right time of pregnancy is important to provide the appropriate health service. In order to provide all the knowledge, we start by deciding the season of the pregnancy. Then according to personal, medical, obstetric history and physical examination and laboratory test, decisions specific to the situation are generated by the knowledge base. Decision trees contained in this model have detailed child and grandchild branches to represent tasks to be performed.

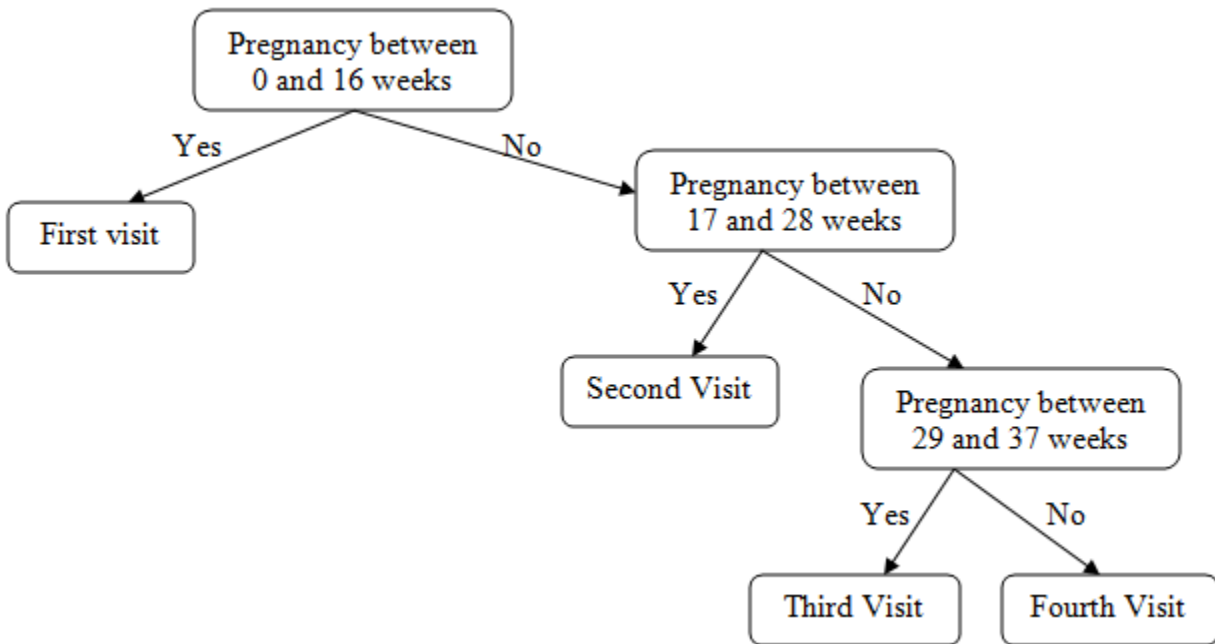


Figure 16 Classification of the major UN recommended four visits

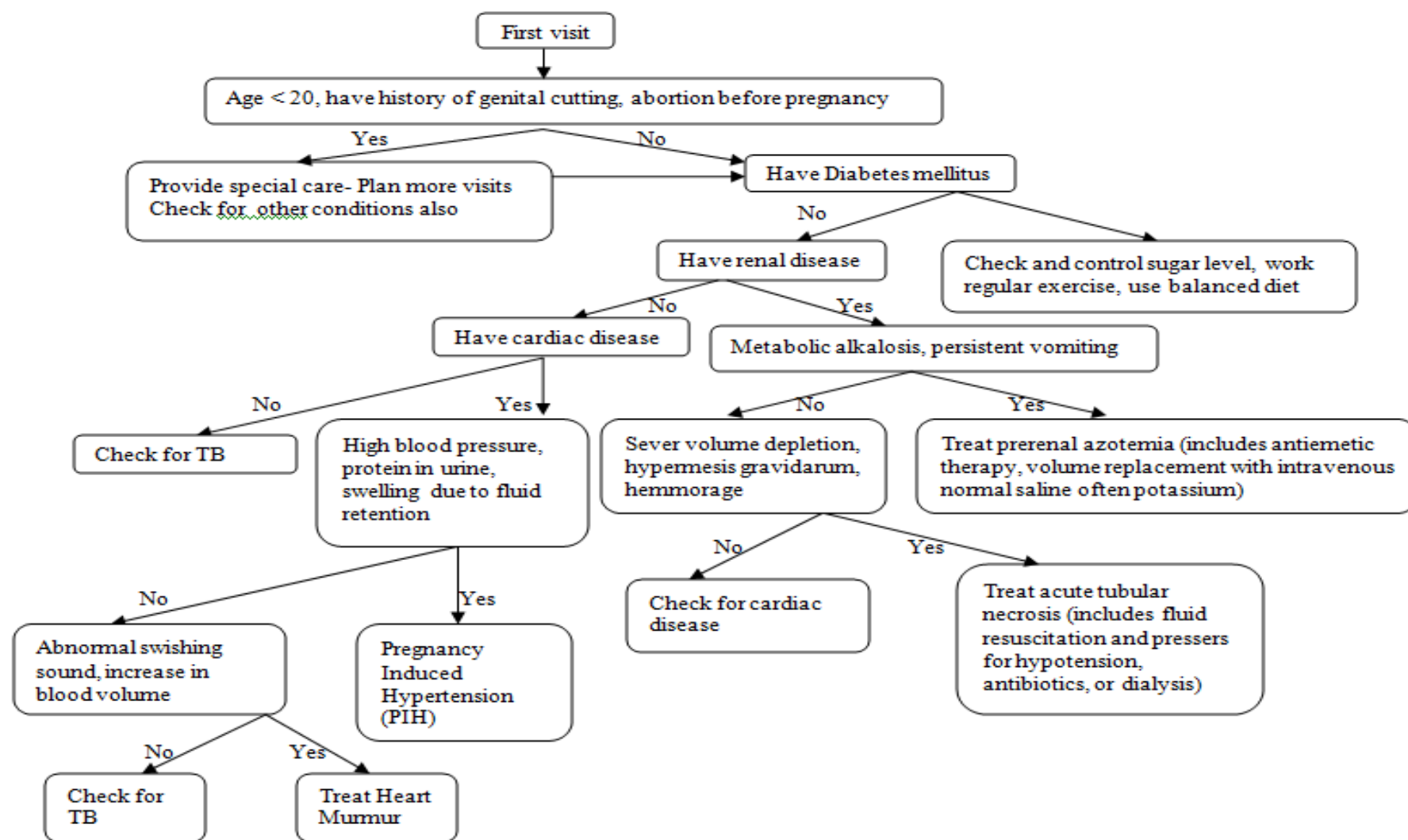
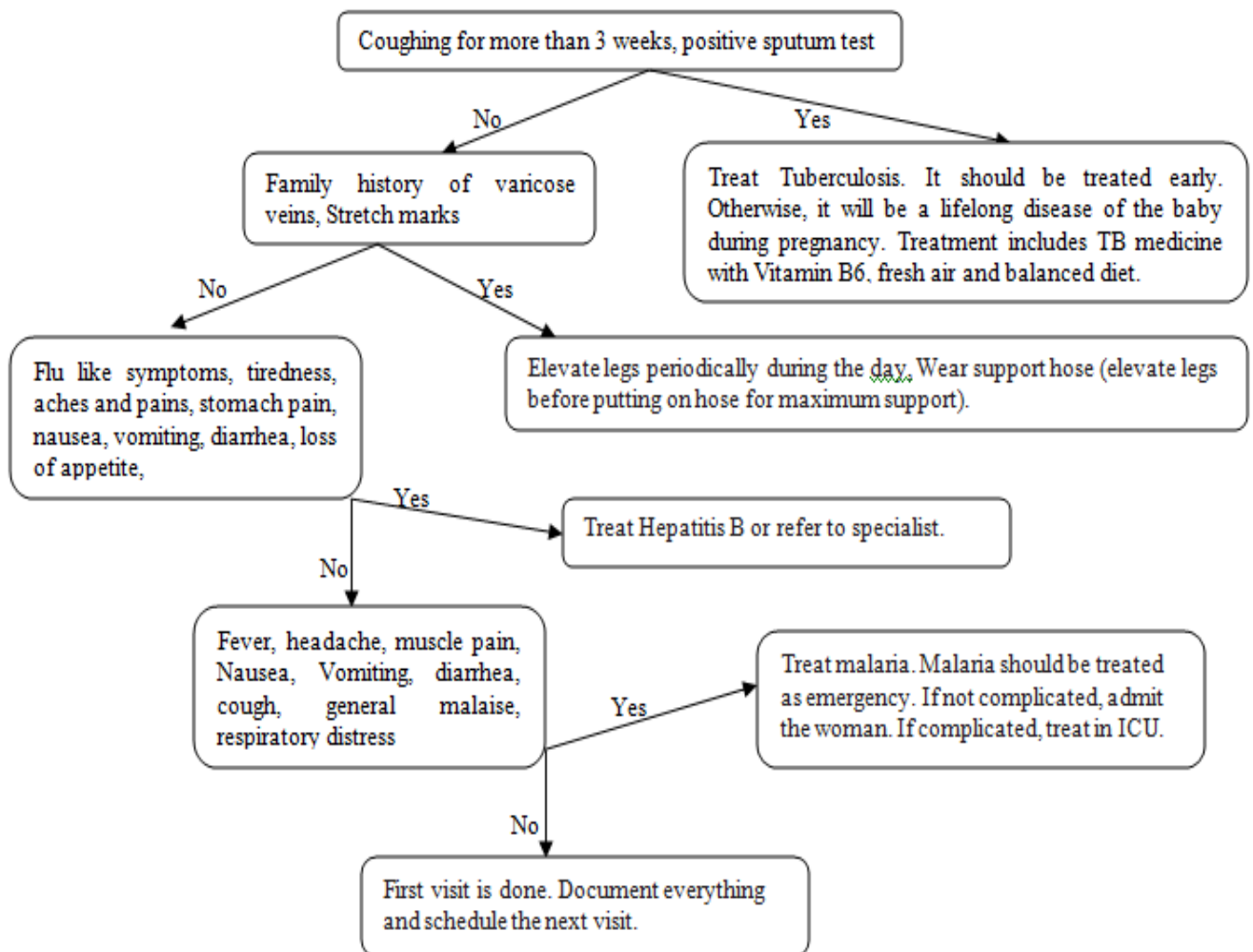


Figure 17 first visit decision tree



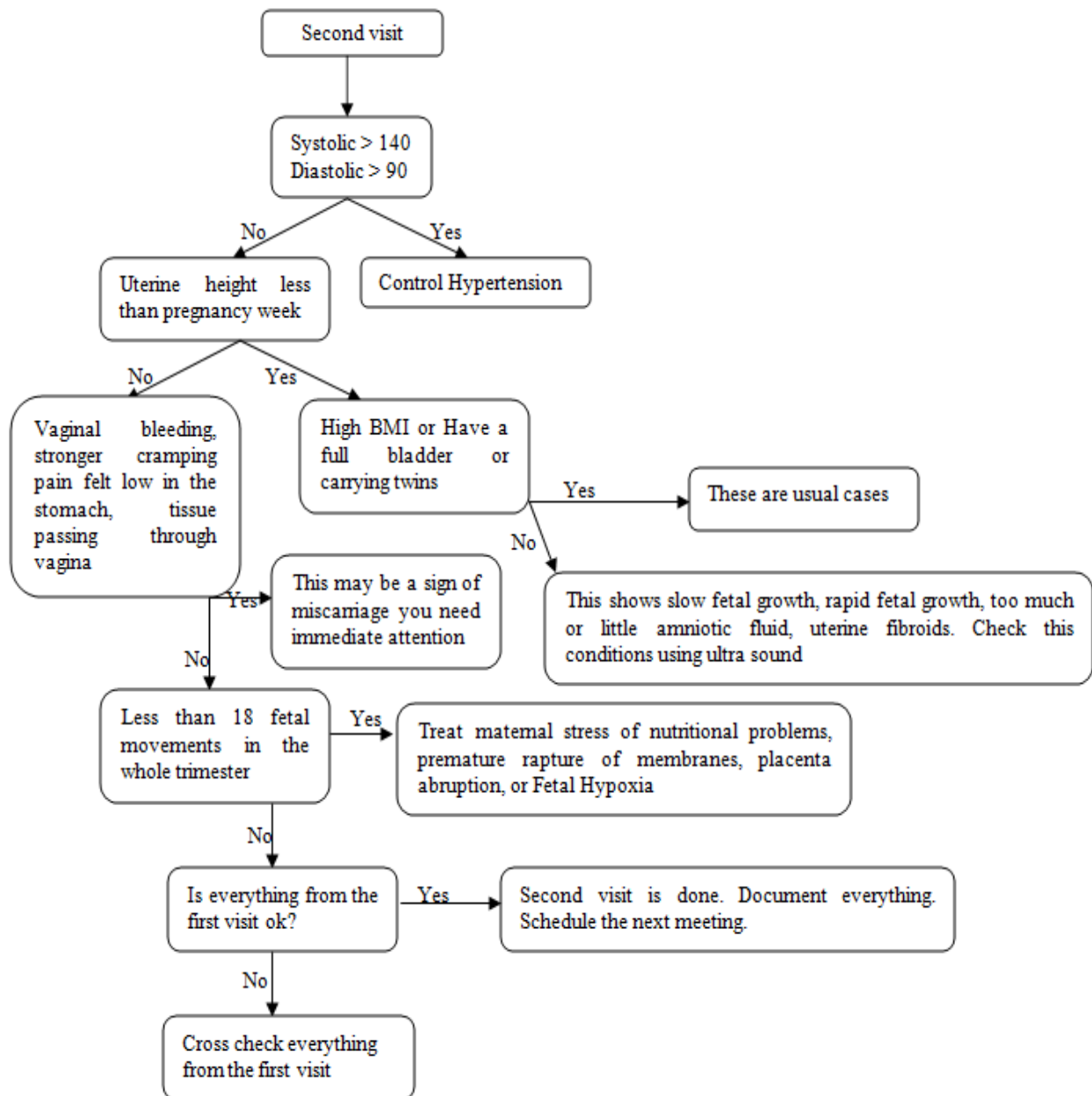


Figure 18 Decision tree of second visit

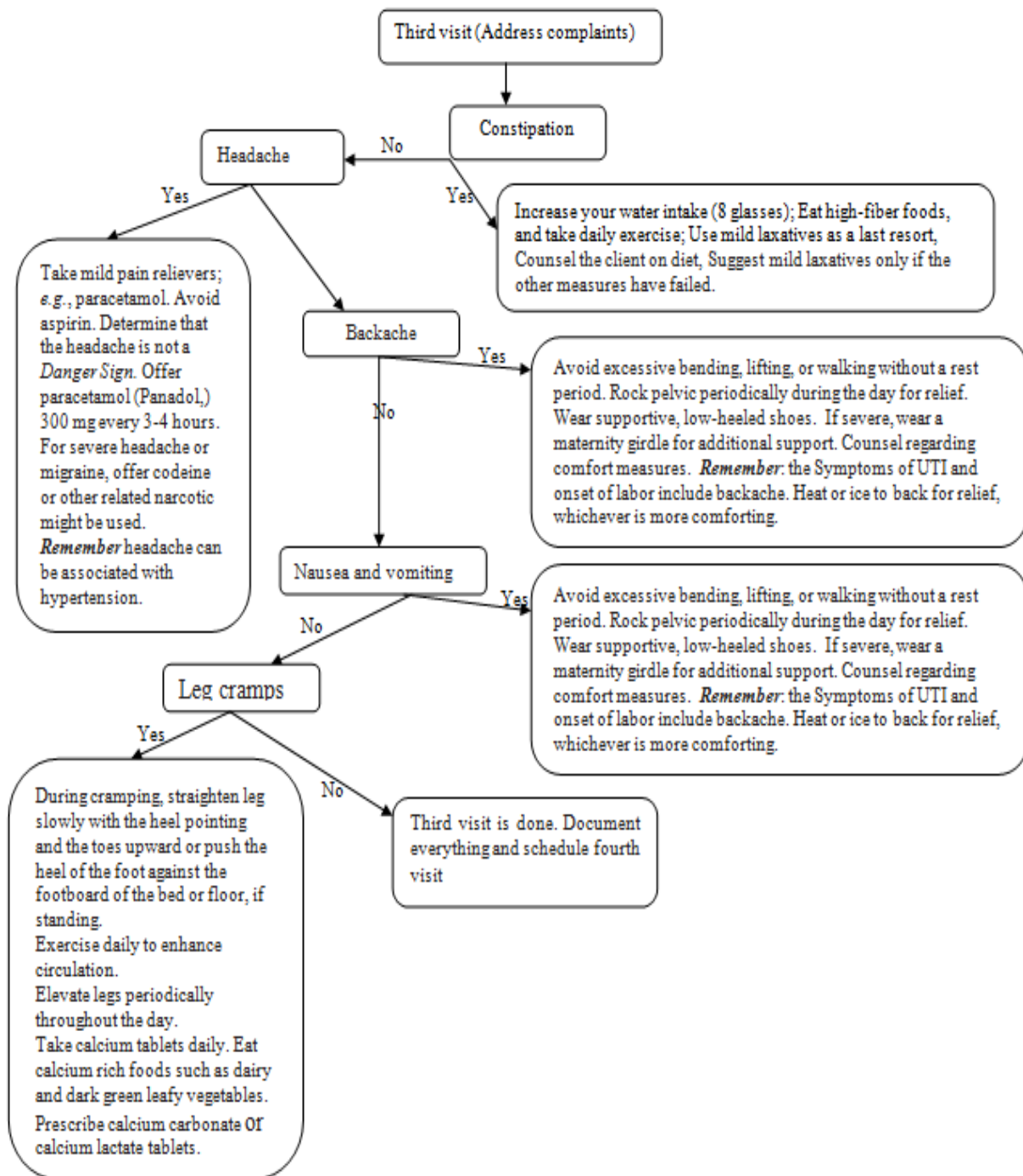


Figure 19 Third visit decision tree

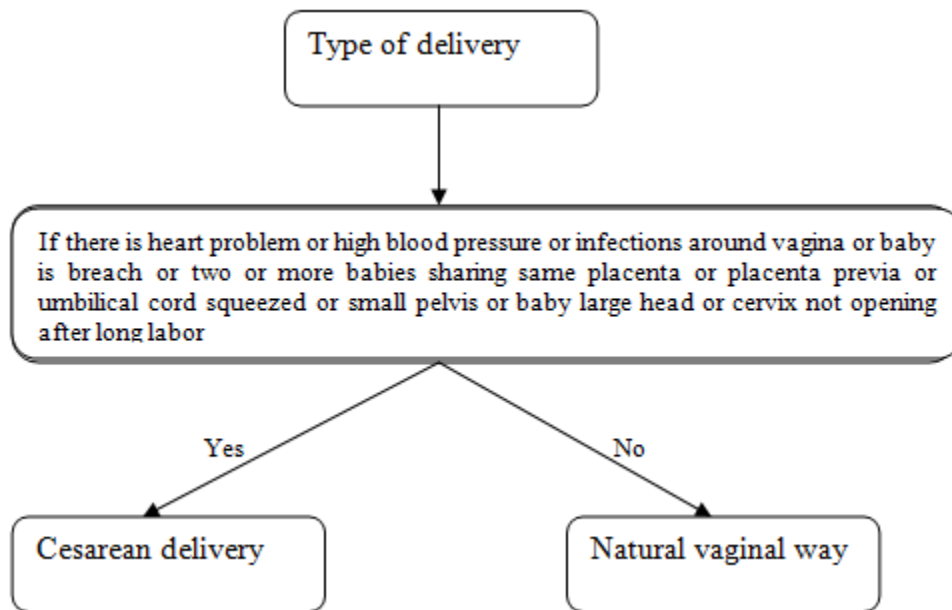
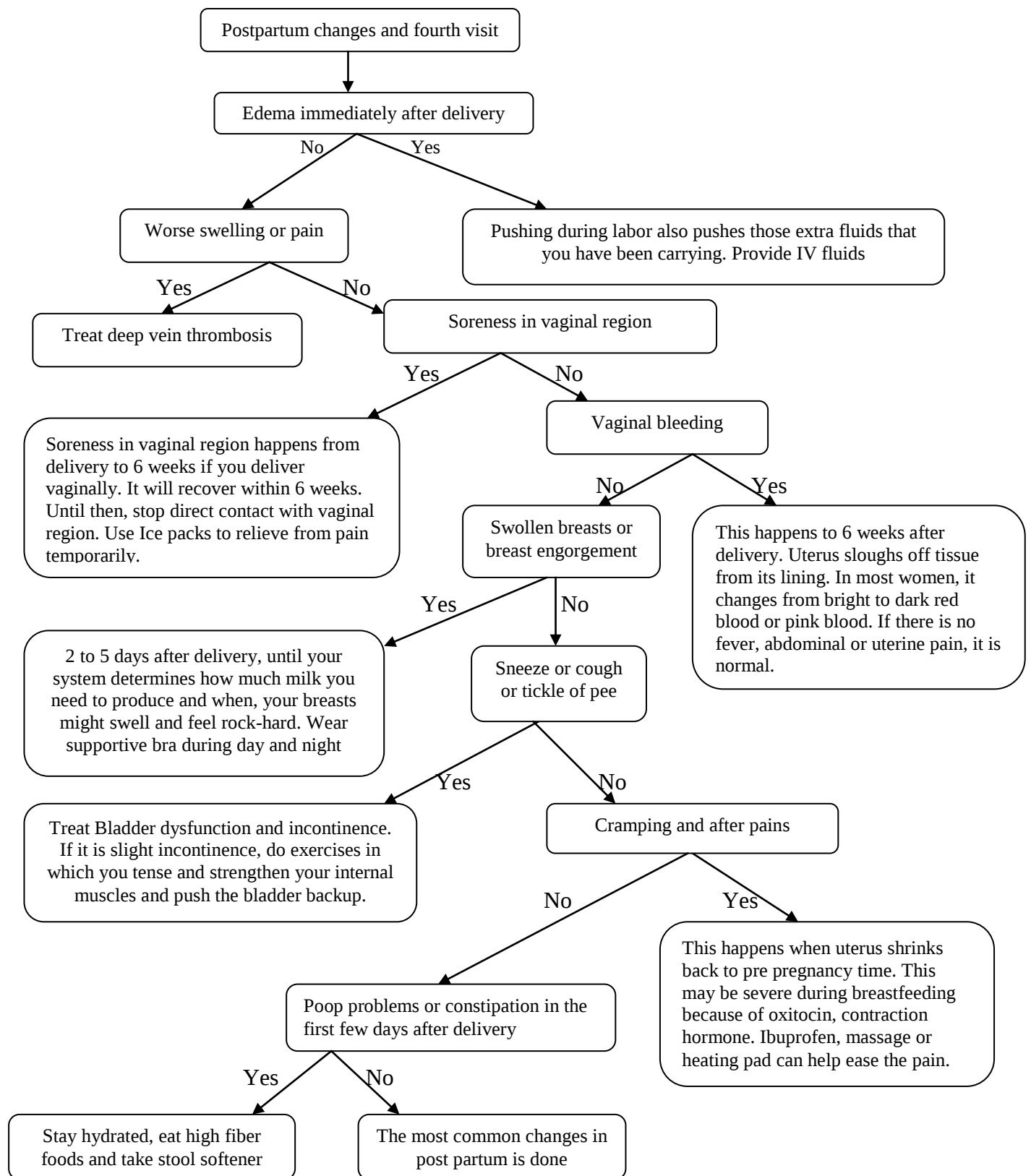


Figure 20 Decision tree for the type of delivery

If one of the above conditions is true the delivery should be held using Caesarean delivery and the health professionals should not allow the woman to suffer from a longer labour.

Figure 21 Visit four decision tree



5.3. Knowledge Representation

Knowledge representation makes the knowledge acquired from domain experts modeled in knowledge model to be represented in the knowledge base.

If the woman has diabetes,

- Advise the woman to check and control sugar level

- Advise the woman to work regular exercise and use balanced diet

- Check for Renal disease

If the woman has renal disease,

- Check for metabolic alkalosis and persistent vomiting

If the mother has metabolic alkalosis and persistent vomiting

- Treat prerenal azotemia. Treatment includes antiemetic therapy

- Volume replacement with intravenous normal saline often potassium

If the woman has severe volume depletion,

If the woman has hypermesis gravidarum,

If the woman has hemorrhage,

- Treat acute tubular necrosis. This includes fluid resuscitation and pressers for

- Hypotension, antibiotics or dialysis

- Check for Cardiac

If the woman has cardiac disease

If the woman has high blood pressure,

If the woman has protein in urine

If the woman has swelling due to fluid retention

- Treat pregnancy induced hypertension

If abnormal swishing sound in heart,

If increase in blood volume,

- Treat heart murmur

If woman has coughing more than 3 weeks,

If the woman has positive sputum test,

- Treat tuberculosis. It should be treated early.

- Otherwise, it will be a lifelong disease of the baby during pregnancy

- Treatment includes TB medicine with Vitamin B6, fresh air and balanced diet

If the woman has stretched marks on her body,

If the woman has family history of varicose veins

Elevate legs periodically during the day, wear supportive hose

Elevate legs before putting on hose for maximum support

If the woman has flu like symptoms,

If the woman has tiredness,

If the woman has aches and pains,

If the woman has stomach pain,

If the woman has nausea,

If the woman has vomiting,

If the woman has diarrhea,

If the woman has loss of appetite,

Treat Hepatitis B or refer to specialist

If the woman has fever headache,

If the woman has muscle pain,

If the woman has nausea,

If the woman has vomiting,

If the woman has diarrhea,

If the woman has cough,

If the woman has general malaise,

If the woman has respiratory distress,

Treat malaria. It should be treated as emergency, if not complicated

Admit the woman, if complicated treat in ICU

For all decisions to be made in all the 37 weeks, the same way is followed.

5.4. Overview of the new system

As explained in chapter 3 section 3.1.1.2, the Hospital uses a Smart Care System in the process of followup and treatment of maternal mothers. A Mother directly go to Triage. The Triage decides where to send the mother and puts an information on a small card. The mother then take the small card and go to the Card room and personal information about the mother is recorded in to the Smart care system. The triage Room continuously fetches information from the data stored in the data base by the Smart Care system. The data shows the history of the mother in the previous visits. Accordingly, the triage room assigns the department to which the mother should head to.

The departments such as In Patient Department, Outpatient department, ANC department, Delivery department, Emergency department, Gyneacology department receive the mother's information and get the history of the mother from the Smart Care system.

This history is also a history about the previous visits. If the mother is coming for the 3rd time, the previous 2 visits will be attached with the current vital sign.

In the new system the input to the department which performs care and treatment will not only come from the previous visits, but also from summary of every day clinical information collected through mobile phone. Since information sent through mobile phone to the server and the existing smart care system is kept in sorted priority from very dangerous to less critical symptoms, an emergency call will be made to the mother at any time before the time of the scheduled visit.

Accordingly, the view of the new system integrated with the existing system will be as follows.

A mother coming to Gandhi Hospital for the first time follows the same existing procedure of the hospital. This time, the mobile phone of the mother is necessarily registered. If she has no mobile phone, a mobile phone from her family or relative should be registered necessarily. It is advisable if more than one mobile phone be registered.

The next physical visit depends on the clinical summary of the mother to be on or before the schedule. But, the follow up, advice and situation report continues to reach the mother using her mobile phone. The existing system uses SQL 2008 database system and Microsoft Windows Server 2008 to run the Local Smart Care system.

To be integrated with the existing system, the system needs a public IP so that all mobile phones access the server, Android Running Environment and Internet Connection. The mobile phone based maternity care and follow up system will be a subsystem inside the existing system.

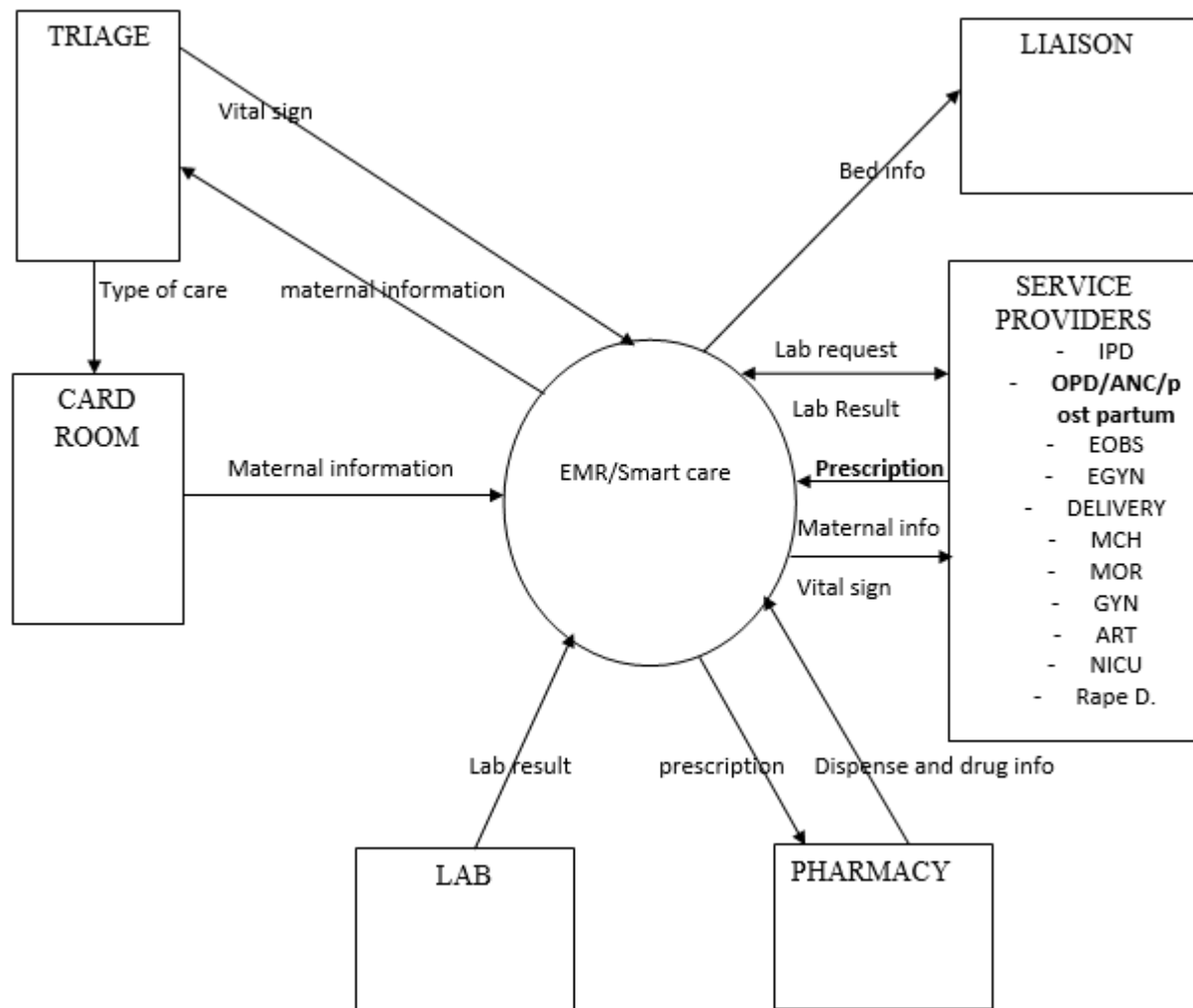


Figure 22 Existing Smart Care system in Gandhi

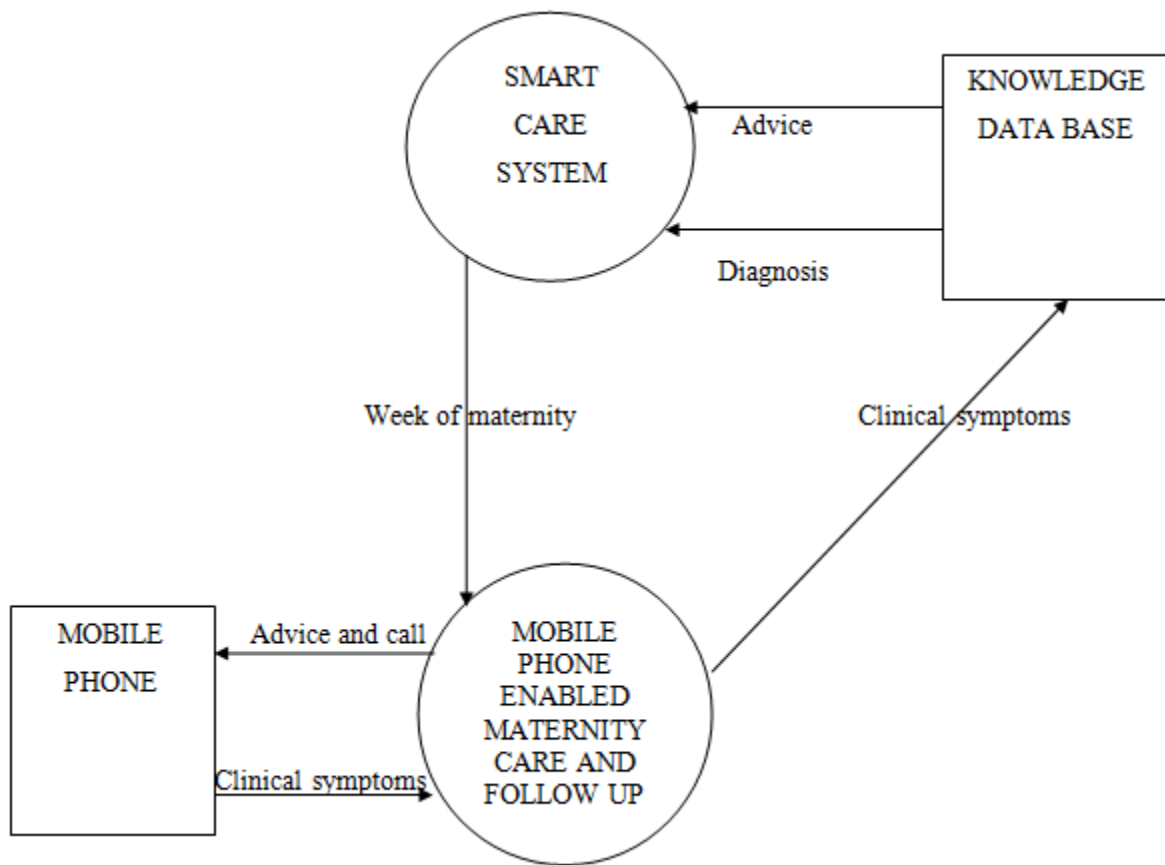


Figure 23 Mobile phone enabled maternal care and follow up system

5.5. Sample output screen (see sample code in annex-2)

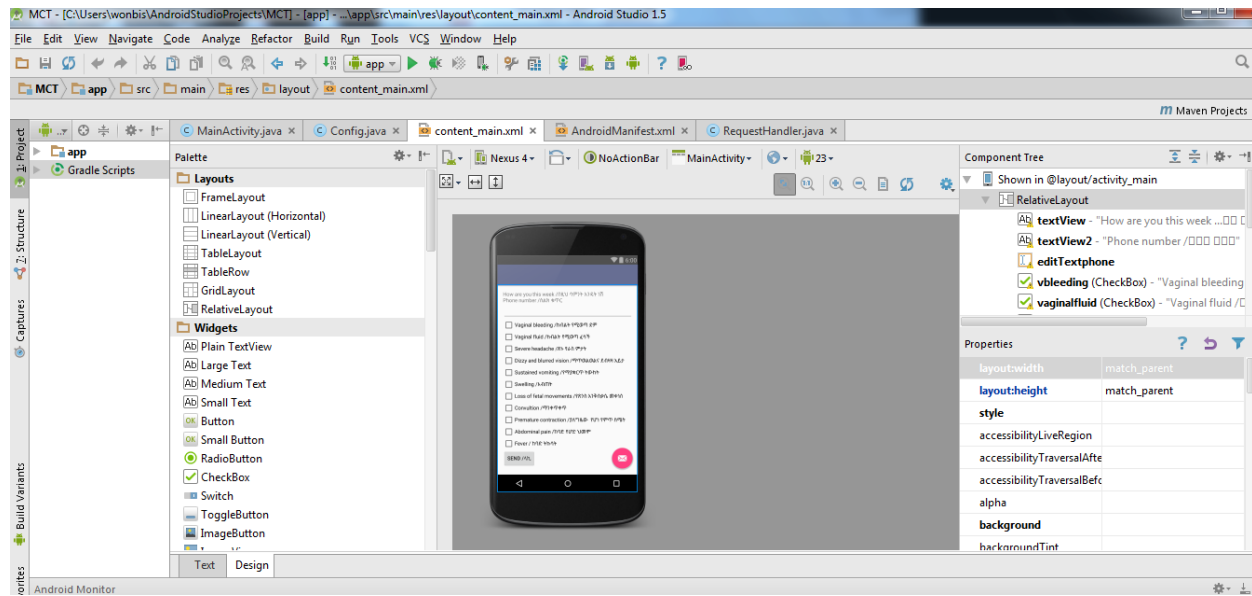


Figure 24 Android Studio IDE

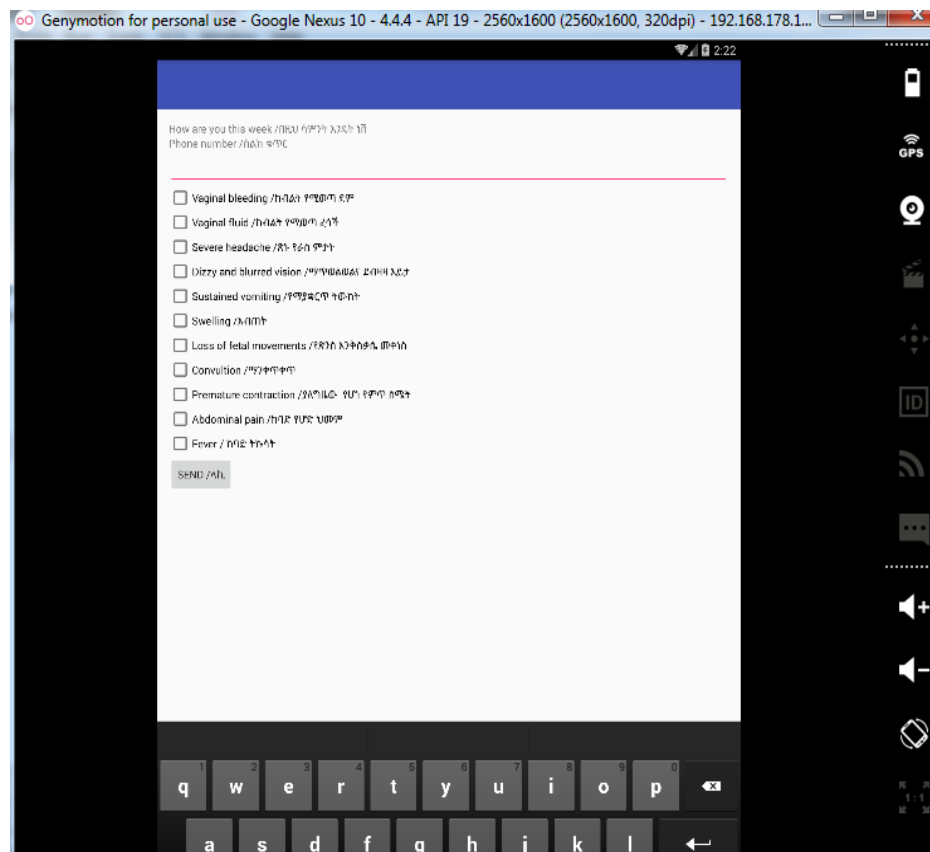


Figure 25 Week 1 Output Screen

CHAPTER SIX

CONCLUSION AND RECOMMENDATION

6.1. Summary and Conclusion

This study researches applicability of mobile phones in solving the well known social problem in maternity health care and treatment. In Ethiopia, 420 mothers die out of 100,000 mothers. Maternal health is one of the Millennium Development Goal, which means it has a global concern.

A well performed Ante natal and post natal care is very essential in avoiding maternal mortality. United Nations has recommended at least 4 times visit to Health organizations before delivery. Mobile phone enabled maternity care and follow up system boosts the number of visits to weekly or even daily basis until delivery. This ensures everything is going on the right track. A perfect follow up is the reason to perfect delivery, hence No death of maternal mothers. To this end, this study attempts to integrate mobile computing with knowledge base to provide an intelligent care follow up and visit to women.

This study also attempts to show how to use the real fact at hand about the maternal mortality problems to be used as an input for mobile computing and knowledge based studies. Lack or inadequacy of maternal visits and skilled health professionals is a well studied fact to be the cause of maternal mortality. This study tries to show how to overcome this challenge by overridden the geographical limits of visit using mobile phone to make a visit to a woman without her physical presence in health stations. On the other hand, to make the visit more successful and fill the gap to skilled health professionals, a knowledge based system provides intelligence. Every day of a pregnant mother comes with a new or usual sign and clinical symptoms. The frequency of usual symptom and the emergence of new symptom have causes and if not properly managed result in undesirable or dangerous consequence. No symptom should be ignored without the prior knowledge of health professionals or knowledge base. The mobile phone is the nearest, simple and powerful resource of a mother which acts as an information bridge between mother and health professionals.

Currently there are 40 million mobile subscribers and 10 million internet subscribers in Ethiopia. There is a plan to increase mobile subscribers to 64 million and internet subscribers to 46 million in 2020. If this much amount of people have mobile subscription, this is a big technological opportunity to solve a major problem of our society. This is an opportunity provided by an information age. There are different approaches offered by this opportunity to solve maternal health problems and categorized under M-Health. This study shows one of the possible approaches to M-health, which is integration of Mobile computing with knowledge base.

Moreover, a mother unaware of or unadvised of every symptom in a more scientific way, may be scared of everything she faces in her home or workplace and may be forced to go to health institutions more frequently, which is costly in terms of time, money and resources. This also costs and limits the time and effort of health professionals to address many more urgent issues.

Even though there are many researches and projects made in relation to maternity and mobile phone, most of them are only one way communication. The mother is not interactive with the system. A Mother doesn't express her daily or weekly feelings to the system. In some of the cases simplicity is the major problem. If the mother ever has any question, she should prepare it before sending, which is not simple to do. In other case, the mother should pick up her phone and make a call to health institution. How many mothers call? How many institutions and health professionals handle this call? How often mothers should call is very difficult to answer. Intelligence is the other aspect of this research. After getting the status of the woman, this system recommends care, follow up and treatment options.

The experiment of this research is done in Mahatma Gandhi Memorial Hospital. This hospital is chosen because it is the fully engaged specialized maternity hospital. The hospital already has a system called SMART CARE, which handles the Medical Triage process of maternity. The mobile system is integrated with the existing system in the current working setup of the hospital, except it uses public IP to collect clinical symptom from mothers' remote mobile.

Questionnaire and interview data are collected in the presence of the researcher and some staff from the ICT department. Genymotion is the mobile phone emulator used in the experiment of this system. Android Development Kit and Java Development Kit are integrated programming Environments used in this process. Mysql database system is also used in the process.

6.2. Future works

This research is a generalization of applicability of mobile phones in any Maternity care and treatment sector. When further researches on this paper may go down to specific cases, it will be applied to specific people, specific culture, specific language and specific economical and social situations. There are mothers who can't read and understand English terms. Especially English versions of medical terms are difficult to read and understand. Although this system tries to present these terms in simple language format, it may not be adequate to leave it this way. Therefore alternative approach to different local languages including Amharic is essential. On the other hand, there may be mothers who can't even read but listen. In future works of this research, these situations will also be considered. For this version of this research, neighbors or relatives or members of house hold of the mother will be needed. If this research continues growing more widely, it will also be possible to integrate the system with digital thermometer that uses an electronic probe to measure body temperature and other simple devices which can be easily used in home. In future, the cost of operation on the mother side should also be taken in to account. Some form of sponsorship, advertisement or other ways will be important to improve consistency of the service. Security is another concern which strengthens this research. Personal information of maternal women should be protected against fraud. Moreover, if researches about the power of symptoms without any laboratory of vital sign checkups are done, the visit of woman without physical presence by only collecting symptoms will be more effective. In these and similar ways, future researches on this study will strengthen it and be more effective way of solving maternal health problems of our society.

6.3. Recommendations

On the basis of this study, the following recommendations are suggested for practical action.

- The hospital already has an Existing Local Area Network based Smart Care System. They should upgrade the Server to be publicly accessed. To make this happen, the hospital will buy a Public IP from the only ISP in Ethiopia, Ethio telecom.
- The hospital should upgrade the internet from ADSL to Fiber based and the capacity of Internet from 2MB to more than 10MB.
- The hospital may also need to buy Wired or Wireless router.
- The hospital may also need to assign dedicated professionals to handle the transaction and operation of this system.

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Annex-1- Questionnaire and interview

NB: The questionnaire and interview were structured together in order to overcome the challenge of misunderstanding the questionnaire and the difficulty to present more than 1 session (Interview and Questionnaire) for the health professionals. Therefore, the researcher personally presented both the interview and the questionnaire for the respondents. Accordingly, the open ended questions are categorized under interview and the multiple choice questions are questionnaire.



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Adama Science & Technology University

Department of Computing Postgraduate Program

QUESTIONNAIRE TO BE FILLED BY GANDI HOSPITAL

Researcher: Wondimagegn Leta

Research Topic: - Mobile computing enabled maternity care and follows up system

Dear Respondents:-

I would like to express my sincere appreciation and deepest thanks in advance for your generous time and frank and prompt responses.

Objective:

The main objective of this research is to make sure we can use USSD integrated web based mobile computing to support the maternity care, follow up and treatment of maternal mothers.

Confidentiality:

The researcher want to assure you that this research is only for academic purpose authorized by the Adama University MSc program Coordination office and the result will not be presented for other purposes. Thus, your ideas and comments are highly respected and kept confidential.

General Guideline:

Please circle those questions that are followed by choices and write your short and precise answers for those followed by blank spaces.

Purpose of this questionnaire

The purpose of this questionnaire is:

- To have a knowledge of your experience in treatment and care of maternal cases with and without using the information technology tool
- To identify where to start and how to start this research with Gandhi Hospital
- To understand your opinion towards the system recommended in this research.

Contact Address : If you have any query, I am available as per your convenience at:

- Phone; 09-11-92-40-06 or 09-16-26-90-91
- E-mail; wondimagegnleta@gmail.com

Part I- Personal information

1. How many years of experience do you have in relation to maternity health service?

2. What is your field of specialization?
 - a. Health assistant
 - b. General Nurse
 - c. Midwifery Nurse
 - d. Health Officer
 - e. General practitioner Doctor
 - f. Gynecologist
 - g. Other please specify _____

Part II- Maternal health and information technology

3. Which of the following information technology tool/device have you used during your professional maternal service process?
 - a. Computer
 - b. Mobile phone or any kind of smart device
 - c. None
 - d. Other, please specify _____
4. If you have ever used any information technology tool or device in the process of providing maternal health service, which one of the following can be the reason?
 - a. To follow up the status of pregnant mothers
 - b. To provide advice for pregnant mothers
 - c. To refer to a knowledge base related to the treatment of maternal cases

Part III- Maternal Health related

5. What are the possible maternal complications (death and lifelong health problems) which arise due to lack of adequate follow up before and after delivery?

_____	_____
_____	_____
_____	_____
_____	_____

6. Is it possible to see symptoms in day to day basis in the periods before delivery?
- Yes
 - No
 - Other, Please specify _____

7. Please list the sign and symptoms maternal mothers see before delivery as possible

The first three months

_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

The second three months

_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

The last three months

_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

8. Is it possible to see symptoms in a day to day basis in the periods of 2 years after delivery?
- Yes
 - No
 - Other, please specify _____

9. List the most common symptoms mothers see after delivery as possible?

_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

10. Please suggest most reliable and current hardcopy, softcopy or online reference which will be helpful to provide diagnosis according to the above sign and symptoms
- a. Hard copy, please specify _____
 - b. Softcopy , please specify _____
 - c. Website, please specify _____

Part IV –Current situation

11. How much percent of your plan in the follow up process of maternal mothers is successful?
- _____
12. How much of the mothers do you guess strictly engage in the follow up process at least 4 times before giving birth?
- a. Most
 - b. Few
13. How much of the mothers do you guess strictly engage in the follow up process more than 4 times before giving birth?
- a. Most
 - b. Few

Part V - Attitude towards the future system

14. Do you think using a very simple mobile phone based communication system motivates mothers to attend the follow up process regularly?
- a. Yes
 - b. No
15. Do you agree a knowledge base system helps all of the health professionals in the process of maternal treatment?
- N:B- knowledge base system takes input from maternal mothers about the sign and symptoms and recommends what kind of care and treatment to be given for mothers?*
- a. Strongly agree
 - b. Agree
 - c. Disagree
 - d. Strongly disagree

Annex-2 Sample Code

```
class Addwoman extends AsyncTask<Void, Void, String>
{
    ProgressDialog loading;

    @Override
    protected void onPreExecute() {
        super.onPreExecute();
        loading = ProgressDialog.show(MainActivity.this, "Adding...",
"Wait...", false, false);
    }

    @Override
    protected void onPostExecute(String s) {
        super.onPostExecute(s);
        loading.dismiss();
        Toast.makeText(MainActivity.this, s, Toast.LENGTH_LONG).show();
    }

    @Override
    protected String doInBackground(Void... v) {
        HashMap<String, String> params = new HashMap<>();
        params.put(Config.KEY_MAT_phone, phone);
        params.put(Config.KEY_MAT_Vbleed, vbleed);
        params.put(Config.KEY_MAT_Vfluid, vfluid);
        params.put(Config.KEY_MAT_sheadache, sheadache);
        params.put(Config.KEY_MAT_Dizzblurr, dizzblurr);
        params.put(Config.KEY_MAT_vomit, vomit);
        params.put(Config.KEY_MAT_swell, swell);
        params.put(Config.KEY_MAT_fetalmov, fetalmov);
        params.put(Config.KEY_MAT_convultion, convultion);
        params.put(Config.KEY_MAT_prematcontra, prematcontra);
        params.put(Config.KEY_MAT_abdopain, abdopain);
        params.put(Config.KEY_MAT_fever, fever);
        params.put(Config.KEY_MAT_priority, priority);

        RequestHandler rh = new RequestHandler();
        String res = rh.sendPostRequest(Config.URL_ADD, params);
        return res;
    }
}

Addwoman aw = new Addwoman();
aw.execute();
}

@Override
public void onClick(View v)
{
    if (v == sendbutton)
    {
        addwoman();
    }
}
}
```