

Mother and Children Health Reporting System: Innovative Information System Application in the Rural West Bandung Area, Indonesia, by Using Multimodal Communications Systems

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Abstract- Objectives: Digitalization of maternal and post-natal care system (DigiMAPS) is a system consist of electronic medical record for mother and children health (KIA) also for tele-consultation facility called “Tele-Obgyn”. Our project focuses on the development of KIA Online and a cloud computing-based video conferencing as a basis of Tele-Obgyn platform. The web-based network allows online access not only among primary health care but also between government and private institution. DigiMAPS platform is designed to meet the needs of database management and its interphase with other services that are responsible for data acquisition and visualization. **Methods:** DigiMAPS combines the open-source flexible system design that benefits for implementation and development needs as well as support for mobile devices to enable high quality of patient care. The system has been developed gradually following lean-innovation management concept which focuses on customer-problem-solution matching with rapid prototyping and validation from idea to solution. There was significant effort to establish a close relationship and learning process with prospective users of DigiMAPS, hence in the broader perspective we used a participatory research approach. DigiMAPS act as central-portal and -data base in the communication information system (ICT), designed to compile patient report paperless and equipped with tele-consultation. **Results:** DigiMAPS developed for a variety of administrative processes. This system will simplify the work process and can be integrated with primary health care system, Health Department and the Ministry of Health. A good ICT will be useful in collecting clinical information than conventional paper-based reporting system and to minimize errors in the reporting chain. **Conclusions:** By using lean innovation management, several inputs are gathered from prospective users including health authority, head of local clinics, midwives, obgyn doctors, and public health staffs. Our system may bridging gap between clinical needs and digital documentation, telemedicine-monitoring and improve the quality of patient care, facilitate communication within both the scope of the internal (primary health care) and external (stakeholders and follow-up), increasing productivity and reduce overall expenses.

Keyword: Digitalization of maternal and post-natal care system (DigiMAPS); Medical IT; Information Communication System (ICT); eHealth Cloud Computing.

I. INTRODUCTION

According to 2010 Directorate Mother and Children Health, Indonesian Ministry of Health, West Java province contribute 19.8% of maternal mortality in Indonesia, which is the highest compared to other provinces in Indonesia. In 2012, there were about 228 pregnant mother deaths per 100.000 pregnancies in West Java [1]. There are about 18 regions and 9 cities in West Java Province. Bandung Region contributed 46 mother deaths while West Bandung Region 28 deaths during 2012. Neonatal mortality rate in Bandung Region is about 34 among 1000 live births, which is very high compared to the target 23 per 1000 live births.

DigiMAPS program aims to support midwives in performing mother and children health record as part of their daily task in the rural area [2]. Based on the fact that all maternal and postnatal data are standardized in paper-based formats, thus we developed a new way to capture the data then store them digitally. In addition that the data are also useful for area-based health surveillance reports, we developed new ways to aggregate the data into a management report format. Furthermore we introduce a multimodal communication concept in order to allow prospective users such as midwives and doctors can access the application anywhere anytime from any devices. Multimodal communication basically refers to the use of public broadband access to reduce capex and human resource issues which are usually experienced by telemedicine initiatives.

This research project is conducted by, Innovation and Design Center (IDeC) of PT. Telekomunikasi Indonesia Tbk. (TELKOM), and fully supported by: Faculty of Medicine Universitas Padjadjaran (FK UNPAD)–Hasan Sadikin Hospital (RSHS), Indonesia; Health Office, West Bandung County, Government agency, Indonesia; Basic Human Needs (BHN) Telecom Association, Japan and Kagawa University, Japan. DigiMAPS concept and system has been disseminated to local authorities including: Indonesian Public Health Care Centre “Puskesmas” in the rural area; Referral hospital in West Java on its responsibility to provide expert; Health Service Office of West Java Province; The centre of data and information of the Indonesian Ministry of Health, Jakarta; Department of Obstetrics and Gynaecology (Obgyn) FK UNPAD–RSHS, Bandung, Indonesia.

DigiMAPS covers collaborative research in the field of broadband deployment, e-health applications, mobile communication technologies, new approach for rural ICT infra-structures and technologies for realizing ubiquitous network. The objectives of this project are: (i) To translate current maternity and postnatal reporting procedures into DigiMAPS in order to speed-up reporting procedure and improve data accuracy. (ii) To design and develop tele-maternal care system in order to connect midwife and medical doctor in rural and remote area with Obgyn specialist in top referral hospital during maternity and postnatal events. (iii) To design and develop device, network and application for consultation purpose and multimodality communication systems that supporting various user accesses including web-based, SMS and mobile application-based entry.

DigiMAPS is designed to manage patient's data for services purpose, education and research. There are special requirements for acquisition and visualization. Central portal and data collection is required for this information system to facilitate better data retrieval compared to manual medical record book. In addition, the system is expected to be used for online consultation between resident and consultant, and, in the future, with patient. This server is equipped with cloud computing that allows users to access the system inside and outside the primary health care using an internet connection. This data includes history taking, physical examination, laboratory examination, imaging results and management. This application is aimed to improve reporting systems and patient data retrieval.

Additionally, telemedicine for remote consultation will also be made in this system. The purpose is to facilitate the understanding and use of software for prospective midwives, the first time they use the application. The display of the application is designed to support patient report for educational purposes and provide the transmission of information when referring a patient. This system is also intended to guide a physician during difficult cases through audio-visual tele-consultation, tele-Obgyn. This system is expected to be widely used not only for the Gunung Halu but also for other area within West Bandung County. This is possible because the core engine of the software application is based on web. If the system is integrated with institution or even with other hospitals in Bandung or all over Indonesia, then this system may improve healthcare services. In this study it's important to create web-based DigiMAPS software.

II. MATERIAL AND METHODS

DigiMAPS trial conducted in Gunung Halu area, West Bandung County in collaboration with PT. TELKOM, Bandung. KIA Online includes engine and multimodal data entry systems allowing prospective users to exploit any means of broadband communication systems available in city and rural area. For trial purposes in Gunung Halu, we will use WiFi technology to connect local health center (Puskesmas) to several midwife located in nearby and remote area. In the rural area, the challenge not only comes from communication infrastructure but also electricity. Therefore we have proposed a communication package system comprises communication devices and application to support midwife, volunteer and doctor. KIA Online has designed to capture the maternal and post natal data, reveal the data into report and enhance capabilities of the midwife through it simplicity. The KIA Online engine has been tailored to accommodate current data format and protocol already implemented in the field. Basic requirement of the KIA Online has come from user need validation process, the users and their problem has been validated in the beginning of project. Since the software of maternal and post natal care system has been developed base on practical user interaction in the representative location.

III. RESULTS

Network System and Engine

DigiMAPS system network architecture consists of several sub-systems (Fig. 1):

- Engine management information system
- Multimodal data entry system that allows users to record data using a web browser, SMS and android application
- GIS-based user interface to retrieve DigiMAPS data
- Broadband access for telemedicine and DigiMAPS systems

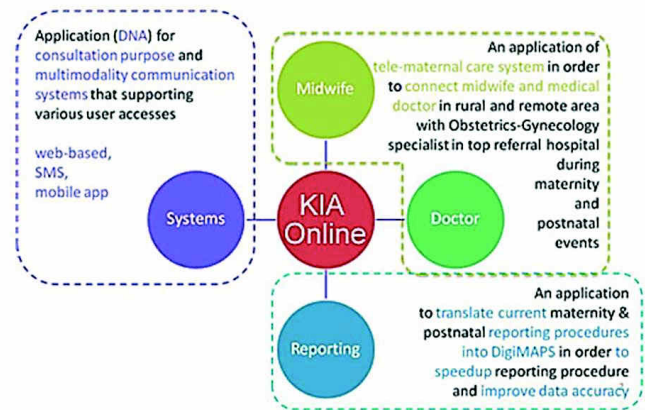


Figure 1. DigiMAPS system network architecture.

DigiMAPS engine and multimodal data entry system will lead users to maximize broad band communication systems usage available in the urban area and the surrounding area. In the future, WiFi technology will be used in the Puskesmas to be connected to surrounding areas and hospitals providing Obgyn and Pediatric services. In isolated or disastrous areas, the biggest challenge is not only due to the broadband infrastructure but also the availability of the electrical source. Based on earlier ideas, a communication package equipped with solar system will be provided, WiFi receiver and DigiMAPS communication tools to support the system. Telemedicine is included along with a teleconferencing system that allows expert to communicate with midwives and physicians. Full communication services will also be built in accordance with the needs of the user.

DigiMAPS engine Engine used is created to accommodate new data design and protocols have been implemented in the field. Training will also be conducted by authorities and midwives to record all medical needs and accommodate it into the system. Basic needs of the system are derived from the needs of users in order to facilitate consumer in completing tasks in the field. DigiMAPS software system is designed to interact with the consumer anytime anywhere.

Logic Representation of DigiMAPS software system New patients and patients in the ward reporting system software will be elaborated into the relationship between actor-system; was shown in Fig. 2. Actor in this system is expressed in Table 1.

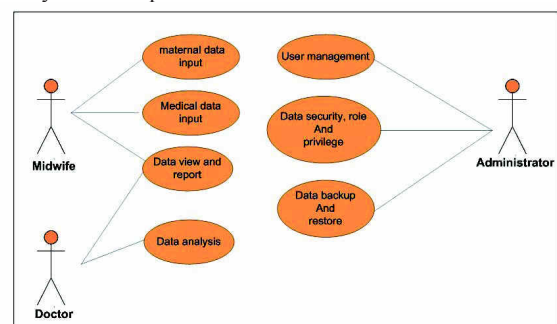


Figure 2. DigiMAPS software will elaborated into the relationship between actor-system.

Tabel 1. Actor report in **DigiMAPS** system of new patient

No	Actor	Descriptions
1.	Administrator	User with Super user roles which gain access to system. Responsible on operation, back up, security and maintenance of system.
2.	Midwife	User with medical data entry and data read roles.
3	Doctor	Expert user with medical data entry, data read, data analysis role

Actor represents people, system, external users or stakeholders who provide input or abstract output of the system. Diagram of this system, both will interact between actors and the system that is built to describe what the system is doing and obtained role based on task. Elaboration will be accommodated into the system (Table 2).

Tabel 2. Detail elaboration in the sistem of **DigiMAPS**

Code	Name	Descriptions
UC_010	Maternal data input	Basic system's capabilities related to data input provided by actor through classified process by using printed form or electronic devices. Main actor of this use case is mid wife who receive hand written report from medical volunteer.
UC_020	Medical data input	Basic System's capabilities related to data collections of patient, diseases, medicine or other issues that need to be confirmed by expert.
UC_030	Data view and report	Basic capabilities of the system include data-presentation feature, -cataloging, -indexing, report generation, etc.
UC_040	Data analysis	Basic capabilities of the system that include: data inspecting, data cleaning, transforming into another format, and data modeling with the goal of highlighting useful information for actors.
UC_050	User management	Is an authentication feature that provides administrators with the ability to identify and control the state of user logged into the system.
UC_060	Data security, role and privilege	Ensure data privacy and compliance with data loss or exploitation prevention method. Protect the data from insider threats, data stealing, malware and unauthorized user.
UC_070	Data backup and restore	Basic capabilities of the system of copying files or databases so that they will be preserved in case of equipment failure or other catastrophe. The opponent capabilities of the system is data restore, basic capabilities that involves copying backup files from secondary storage to the disk.

The use of the above diagram aims to transform into a layer of information that states the general method of interaction. The next step is to arrange diagrams such as: interface diagram, library object programmers, and interface collaboration diagrams. Software system framework code is arranged based on these diagrams.

Coverage of software design of DigiMAPS system includes:

- Service advancement of new patient data capture and patient in the ward, reduce bias due to missing data or written data is converted into digital data, reducing the time to rewrite the data and transform into a report view.
- Making better display than health care system within the FK

UNPAD-RSHS. Some of the better sense is, the better the performance compared to the time before using the system faster data transfer, display better data format, organized presentation of information management, etc.

- The efficiency of the user interface. The main goal in building this system is to provide software that is very easy to use by users, enables users simply by pressing a button or touching the screen, or transfer data to a variety of communication tools available.
- Provide a variety of information to be able to immediately make a clinical decision or action of the received data and their application in the field response.

Entity Relationship Diagram Entity Relationship (ER) diagram of a system built describes the relationship between the stored data into tables that appear. Physical appearance of the table data is usually processed computer to be initiated into the structure of meta-data into a database management system as an object relationship data base in the form of tables, views, stored procedures, and cons trait data. ER diagrams are usually used to modify the design to a rational system of database objects and to maintain the structure of the meta-data from the database. ER diagram of DigiMAPS can be seen in Fig. 3. The first phase of the design of the information system and sub-system that is used in it during the data analysis process needed to describe the information needs or the type of information that will be stored in a database format. Data modeling techniques can be used to describe various forms of ontology (such as an overview, calcification terminology and relationships among them) to display the data as the user desires.

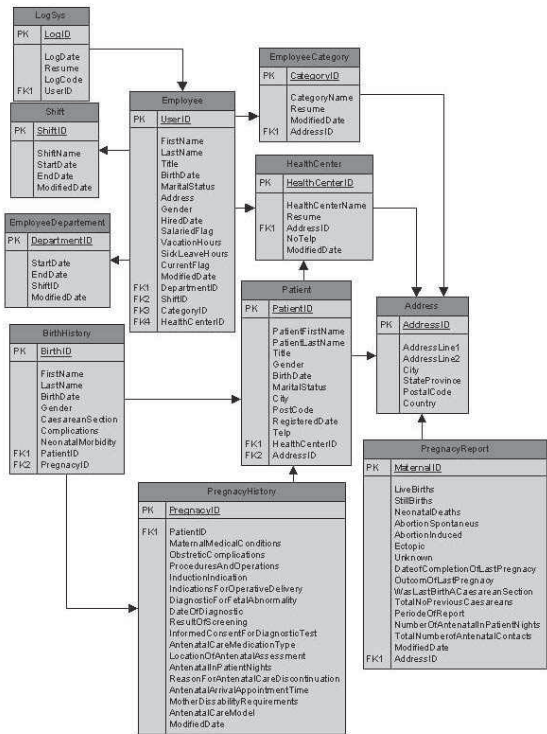


Figure 3. Entity relationship (ER) diagram of DigiMAPS system.

Graphic User Interface (GUI) dan Multimodal Data Entry Other development, when no smartphone, can be sought with text-based mobile phone based services (TBC). TB can be either short message service (SMS) and Unstructured Supplementary Service Data (USSD). Under these conditions, we were to design a data entry that can be matched with the data of the SMS or USSD (Fig. 4).

Geographic Information System (GIS)-based Statistic Reports The use of geographic information systems based on the display can be of much help health authorities to monitor patterns of disease and predict certain region, so that this information can assist policy makers in health issues in area earlier.



Figure 4. Multimodal data entry for DigiMAPS system.

Technology Acceptance Model (TAM) In the information systems required profile data to be used in the reporting system in the West Bandung County. The interface will look like Fig. 5.

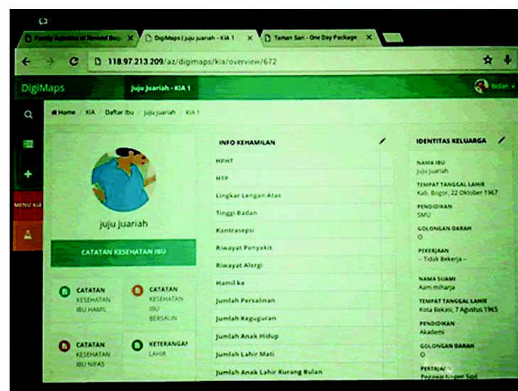


Figure 5. DigiMAPS Graphic user interface (GUI)

We made programming and making of the application display (Fig. 6).

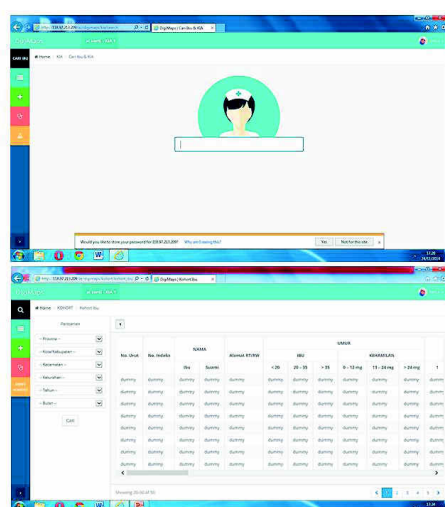


Figure 6. The DigiMAPS system application display.

For the database, we use the SQL server to store data pasien [3]. After the resultant user trial will be performed and the results will be evaluated to be eased user using the technology acceptance model (TAM). From the data entry results of the software developed self-calculating statistic, as shown in Fig. 7.

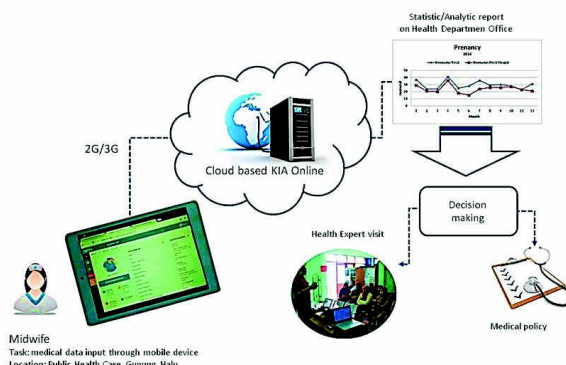


Figure 7. The software developed self-calculating statistic.

Cloud Computing Cloud computing (Fig. 8) is the combined use of computer technology and Internet-based development. The latest development in computer systems technology that allows users to only pay the appropriate use of that offer high-quality technology solutions in a timely, cost-effective and fast response. Advantages of cloud computing:

1. Cost savings, without the need of spending in the establishment of IT infrastructure both software and hardware.
2. Increased storage capacity. It saves data storage media because the data lies in the application and database servers.
3. Automation. Applications are updated at any time.
4. Flexibility. Can be optimized according to business needs.
5. Mobility. Users can access the applications and information anywhere and anytime using mobile devices (laptops, mobile phones, tablet PCs).

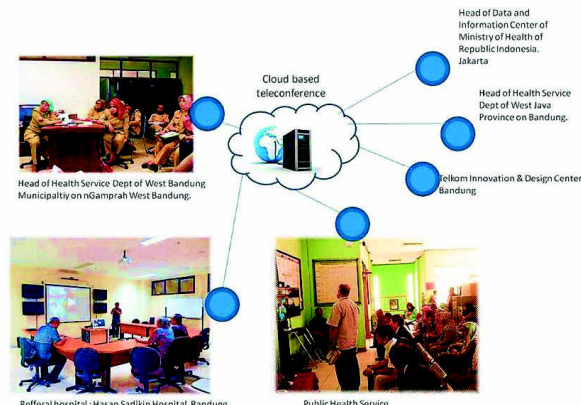


Figure 8. DigiMAPS cloud computing system

Cloud computing is the future of this technology is not only intended for the analysis and examination of neurosurgical disorders alone, but also can be developed into other fields. Its because Cloud Computing based on three parts: software, infrastructure, and platform as a service (SAAS, IAAS, PAAS) [4]. Thus local content can fill the three aspects mentioned above, such as for example, the development of software for applications in hospital, should not mass produced, but can be saved in the computing facilities which could be used by many people and can be adapted to the needs of its users (customize).

Machine-to-Machine (M2M) and Mobile Cardiotocography (MCTG) communication We already integrated DigiMAPS GUI with application of Machine-to-Machine (M2M) and *Mobile Cardiotocography (MCTG)* communication for mother with hypertension (preeclampsia) home care service, the appearance of captured graphical out out of M2M and MCTG shown in Figure 9 and 10, respectively.



Figure 9. Graphical output from M2M in DigiMAPS.

Most of health institutions in Bandung even Indonesia still rely on paper based medical records to support administrative activities. Currently focusing on the development of a web-based application (using PHP-MySQL platform) which will continue to be developed, research of DigiMAPS is one of the priorities in FK UNPAD-RSHS to facilitate services, teaching and learning activities. Most of village-midwives had problems associated with the reporting system including inconsistency in reporting, poor access to individual patient histories and poor access to clinics. These problems resulted in incompleteness and poor timeliness of data transfer [5,6]. Present modules are expected to support the administrative and clinical activities in the region. This application may also develop into a portable electronic medical record application to support midwives and paramedics activities. DigiMAPS is a data processing system that is aimed to support health care services and clinical-based education system in providing information for consultation from remote area.

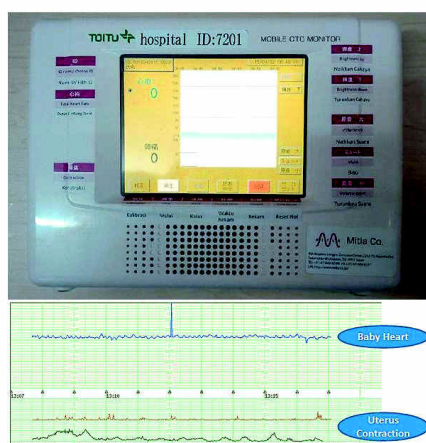


Figure 10. Mobile CTG and baby heart along with uterus contraction digital data.

DigiMAPS can be regarded as a system that provides information to all levels of patients whenever needed. This system can store, retrieve, change, process and communicate information recorded using cloud computing system.

Recently, almost all medical services are competing to develop and improve the quality of health care management by implementing a computer-based information system to support the changes and improvements in all aspects and related fields, in terms of infrastructure, facilities, financial, multi medical devices and human resources. Another important factor is the human resources (HR) reliable to operate the information system. Information system technology play a major role to resolve common problems in hospitals, such as unorganized data, error in outpatient clinic queue number, wrong drug prescription, and so forth. This information system is expected to overcome the problems which ultimately would have a significant impact in the quality of medical services, in this case the invention of DigiMAPS.

Current medical technology is growing rapidly with amazing speed, so it is possible to create a system for reporting, data collection and services to patients faster and integrated could be developed in Indonesia. This system will be tested in patients before then we will do a trial on a larger scale and its complexity. Early research is primarily to assess how fast, effective programming system that we design and any interference that may interfere with the system DigiMAPS earlier. This is important because the application will be made on a sample population of the wider community, realtime data entry of patient and or tele-consultations. Several limitation of this system must be addressed. Among them are: (1) we are in our progress to provide the security analysis of the system, since we will transfer the confidential patient data in our system and (2) we also in our progress to validate our realtime data entry in this system compare with the conventional paper-based data entry.

IV. DISCUSSIONS

Our previous project "Digitalization of maternal and post-natal care system (DigiMAPS) in Bandung Barat District" resulted multimodal communications systems as follows:

1. Enhanced DigiMAPS application, platform and communication system so they can improve the user experience, handle larger scalability as a new decision support system.
2. Introduced of a new use-case of telepresence systems to support tele-consultation and continue professional education.
3. Completed the design, develop and implement a mother alert system (of KIA Online) to improve K1-(mother 1st visit) and K4-(mother 4th visit) coverage.
4. Introduced Machine-to-Machine (M2M) and Mobile CTG communications for Mother with hypertension (preeclampsia) home care service.

V. FUTURE WORKS

The usefulness of wifi in the city to support mother and child integrated healthcare system and mobile e-clinic for midwives and /or paramedic officers. The next development project for our system is to up-graded this multimodal communications systems into mobile e-clinic unit of DigiMAPS, equipped with the security system. Not mention, if we can validate the whole system, we can use this core engine for other costumize reporting system in the health care field.

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