APPLICATION OF AN INTEGRATED DECISION SUPPORT SYSTEM TO REDUCE MATERNAL MORBIDITY AND MORTALITY RATE IN KENYA

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DECLARATION

This proposal is my original work prepared with no other than the indicated sources and support and has not been presented elsewhere for a degree or any other academic award.

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CERTIFICATION

The undersigned certify that they have read and hereby recommend for acceptance of Jomo Kenyatta University of Agriculture and Technology a research proposal entitled “Application of an Integrated Decision Support System to Reduce Maternal Morbidity and Mortality Rate in Kenya”.

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ABSTRACT

Maternal Health involves all health aspects of pregnant women during pregnancy, childbirth and the postpartum period including family planning, preconception, prenatal and postnatal care. In the maternal health care domain there may occur maternal mortality and/or morbidity whereby the maternal mortality shows death of a woman brought about by the pregnancy related issues before, during and after birth. There is an estimated 170 million pregnancies every year globally. The risk of sudden and unpredictable complications, which could result in death of the mother or injury of the infant, is seen to be high during pregnancy period. According to statistics presented by WHO and UNICEF, forty percent of all pregnant women will experience some complications and 15% of the complications will be potentially life threatening and will require prompt obstetric care. With the massive amount of data collected in the health facilities in addition to data collected by the community heath volunteers, IT becomes a favourable tool to aid in decision making by discovering hidden patterns from the data. A decision support system thus becomes a necessity to aid in the process of decision making. There exists various decision support system for maternal health in Kenya. They include but not limited to mobile Partnership for Maternal, Newborn and Child Health (mPAMANECH), a quasi-experiment done by APHRC. UAMUZI BORA in western Kenya and Human-Centred Design, Measurement and Evaluation, Technology for Maternal Health by Jacaranda Health Centre in Kiambu. Despite existence of decision support systems for maternal health care in Kenya, it was noted that there is scarce and unreliable maternal health data to be processed thus making it hard to carry out any analytical process to come up with remedies and prescriptive approaches for controlling maternal mortality in Kenya. The objectives of this study are to identify gaps of existing techniques to reduce maternal morbidity and mortality in Nairobi Kenya, to describe maternal health indicators and then develop an integrated DSS for maternal health care. Consequently, the proposed work seeks to develop an improved DSS systems by integrating data collection, data storage, and analysis and information presentation functionalities.

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ACRONYMS AND ABBREVIATIONS

AIDS	-	Acquired Immune Deficiency Syndrome
APHRC	-	African Population Health Research Centre
CHV	-	Community Health Volunteer
DSS	-	Decision Support System
HIV	-	Human Immunodeficiency Virus
MDG	-	Millennium Development Goal
MMR	-	Maternal Mortality Ratio
NUHDSS	-	Nairobi Urban Health and Demographic Surveillance System
SDG	-	Sustainable Development Goal
UNICEF	-	United Nations International Children's Emergency Fund
UNFPA	-	United Nations Fund for Population Activities
WHO	-	World Health Organization
EHR	-	Electronic Health Record
APHRC	-	African Population and Health Research Centre
ARV	-	AntiRetroViral

DEFINITION OF TERMS

Maternal Health refers to the health of women before and during pregnancy, childbirth and during postpartum period(WHO, 2010)

Maternal Morbidity refers to any physical or mental illness or disability directly related to pregnancy and/or childbirth (Koblinsky, Chowdhury, Moran, & Ronsmans, 2012).

Maternal Mortality refers to the of a woman during pregnancy, childbirth and 42 days after childbirth as a result of pregnancy related issues which are neither accidental nor incidental.

Maternity is the period of a woman during pregnancy and continues after childbirth.

Decision Support System is a set of software programs that facilitate data collection, data management and analysis for decision making activities by the end user

Community Health Volunteer are semiskilled persons involved in voluntary delivery of health services in a community

CHAPTER ONE

INTRODUCTION

1.1 Overview

This chapter provides the background information of this research proposal stating the problem statements, the set objectives and research questions of the study. The motivations behind the proposed research are outlined in the justification and significance of the study. The scope to be covered, limitations and assumptions of the proposed work is then covered and finally words considered to be crucial in the study are then defined.

1.2 Background Information

Maternal health refers to the wellbeing of women during pregnancy, childbirth and postpartum period (Afica Progress Panel, 2010). It involves family planning, preconception, prenatal and postnatal care with an aim of giving a positive experience which in most cases would reduce the maternal morbidity and mortality. Whereas maternal morbidity refers to any physical or mental illness directly related to pregnancy and/or child birth, maternal mortality refers to the death of a woman while pregnant or within forty two days (42) days of delivery irrespective of site or pregnancy duration from any cause to pregnancy, or its management but not from accidental or incidental causes(WHO, 2018).The main cause of maternal deaths include severe bleeding, infections, unsafe abortion, high blood pressure and prolonged or obstructed labour.

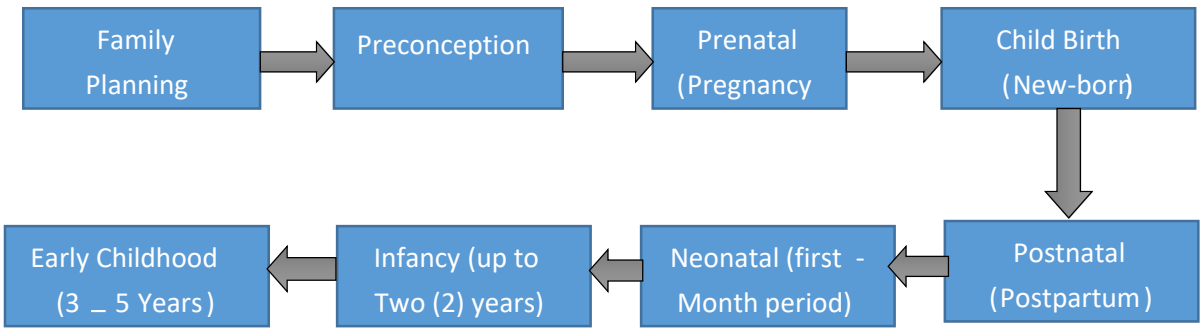

Figure 1.1 Maternal healthcare Chain

Worldwide, it is estimated that 289,000 women died of pregnancy or childbirth related causes in 2013 which include but not limited to severe bleeding , obstructed labour, complications of unsafe abortions, infections, haemorrhage and high blood pressure, all of which have highly effective interventions (Khan, Wojdyla, Say, Gülmezoglu, & Van Look, 2006). This statistics is seen to be higher in Kenya.

Kenya continues to have a high maternal mortality ratio (MMR) despite the commitment from the government to address the issue. According to a survey report by (Survey, 2014) on the maternal mortality rate in Kenya as of 2010, it was estimated that 488 women out of 100,000 died as a result of pregnancy related issues. Consequently, Kenya is ranked as one of the most dangerous countries for a woman to give birth. The high rate of the maternal deaths was attributed to obstructed labour, complications of unsafe abortions, infections, haemorrhage high blood pressure and high number of unskilled personnel involved in delivery and cultural believes and practices.

In an effort to reduce the maternal mortality rate(MMR) in Kenya, the Kenyan government formulated a policy framework that would allow every person the right to access attainable standard of heath which would include the right to health care services including reproductive health care (Kenya Ministry of Health, 2014). In addition, it provided a devolved system of governance which gives the mandate of health care provision to county governments, hence providing an opportunity to address historical inequities in access to health care. Furthermore, in 2013, the Government of Kenya introduced free maternity services in all public health facilities (Bourbonnais, 2013).

Despite the political goodwill from the government to help reduce the MMR in Kenya, inadequate access to quality maternal services including ante-natal delivery and post-natal services continue to be a great challenge. Furthermore, access to skilled personnel during delivery continues to be a persistent challenge (Pyone, Smith, & van den Broek, 2017).Use of

decision support systems (DSS) has so far been identified as an alternative of addressing these challenges.

A Decision Support System refers to a set of related computer programs that analyse data and presents it to end users for decision making activities (Jain, 2016). It facilitates data collection, storage and analysis of data so as to identify hidden patterns that can be useful in predicting probability of occurrence of a given outcome. The DSS system(s) have been tested and applied in the maternal health domain so as to assists the medical personnel while making decision. Due to its data storage capabilities, historical data of each patient can be retrieved hence no need of memorizing each patient's details.

The African Population and Health Research Centre (APHRC) did a research of the role of DSS systems in enhancing community health Volunteers (CHV) effectiveness to improve maternal and newborns outcomes in Nairobi, Kenya. Use of the DSS significantly improved on the collected data completeness. Although there was a significant improvement in the data collection process, there existed gas in the data storage and analysis and information presentation functionalities.

The proposed work seeks to develop an integrated decision support system with an aim of reducing the maternal morbidity and mortality rate in Nairobi, Kenya. The approach would integrate data collection, storage, management, and analysis and information presentation functionalities. Consequently, the proposed work would help reduce on the maternal morbidity and mortality rate in Nairobi, Kenya.

1.3 Problem Statement

Despite existence of decision support systems for maternal health care in Kenya, it was noted that there is scarce and unreliable maternal health data to be processed thus making it hard to carry out any analytical process to come up with remedies and prescriptive approaches for controlling maternal mortality in Kenya. This could be attributed to the fact that most, if not all,

of the existing DSS systems concentrate more on data collection rather than the whole functionalities of DSS systems which are data collection, storage, management, and analysis and data reporting. The proposed work seeks to develop an improved DSS systems by integrating data collection, data storage, and analysis and information presentation functionalities.

1.4 Objectives

1.4.1 General Objective

The general objective of this research work is to develop an integrated information decision support system by incorporating data collection, storage, management, analysis and data reporting functionalities to reduce on the maternal morbidity and mortality rate in Kenya

1.4.2 Specific Objectives

i. To identify gaps of existing techniques to reduce maternal morbidity and mortality in Nairobi Kenya
ii. Describe maternal health indicators
iii. Develop an integrated DSS for maternal health care

1.5 Research Questions

i. What are the gaps of the existing techniques for maternal health care in Nairobi?
ii. What are the maternal health indicators?
iii. How can an integrated DSS for maternal health care develop and/or reduce maternal mortality and morbidity rate

1.6 Justification of the Study

The developed integrated decision support system is expected to provide solutions to the challenges that have adversely affected women and newborns during the maternity. The system will provide a technologically based approach that would facilitate the process of data collection, data storage and management, data analysis and reporting. Using this system, medical practitioners would thus be in a position to handle more patients without the need of having to memorize each patient's medical data thus minimize on the errors which may be as a result of human fatigue.

Additionally, this study will contribute knowledge to the maternal health care and decision support systems domain. Consequently, if adopted, it will greatly help to significantly reduce the

maternal mortality rate (MMR) in Nairobi, Kenya, by supporting in making an informed decision.

1.7 Research Scope

This study shall focus on maternal health care and application of decision support systems for maternal health care in Nairobi County, Kenya. Data collected within Nairobi and its environs only shall be used to train, test and validate the system.

1.8 Limitations of the Study

During the period of this study a number of limitations are expected to be encountered. First, like any other research, time constraints will be faced given the task at hand of the research and the desirable delivery timelines. However, the research will make an effort to utilize the limited time by prioritizing key tasks of the study and executing them diligently. Second, financial constraint may affect progress of the study given the limited resources available to the researcher as a student. Despite the constraint, the researcher will strive to use the available resources without compromising on the quality of the work. Finally, the researcher is likely to be faced with the challenges of access patient's medical data that would be key in testing and validating the proposed decision support system due to its confidential nature. However, the research strive to meet and follow the ethical considerations put in place to enable access patient's medical records.

1.9 Assumption of the Study

This study assumes that the data sample obtained to validate the system would include most of the factors that lead to high mortality rate in Nairobi, Kenya. Additionally, it is assumed that the developed system, if replicated to other areas in Kenya and the world at large, would still produce the same results.

CHAPTER TWO

LITERATURE REVIEW

2.1 Overview

This chapter provides a summary of the literature review done on maternal health care concepts, maternal mortality, factors that influence maternal health care, maternal health statistics ,decision support system concepts and existing decision support systems that have been put in place to reduce maternal mortality rate, related studies and the conceptual framework of the proposed study.

2.2 Maternal Health Care Concepts

Maternal Health is the health of women during pregnancy, childbirth and the postpartum period. It includes all aspects of family planning, preconception, prenatal and postnatal care. The identified leading cause of death among women during preconception and prenatal care stage are the pregnancy complications and childbirth. The preconception care goals include but not limited to; providing education, health promotion, screening and interventions for women of reproductive age to reduce on the risk factors that might affect future pregnancies.

2.2.1 Preconception care

Preconception care is the provision of biomedical, behavioural and social health interventions to women and couple before conception occurs. The care is aimed at improving their health status, and reducing behaviours and individual and environment factors that contribute to poor maternal and health outcomes, with an ultimate goal of improving maternal and child health, on both short and long term basis (Swan & Kershaw, 1994).

2.2.2Prenatal Care

Prenatal care involves provision of biomedical, behavioural, social and health interventions to pregnant women before conception. It aims at improving on the health status of the women by reducing on the behaviours, environmental and individual factors that could contribute to poor maternal and child health outcomes (Scholl, Hediger, & Belsky, 1994). Women who begin prenatal care early in their pregnancy have better delivery outcome than women who start their prenatal care in latter stages of their pregnancies and those who do not receive prenatal care during their pregnancies.

2.2.3 Postnatal Care

Postnatal care (PNC) is the care given to a mother and her new-born for the first six weeks after childbirth (WHO Organization, 2013). An effective PNC involves timely recognition of any deviation from the expected recovery after childbirth, evaluating and intervening appropriately. This stage is the most critical stage as nearly two thirds of maternal deaths occur at this stage, especially twenty-four (24) hours after delivery.

2.2.1 Maternal Mortality

Maternal mortality also referred to maternal death refers to the death of a woman while pregnant or within forty two days of the pregnancy termination that happens as a result of the pregnancy related issues or its management, but not incidental or accidental causes. This is irrespective of the duration and site of pregnancy.

The identified main causes of maternal deaths include but not limited to haemorrhage, sepsis and hypersensitive disorders such as eclampsia, abortion related causes and obstructed labor. Abortion related causes account for 13% of the total maternal deaths while obstructed labor accounts for 8% of the maternal deaths. According to UNFPA, maternal deaths have direct and indirect causes and about 80% are attributed to the direct causes. The identified internal causes include obstetric complications such as severe bleeding, infection, unsafe abortion, hypersensitive disorders and obstructed labor.

2.2.2 Maternal Morbidity

Maternal morbidity refers to any physical or mental illness or disability directly related to pregnancy and/or childbirth. It is not life threatening but can have impact on the quality of life (Koblinsky et al., 2012). According to WHO, forty two (42) percent of women who give birth annually experience mild complications during pregnancy. Additionally, an estimated fifteen million women develop disabilities due to pregnancy related complications annually.

Maternal morbidity not only puts the woman at risk but it also exposes her infant to its consequences (Geller et al., 2018). There exists a challenge of identifying the maternal morbidity indicators particularly at the community level. This is mostly attributed to the fact that the existing literature tends to have inaccurate and inconsistent records. Despite this short coming, the Community Level Interventions for Pre-eclampsia (CLIP) identifies current maternal morbidity indicators as:

1. Serious end organ complications of pre-eclampsia
2. Eclampsia which can be defined as the occurrence of convulsion during pregnancy, labour or within 42 days after child birth in the absence of epilepsy or another condition inclined to convulsions.
3. Stroke which is hemiparesis and/or blindness developed during pregnancy or 42 days of the postpartum period that lasts for 48 or more hours
4. Coma which is a prolonged unconsciousness for more than12 hours
5. Antepartum haemorrhage that refers to vaginal bleeding of 15 millilitre or more with or without pain before onset of labour
6. Disseminated intravascular coagulation (DIC). This is abnormal bleeding experienced through the mouth and/or ears
7. Other major causes of maternal mortality
8. Obstetric sepsis
9. Vesicovaginal or rectovaginal fistula. This refers to the continuous loss of urine and/or faeces after delivery

2.3 Maternal Health Indicators

Maternal health indicators includes all aspects that shows improvement of a country's maternal health. The common identified factors that influence maternal health care include; substandard health services and lack of available medical equipment and supplies at the time of labour, delivery and immediately after birth, inaccessible health care and lack of skilled care at childbirth.

According to WHO there exists 11 indicators for maternal, new-born and child health. These indicators are:

1. Maternal mortality rate

2. Under-five child mortality with the proportion of new-born deaths
3. Children under five who have stunted growth
4. The need for contraception is met whereby the proportion of demand for family planning is satisfied
5. Antenatal coverage of at least four times during pregnancy
6. Antiretroviral (ARV) prophylaxis among HIV positive pregnant women to prevent HIV transmission and antiretroviral therapy for pregnant women who are treatment eligible
7. Availability of skilled attendant during delivery
8. Availability of postnatal care for mothers and babies within forty two days after birth
9. Exclusive breastfeeding for six months
10. Three doses of combined diphtheria-tetanuspertusis (DTP3) immunization coverage
11. Antibiotic treatment for suspected pneumonia

2.4 Maternal Health Care Statistics

About 500,000 women die each year as a result of pregnancy related issues an of these incidences, 90% occur in developing countries. These cases, mostly in developing countries, are attributed to the fact that at least 35% of pregnant women in these countries receive no antenatal care during pregnancy and 70% receive no postpartum care during the six weeks following delivery.

2.4.1 Maternal Health Statistics in Kenya

Reducing maternal mortality has been of great priority at the top of the global health agenda. To build upon the momentum generated by the 5th Millennium Development Goal(MDG 5), a transformative new agenda for maternal health has been laid out as part of the sustainable development goal (SDG) to reduce the global MMR to less than 70 out of 100,0 live births by 2030 in which Kenya is a signatory.

The high rate of MMR in Kenya are attributed to factors which include but not limited to; lack of sufficient skilled labour during delivery time, lack of access to hospital facilities especially in the rural areas, high cases of HIV and AIDS infections, unsafe abortions among other causes. The calculations done by WHO, UNICEF, UNFPA and the World bank based on the available

national data for Kenya, shows that MMR declined by twenty six (26) percent between 190 and 2015 from 687 per 100,000 births to 510 and the life time risk of maternal death is one (1) out of forty two(42).

2.4.2 Maternal Health Statistics in Nairobi, Kenya

In Nairobi, maternal mortality is higher and skilled attendance at delivery is lower especially in the slums of Nairobi. Lower number of public health facilities compared to its population, greater distance to the facilities and high costs of maternal health services could best explain the high rate of maternal mortality in Nairobi.

A number of studies have shown that the residents of the slum areas in Nairobi, which account to sixty (60) percent of its total population, register poorer health outcomes than other urban resident. The MMR was as high as 706 maternal deaths out of 10000 births between 2003 and 2005 in two slums of Nairobi covered by the Nairobi Urban Health and Demographic Surveillance System (NUHDSS).

2.5 Decision Support System Concepts

In the medical domain, decision support systems can be referred to as are computer systems that have been designed to assist physicians or other health care professionals in making clinical decisions. They also help physicians to organize, store and apply the massive amount of data. They are expected to improve on the quality of care by providing more accurate, effective and reliable diagnoses and treatments in addition to avoiding errors due to physician's insufficient knowledge and/or tiredness.

Decision support systems constitutes mainly of four components, that is, the knowledge base, model base, user interface and as illustrated in the figure…The knowledge base consists of compiled information that can be in form of rule or case base. The model base contains formulas for combining the rules or association in the knowledge base with actual patient data. The user

interface gives the platform of getting the patient data into the system and getting the output of the system to the user who will make the actual decision

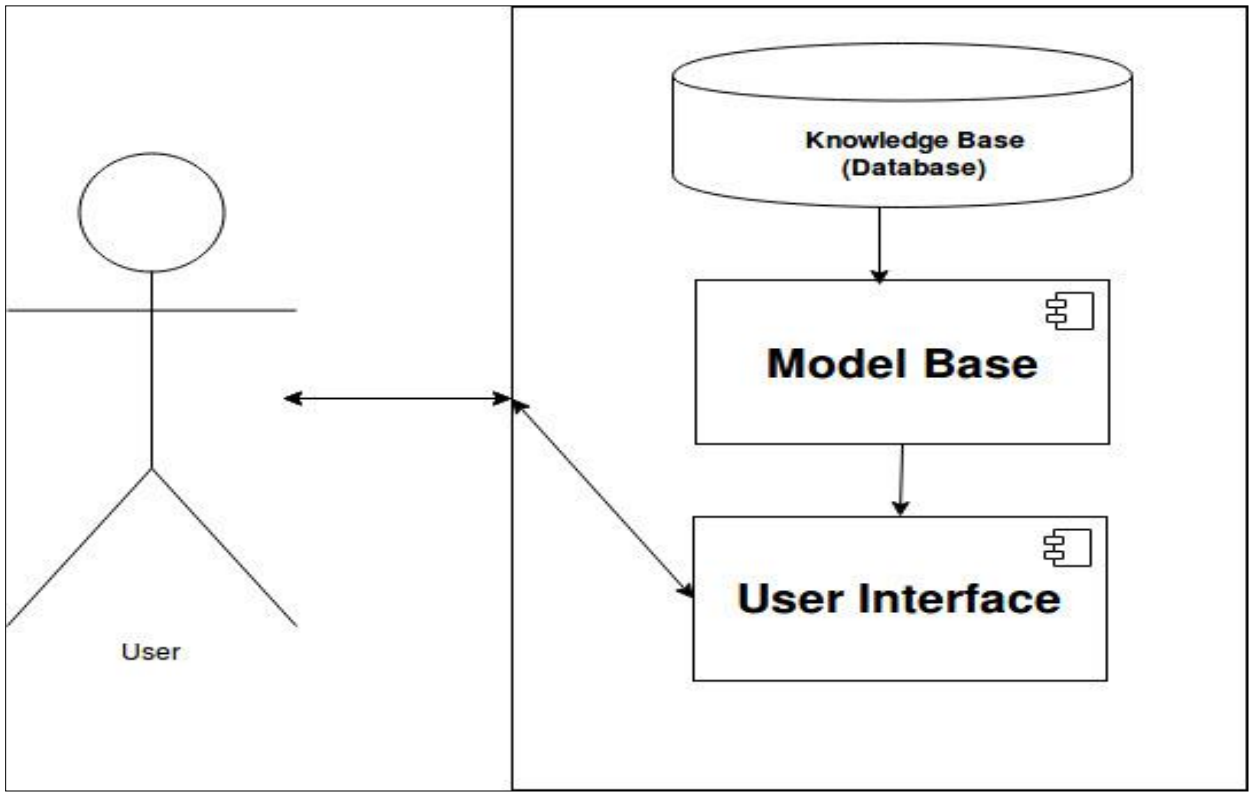

Figure 2.2: Decision Support System Components

Haettenschwiler's and Gachet in (Gachet & Haettenschwiler, 2003) classified DSS systems according to the relationship with the users to:

i. *Passive DSS* is a system that aids the process of decision making but cannot bring out explicit decision suggestions or solutions
ii. *Active DSS* helps to bring out decision suggestions or solutions
iii. *Cooperative DSS* allows the decision maker to modify, complete or refine the decision suggestions provided by the stem before sending them back to e system for validation.

According to Daniel Power in (Power, Sharda, & Burstein, 2015), decision support systems can be classified to:

i. *Communication driven DSS* supports more than one person working on a shared task
ii. *Data driven DSS* emphasizes access to and manipulation of a time series of internal company data and sometimes external data
iii. *Document driven DSS* which manages, retrieves and manipulates unstructured information in a variety of electronic formats
iv. *Knowledge driven DSS* that provides specialized problem solving expertise stored as facts, rules, procedures or in similar structure
v. *Model driven DSS* that emphasizes access to and manipulation of statistical, financial, optimization or simulation model. It utilizes data and parameters provided by users to assist decision makers in analysing a situation.

The defining characteristics that differentiate DSS system from other software is that they collect, store, analyse and present information. These functionalities are supported by its basic components which include the system inputs, user knowledge and expertise, outputs and decisions. The inputs include all factors and or/ characteristics that need to be analysed while the user knowledge and expertise constitutes the inputs that require manual analysis by the user.

The section 2.5 discusses the implemented DSS systems in Kenya for maternal health stating their contributions in the maternal health care domain and their limitations.

2.6 Decision Support Systems for Maternal Health Care

Currently mobile based systems have been put in place to aid community health workers (CHWs), who are the point of care for newborns and women during delivery. Some of the mobile based systems include;

momConnect; a cell phone based health service for pregnant women and mothers of children less than one year

openData kit clinic; stores patient specific data

Healthine and vase response technology; it is a ‘call in” system that provides expert medical advice and information to people in need of quality health care

mumHealth; a mobile messaging service delivering maternal, new-born and child health information to pregnant women and new mothers through voice and text messages in local dialect.

2.7 Related Studies

Pauline , Eva , Milka, Ziraba and Catherine in (Bakibinga, Kamande, Omuya, Ziraba, & Kyobutungi, 2017) sought to address the identification and referral of ill mothers and newborns especially in the slums. They used the existing CHV work tools and mobile phone technology to show how an evidence based intervention can improve health outcomes a community level. The overall objective of their work was to develop and validate a decision support algorithm within a mHealth application in improving maternal and new-born outcomes in urban slums of Kamkunji in Nairobi, Kenya. Using the proposed system, it was anticipated that the CHVs would identify pregnant women who faced high risk hence refer them t the necessary health facilities. Despite these advances, heir project was faced with challenge of possible technology failure, loss of equipment (phones) and CHV turnover. In addition, the CHV workers are not medically trained hence are not allowed to treat rather than refer, even when the system suggests so with possible negative health consequences for the mothers and their newborns.

In the study by (Haskew et al., 2015), a cloud based electronic medical record(EMR) for maternal and child health was proposed. The EMR system, referred to as Uamuzi bora., was implemented in a maternal and child health outpatient setting in Western Kenya between April and June 2013.The impact of the system on improving completeness of data collected by clinical and health services was assessed in their work. Significant improvements in completeness of the antenatal record were recorded through implementation of the system. A difference of 42.9% in missing data was recorded. Despite the significant impact of the system on data completeness, overall screening rates in the antenatal care were low. They recommended that data management and patient confidentiality must be considered when developing decision support systems for maternal health care.

CHAPTER THREE

METHODOLOGY

3.1 Overview

This chapter explains the research design that is proposed in the study. It further elaborates how the experiment will be setup, how data collection, data analysis and data presentation will be done. The scope of the study is then elaborated stating the sampling procedures and size that will be considered. The measures put across to ensure that quality control measures will be adhered to are then discussed under the reliability and validity section. The chapter ends by giving a brief summary of the methodology that will be used to conduct the research and also the ethical considerations that will be put in place.

3.2 Research Design

This study is an experimental research based on the principles of data manipulation. It will be based on the principles of:

Randomization whereby the experiment condition to be measured will be assigned randomly to the experiment units so as to avoid biasness.

Replication that requires the experiment to be repeated on many experimental units in a bid to increase scope of inference.

Local control so as to minimize the experimental error by balancing, blocking and grouping the experimental units.

3.3 Population and Sample

This study will consider sample data samples collected from health facilities in Nairobi County, Kenya. The data collected will include all the pregnancy related stages, that is, prenatal, antenatal and postnatal data. The prenatal data will consist of all details pertaining to health of the mother and child before birth, the antenatal will include all attributes related to the mother and child during pregnancy while the postnatal data will consist of all factors after birth.

3.4 Data collection

A high quality data will be required for realizing best results, it is therefore important that its acquisition be highly reliant on the quality of the data collection process. The study will rely on the utilization of maternal health data collected from health services in Nairobi.This research proposal will be forwarded to the School of Computing and Informatics for approval in Jomo Kenyatta University of Agriculture and Technology. After its approval, the researcher will approach the relevant bodies to request for the patient's records, which are normally recorded in the facilities Electronic health records (EHR).

3.5 Experimental Setup

After collecting the data, data pre-processing will be done to remove redundant data. In addition the missing feature values will be dealt with. The experiment will involve data pre-processing activities, feature selection, algorithm development process and performance evaluation.

3.5.1 Data Pre-processing

The raw collected data will be pre-processed with an aim of producing data that will be suitable for training and the testing the developed decision support system for maternal health. Records such as the patient's bio-data will be removed as they are not relevant for the maternal health care processes. The DSS developed will include algorithms that fill missing feature values in a dataset so as to complete the aspect of completeness. After missing the feature values, the performance of the missing feature algorithm will then be evaluated. If the performance level produced will be less than the anticipated level, the process of filling the missing values will be repeated until the desired level of performance is reached.

3.5.2 Feature selection

Feature selection procedures will facilitate selection of attributes that will be more relevant to the decision support model of this research hence improving on the quality of the data and reducing the time required to classify it. Both filter and wrapper methods for feature selection will be used in this study.

3.5.2.1 Filter Methods for Feature Selection

The filter feature selection techniques will select features on the basis of their scores in various statistical tests. The scores will then be used to rank the attributes and the attributes with a score below a given threshold are discarded and those with a score above the threshold used as input to

the classification algorithm. The filter methods that will be applied in this study will be information gain and correlation coefficient.

Information gain will be used to measure the dependency between variables and a score will be assigned to each variable based on the amount of information that can be derived about the class when the variable is used. The level of usefulness will be determined by how great the entropy of the class will decrease when the attribute is considered with each of the corresponding features .Hence the decision tree will be constructed with attributes that have a high information gain, that is, the most homogeneous subset.

The correlation coefficient method will perform feature selection using the theory that the best feature subset contains features that are highly correlated to the class and uncorrelated with each other thus screening out irrelevant and redundant features. It will be used to provide information of how predictive a set of feature to a class is and the also the redundancy of the attributes.

3.5.5.2 Wrapper Methods for Feature Selection

The wrapper methods will be used for feature selection by evaluating the performance of a variable subset by training a model. Based on the inference made, after training, one can decide to add or remove an attribute from the subset. The sequential forward search and sequential backward search method will be applied in this study as a wrapper technique for feature selection.

The sequential forward search (SFS) method will involve addition of features in a sequential manner such that they will be trapped in local minima. The SFS method will begin at an empty set and feature that increase the classification accuracy will be added sequentially. This will be repeated until the required number of features are added.

The sequential backward search (SBS) method will start from a full set, removing features that reduce the classification accuracy level. This process will be repeated until the set has the number of the required attributes.

3.5.3 Decision Support System for Maternal Health Development

3.5.4 Performance Evaluation

The effectiveness of the developed decision support system for maternal healthcare will be measured based on factors such as user satisfaction, decision performance to measure DSS success, decision errors and/or cost and the decision regret factor. The regret factor is when a decision taken proves to be a wrong decision and the decision making team regrets for the decision that was made. In this regard DSS is used to take a decision so that the regret factor can be minimized or in other words it can be said that the probability of success will be increased. Additionally, the percentage of problem resolved after decision made, the speed of decision made, or duration or percentage of decision pending and the decision process bottleneck and traffic will also be take into consideration while evaluating the performance of the developed DSS.

3.6 Reliability and Validity

The reliability and validity of this research are discussed in section 3.6.1 and 3.6.2 respectively.

3.6.1 Reliability

Reliability is a measure of how consistent, stable and repeatable a research is and that the results obtained will be identical in the same situation but different circumstances(Twycross, Shields, & Rgn, 2005).The experiments will be run multiple times and results for each experiment recorded so as to evaluate if there exists any difference in the experiments.

3.6.2 Validity

Validity can be defined as the degree to which a research measures what it is supposed to measure and it achieves content, construct and criterion-related validity. The content validity measures degree to which a randomly selected item represents a domain of property or trait being measured whereas the construct validity is concerned with the degree to which a research measures the construct it is designed to measure while the criterion-related validity detects presence or absence of one or more criteria considered to represent traits or the constructs of

interest(Thatcher & Ph, 2010). Content and construct validity will be ensured by experts, peer reviews and supervisors

3.7 Data Analysis

The data analysis process will involve identifying common patterns in the data and critically analyzing them in order to achieve the research objectives by obtaining usable and useful information. The R studio will be used to perform data analysis by building models that will test and validate the system. Both qualitative and quantitative data analysis procedures will be done.

3.7.1 Qualitative Data Analysis

Qualitative data analysis will be used to provide explanations, understanding and interpretation of the study phenomena based on the data collected from literature review. It will aim at examining the meaningful and symbolic content that will be found within the literature.

Content analysis will be used to come up with an interpretation and explanation of the descriptive information. It involves systemic analysis of literature with an aim of making valid inferences from the examined material. The content analysis process will involve identifying themes, patterns and relationships related to the study such as searching for missing information and comparing research findings to a phenomena from a different area and discussing the similarities and differences, then later summarizing the data by linking the research findings to the study objectives.

3.7.2 Quantitative Data Analysis

Quantitative analysis will be done using descriptive statistics, inferential statistics methods such as correlation and regression analysis with an aim of determining associations between independent and dependent variables, their significance and prediction.

Alpha level(p level) will be used to find significance in the results obtained, thus the acceptance or rejection of a hypothesis will be based on the alpha (α) level- its significance level. In instances that the hypothesis will be proved to have lower significance level, new hypothesis will be formulated and tested over and over again until the hypothesis achieves a higher significance level.

3.8 Ethical consideration

An approval from the Ethical Research Committee (ERC), Board of Postgraduate Students of Jomo Kenyatta University of Agriculture and Technology and a permit from NACOSTI will acquired before carrying out any of the research activities. The patient data that will be acquired will only be used for this research work and will not be published or shared without the consent and permission from the organization providing it.

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APENDIX A: WORK PLAN

Items of work activity	**Months (Year 2018)**			**Months (Year 2019)**								
	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sep**
Proposal writing and submission												
Proposal corrections												
Resubmission of final draft												
Thesis writing												
Conferences and seminars												
Preparing journal papers for publication												
Submission of draft thesis for review												
Thesis defence												
Correction and final thesis Submission												

APPENDIX B: BUDGET

ACTIVITY	QUANTITY	UNIT COST	TOTAL COST
DATA COLLECTION:			
i. Stationary	5 reams	400.00	2000.00
• Pens	1 dozen	40 x 15	600.00
• Flash disk	1 - 32GB	2500.00	2500.00
• Spring file	5 pieces	25.00	125.00
ii. Typesetting and printing	250 pages	3.00	3500.00
iii. Binding			4500.00
iv. Literature review			15000.00
SUB TOTAL			**28, 225.00**
DATA COLLECTION, STORAGE:			
i. Android smart phone	1	22000.00	22000.00
ii. Cloud storage service			75200.00
iii. Laptop	1	70000.00	70000.00
iv. Mobile wireless router	1	10000.00	10000.00
v. Mobile data bundles	100GB	1000.00	100000.00
SUB TOTAL			**277,200.00**
DESIGN AND DEVELOPMENT			**120000.00**
DATA ANALYSIS			**30000.00**
THESIS PREPARATION:			
i. Typesetting and printing	150 copies	35.00	
ii. Photocopying	700 copies	3.00	
iii. Binding	7 hard bound	400.00	
iv. Transport and local subsistence	21 days	1200.00	
SUBTOTAL			**131,220.00**
CONTINGENCIES			**35,000.00**
GRAND TOTAL			**621,645.00**