A WEB-BASED TELEPRENATOLOGY PLATFORM FOR ANTENATAL CARE
MANAGEMENT IN REMOTE AREAS

NORAINI BINTI JALIL

A thesis submitted in fulfilment of the
requirements for the award of the degree of
Master of Engineering (Biomedical)

Faculty of Biosciences and Medical Engineering
Universiti Teknologi Malaysia

MARCH 2015

To my beloved parents, brothers, sisters and friends

For their endless love, support and encouragement

Only Allah will return all your kindness.

ACKNOWLEDGEMENT

ABSTRACT

According to World Health Organization, approximately 289,000 women had died due to complications of pregnancy and childbirth in 2013, largely in developing countries. Indonesia as one of the biggest developing countries in the world; the number of midwives is high while the number of medical specialist is low. In addition, existing ultrasound system is not suitable for midwives to manage high risk pregnancy during remote antenatal check up. As a result, high risk pregnancy cases detected by midwives in rural areas can not be identified and referred to medical specialist immediately. In this study, a new teleprenatology management platform has been designed and implemented for rural areas. This platform enables the communication between midwives in rural area and distant medical specialists. The platform consists of prenatal server, prenatal data assistant and prenatal workstation with two main functions; teleconsultation and electronic medical record. A user-friendly web-based solution was implemented using technologies such as Python with Django framework along with JavaScript, Ajax, Jquery and html in front-ends. To explore and describe the perceived needs and specific requirement for this platform, the adoption of a user-centered design (UCD) approach has been proposed. Research study had been successfully conducted at several clinics in Kampar, Indonesia. After the platform has been designed according to the user's feedback on their need and specific requirement, the user usability and user acceptance of the proposed platform were tested. User acceptance result showed that all five constructs mean were above 60%. Among the construct, behavioural intention to use had the highest mean values of 90.8% ($\pm$15.6). In case of usability testing, analysis also showed an overall mean value of over 60% and ease of navigation had the highest mean value of 84%. Images transmitted during teleconsultation met the standard medical quality of service (m-QoS) and were sufficient for diagnosis purposes. In conclusion, a positive agreement was observed asserting that this low cost teleprenatology platform is acceptable and easy to use. However, further studies are needed to improve the real-life implementation of this platform.

ABSTRAK

Menurut Pertubuhan Kesihatan Sedunia (WHO), pada tahun 2013 terdapat sekitar 289,000 wanita meninggal dunia akibat komplikasi kehamilan dan kelahiran dan 98 peratus kes dilaporkan berlaku di negara yang sedang membangun. Di Indonesia, jumlah doktor pakar perbidanan dan sakit puan didapati sangat kurang dibandingkan dengan jumlah bidan terutamanya di kawasan pedalaman. Selain itu, sistem ultrabunyi yang sedia ada tidak sesuai untuk bidan untuk menguruskan kehamilan berisiko tinggi semasa pemeriksaan kehamilan. Akibatnya, kes berisiko tinggi yang dikesan oleh bidan sukar dirujuk kepada pakar dengan segera. Oleh itu, dalam kajian ini satu platform baru bagi pengurusan telepranatal telah direkabentuk bagi kegunaan bidan di kawasan luar bandar, yang mampu untuk menghubungkan bidan dan doktor pakar secara jarak jauh. Platform ini terdiri daripada sistem pelayanan pranatal, pembantu data pranatal, dan stesen kerja pranatal dengan dua fungsi utama iaitu sebagai perekod elektronik perubatan dan telekonsultasi. Penyelesaian berasaskan web mesra pengguna ini dilaksanakan menggunakan kerangka kerja *Django* dengan bahasa pengaturcaraan *Python* serta *JavaScript, Ajax, Jquery* dan *html* sebagai pemproses bahagian depan. Dalam usaha untuk menghuraikan keperluan pengguna dan spesifikasi platform ini, penyelidikan ini menggunakan pendekatan reka bentuk berpusatkan pengguna dan tinjauan telah dijalankan di beberapa klinik di Kampar, Indonesia. Setelah platform direka berdasarkan maklumat dari hasil tinjauan, peratus kebolehgunaan pengguna dan penerimaan pengguna telah diukur ke atas platform ini. Untuk penerimaan pengguna menunjukkan bahawa semua kadar purata peratusan bagi lima parameter adalah melebihi 60 peratus dan purata peratusan tertinggi adalah niat berperilaku iaitu 90.8% ($\pm$15.6). Bagi ujian kebolehgunaan, purata peratusan keseluruhan juga adalah lebih dari 60% dan diantara parameter yang diukur, kelancaran pelayaran mempunyai purata kebolehgunaan tertinggi iaitu 84%. Selain itu, imej yang dihantar semasa telekonsultasi didapati mematuhi piawaian kualiti servis perubatan dan mencukupi untuk tujuan diagnosis. Secara keseluruhan keputusan positif yang telah diperoleh menegaskan bahawa platform telepranatal kos rendah ini adalah diterima oleh pengguna dan mudah untuk digunakan, tetapi perlu diperbaiki untuk pelaksanaan yang sebenar.

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LIST OF ABBREVIATIONS

ANC   -   Antenatal Care

EMR   -   Electronic Medical Record

Ob-Gyn   -   Obstetric And Gynaecologists

WHO   -   World Health Organization

IRPM   -   Integrated Remote Prenatal Monitoring

QoS   -   Quality of Service

TBA   -   Traditional Birth Attendant

TT   -   Tetanus Toxoid

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CHAPTER 1

INTRODUCTION

1.1   Background of the Study

Maternal and infant mortality is unacceptability high. According to WHO, almost 800 women died from preventable causes related to childbirth, whereas stillbirths are more than 7200 in each day. In 2013, approximately 289,000 women died due to complications of childbirth. 28% of maternal mortality rate is due to pre-existing medical conditions exacerbated by pregnancy such as diabetes, malaria, HIV, obesity. Meanwhile haemorrhage (27%) has been known to be the second important cause of maternal mortality worldwide. The other causes of maternal mortality are induced high blood pressure (14%), infection mostly after childbirth (11%), obstructed labour and other direct causes (9%), abortion complications (8%), and blood clots (3%). Globally, almost 99% of maternal mortality occurs in developing countries, meanwhile two-thirds of stillbirths happened in rural areas [1]. Particularly in Indonesia, maternal mortality ratio is 240 per 100,000 live births [2].

In third world countries, the main cause of maternal mortality is due to lack of skilled birth attendant in particular midwives and physicians. They are not always available for essential care during childbirth and for obstetric emergencies, including Caesarean sections.   According   to   United   Nations   Population   Fund   (UNPF),

Indonesia has a high number of midwives, 93889 to cover 64,292 women of reproductive age between 15 until 49 [2]. Unfortunately, the job scope of a midwife is only limited to cover normal pregnancy during antenatal care. Ob-Gyn personnel monitor for high risk pregnancy. However, there are only 870 numbers of obstetricians which is far from sufficient to cater to the high risk pregnancy cases in that country [2].

Maternal mortality occurs also due to shortage of maternal healthcare, and facilities. For example, in rural clinic, there is no ultrasound to monitor pregnancy. Ultrasound is an important tool for all trimesters of pregnancy that can check baby's heartbeat and monitor the development of baby inside uterus. In the first trimester, ultrasound helps to check the exact position of the developing embryo in the uterus since ectopic pregnancy is the leading cause of maternal mortality during early pregnancy. The most common location for an ectopic pregnancy is the fallopian tube. There are many occurrences where women experienced abdominal pain and vaginal bleeding within the first trimester. Since clinical signs and symptoms may not be reliable, ultrasound can assist in early identification of high risk complications in pregnancies and prompt intervention can be given to those women. Ultrasound helps in identifying the mortality risk factors and estimates gestational age in second and third trimester of pregnancy. The developed system can be very helpful in the diagnosis and management of preterm labor and any complication during pregnancies. Even though, ultrasound has been known to be very useful instrument, unfortunately the existing ultrasound machines remain highly operator dependent and necessitate training and practice for providers to produce interpretable images [3]. Furthermore diagnosis result may vary, based on their expertise and experience while expert distribution which is Ob-Gyn concentrated in developed countries and urban areas.

Although there is a high number of a midwife, most midwives have limited knowledge, lack of training and skills to handle high risk pregnancy. Help and guidance from Ob-Gyns to midwives are essential in these cases. If any complication occurs the woman needs to be referred to hospital immediately.

Moreover, there are many obstacles in sending patient to hospital from remote areas. Distance to hospital, poor road infrastructure, and lack of ambulance with complete equipment, cost for commuting, poverty issues, and geographical problems are seen Indonesia being an archipelago, a country comprising thousands of islands, has a much more challenging issue to provide access to healthcare.

Good management for antenatal care is important in order to give proper care to the pregnant woman. Most of the clinics are still using paper based record managements instead recording them electronically. If data is misplaced or lost, they have no back up data to restore. Currently, paper records represent massive fragmentation of clinical health care management which is not economical or environmental friendly. By using EMR system as a replacement for paper records, the health services can be improved. Some advantages of using EMR over paper health records are increasing storage capabilities for longer periods, accessible from remote sites to many people at the same time, retrieval information almost immediate without moving to far distance, and providing medical alert and reminders [4]. Besides that, it is very useful during emergency case, where specialists are able to access the information before the patient arrives to hospital.

Therefore, telesonography is one of the solutions and had been implemented to overcome the gap and distribution of problems. It combines telecommunication technology and medical expertise for the delivery of ultrasound images for interpretation or consultation purposes. By telesonography, patient may ask interpretation or second opinion of ultrasound image from afar that is distance worldwide. Telesonography can minimize maternal death because many complications could be cured if detected early and treated effectively. This research was designed and implemented through telehealth platform for prenatal management. The system was invented to reduce fetal and maternal mortality rate specifically in rural areas. Implementation of this system will indirectly help the United Nation to achieve their fourth and fifth Millennium Development Goal (MDG) which deal with 'reduce the child mortality', and 'to improve maternal health by three quarters of the maternal mortality ratio and achieving universal access to reproductive health' [5].

1.2   Problem Statement

Telemedicine is medicine practiced across distances and involves the electronic transfer of information [6]. Telemedicine has been advocated in situations where the health professional on duty has little or no access to expert help. It is able to offer remote physician access to otherwise unavailable specialist opinions, providing reassurance to both doctors and patients. There are many branches of telemedicine applications. The telemedicine module survey of 2009 examined the current level of development of four fields of telemedicine: telepathology, teleradiology (telesonography), telephsycology, and teledermatology. One of the emerging telemedicine branches is telesonography, which is ultrasound remote diagnosis. Some of the earliest projects using telesonography were applied to subspecialities such as obstetric and cardiology [7, 8]. There are many existing telesonography research options in obstetrics which can reduce medical cost and improve patient care [3, 9-14]. In previous research, they transferred two types of data transmission between transmitter and receiver end which are synchronous (real time) and asynchronous (store and forward) with recurrent objective themes with respect to quality of transmitted images, clinical applications and technical and non-technical barriers to implementation [8]. Nowadays, in this era of globalization, telesonography is increasingly become popular and expanding. However, it is not widely used and not being fully adopted in healthcare centres in developing countries. One can question why telemedicine technology is not being used there and it will be discussed later in this section.

One of the reasons telesonography is not successfully implemented is because some critical success factors enabling adoption in healthcare and several technical problems exist. One of them is the mismatch between technology and perceived usability by the users. The technology acceptance by the user depends on the need and requirement factors. It is important to identify the compelling need before design and implementation process is done and from high level problems or several problems, the fact is telemedicine need and can solve the problems. In addition, user requirements are very important and need to be given consideration because it will

greatly affect the implementation of telemedicine applications. Most of the existing teleultrasound systems are found not considering the human factor and too sophisticated especially for low healthcare providers. As mentioned by Sukdershan Singh [15], at the national level, there is no in-depth study about physician teleconsultation, adoption, human and environmental/technology factors haven't yet included in the existing teleconsultation software [9, 15-17]. There are many remote services for ultrasound; but there is no clinical telesonography for low end user like midwives because the need of telesonography for them is not well clear understood. Existing ultrasound system is not suitable for midwives (low end user) to manage high risk pregnancy during remote antenatal check up [18, 19].

Besides that, one of challenges of telesonography implementation is communication between existing medical imaging device and communication network. Several ultrasound devices do not have connection to existing network infrastructure so the image data cannot be delivered to a distant location for analysis. Also, protocol standardization of telesonography that enables interoperability and manufacture-independence is still a big issue that limits teleultrasound use. IT working group of German Radiology Society has proposed standard for basic teleultrasound in 2005. It was used daily in over 50 hospitals and institutions [20]. One of widest protocol used in telesonography is Digital Imaging and Communication in Medicine, published by National Manufacturing Electrical Association (NEMA) [21]. It supports off-line media environment using industry standard media. DICOM-based softwares for telesonography application have been developed by researchers [20, 22, 23].

Even though telesonoghraphy has been promoted, but most of the clinics are still using paper based record for obstetric managements instead of recording in computer or electronic medical records (EMR). If the data get lost, they don't even have any data back up whereas data management especially keeping data record is very important in order to give best care to mother. Currently the paper records represent massive fragmentation of clinical health management, which leads greater cost due to consequent current and future patient care [24]. By using EMR as a

replacement for paper records, the health services can be improved. Some of advantages using EMR over paper health records are it increases storage capabilities for longer periods, it is accessible from remote sites to many people at the same time. People involve can retrieve information almost immediately without moving, and provide medical alert, reminders and many more advantages [25].

1.3   Research Objectives

In general, the objectives of this study are to design and implement a teleprenatology platform for antenatal care management in remote areas.   This objective can be detailed as:

1. To conduct a comprehensive survey for need and requirement analysis by considering human and environmental/technological factors for teleprenatology platform.
2. To develop clinical teleprenatology platform that is specific for midwives in rural areas for antenatal care.

1.4   Significance of Study

This web-based teleprenatology platform is meant to improve the management of high risk pregnancies and can be used by midwives in rural areas to communicate with specialist in different places.   Early detections of diseases or complications can be found on and early treatment can be provided to women by referring to hospital.   So, this model can increase the quality of prenatal care and indirectly can reduce maternal and infant mortality.   It will also indirectly help the

United Nations to achieve two of their Millennium Development Goal, which are goal number four; to reduce the child mortality, along with goal number five; to improve maternal health by reducing to three quarters of the maternal mortality ratio and achieving universal access to reproductive health [5].

1.5 Scope of the Study

The overall studies are focused on only antenatal visits for uncomplicated pregnancy, in first trimester, second trimester, and third trimester until delivery. The postnatal care is not included in the research.

The users of this platform include healthcare providers such as prenatal physicians and midwives in developing countries. Our main focus was midwives in rural areas of Indonesia.

The technology design focused more on flowchart in the system for front end and back end users. The web-based platform was integrated with modified ultrasound machine to produce offline image and streaming video, however streaming ultrasound video, existing software will be used in this study and the application was be embedded into the platform.

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