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MERCY CORPS

An Exploratory Study: The Adoption of Clinical Information System (CIS) and Clinical Decision Support System (CDSS) in Hospitals in Indonesia

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About CHMI and Mercy Corps

The Center for Health Market Innovations (CHMI) is a global network of partners that seeks to improve the functioning of health markets in developing countries with large numbers of private healthcare providers. Funded by the Rockefeller Foundation and the Bill and Melinda Gates Foundation, CHMI works to accelerate the diffusion of Health Market Innovations that lead to better health and financial protection for the poor. CHMI focuses on identifying, analyzing and disseminating information about the universe of Health Market Innovations operating in developing countries. Health Market Innovations are programs and policies—implemented by governments, non-governmental organizations (NGOs), social entrepreneurs or private companies—that have the potential to improve the way health markets operate. These programs and policies increase efficiency and effectiveness in transactions that occur in the health care marketplace which contribute to improving health and financial protection, especially for the poorest and most vulnerable populations. CHMI categorizes programs according to five distinct program types – organizing delivery, financing care, regulating performance, changing behaviors, and enhancing processes.

The Center for Health Market Innovations is coordinated by the Results for Development Institute (R4D) and relies on a broad network of in-country institutions and other partners to collect and disseminate information, conduct analytical work, and form and maintain relationships and networks. The CHMI network of partners includes organizations that work in the USA, Brazil, Ecuador, Bolivia, Peru, South Africa, Ghana, Kenya, Tanzania, Uganda, Rwanda, India, Pakistan, Bangladesh, Vietnam, Cambodia, the Philippines, and Indonesia. In Indonesia, CHMI is implemented by Mercy Corps, in partnerships with the Indonesian government, and various for-profit and not-for-profit organizations, to facilitate knowledge sharing and create linkages amongst the stakeholders of health market innovations in the country.

CHMI Profiles and Case Studies

CHMI's documentation in Indonesia includes 50 profiles of innovative programs and three country-specific case studies published on the CHMI website. In 2012, three thematic studies focusing on technology will be published. The case studies are designed to give readers a deeper look at the structures, activities, and potential impact of new and innovative programs. By deriving results and lessons learned from the experience of various health innovation programs, the case studies are designed for:

a. Program implementers seeking to learn from the experience of the adoption and implementation of the program.

b. Funders wishing to do an initial screen for eligibility of this program for funding.

c. Researchers wishing to learn about this program and to use the study for more in-depth studies in the future.

d. Policy-makers wishing to apply lessons learned from the program to shaping of more effective health market policies.

The past three studies focused on individual programs that addressed MDG 4 on Child Health, MDG 5 on Maternal Health, and MDG 6 on HIV/AIDS. The current case studies will address the adoption of technology models to improve health literacy, increase patient safety by reducing diagnostic errors, and enhance the health knowledge of clinical health workers. These studies will address issues relating to MDG 4, 5, 6 and MDG 8 on Global Partnerships, particularly cooperating with the private sector to leverage the available benefits of new information and communication technologies in improving health.

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List of Abbreviations

CIS	Clinical Information System
CDSS	Clinical Decision Support System
DHO	District Health Office
dr.	Dokter (equivalent to M.D in the United States)
HIS	Hospital Information System
ICD 9 and 10	International Standard Diagnostic Classification
IT	Information and Technology
LAN	Local Area Network
RS	Rumah Sakit
RSIA	Rumah Sakit Ibu dan Anak (Mother and Child Hospital)
RSU	Rumah Sakit Umum (General Hospital)
UGM	University of Gadjah Mada
UMY	Muhammadiyah University of Yogyakarta

Glossary

dr.

In Indonesia, medicine is an undergraduate study, which can be completed within four years. Undergraduates receive a degree with the title *Sarjana Kedokteran (S. Ked)* or Bachelor of Medicine. At this point, the graduate is not yet a doctor, but he or she may choose to work directly as a scientist or in another non-clinical profession. However, most graduates will pursue the conventional path of enrolling in a clerkship program for another 1.5 to 2 years, making the total duration of medical school 5 to 6 years. Upon conclusion of the clerkship, students take their Hippocratic Oath and are awarded the title of *dr.* (medical doctor, equivalent to M.D. in United States). Graduates who hold this title are licensed and may now practice medicine. Note that this title is written in lowercase "d", as opposed to uppercase "D", *Dr.*, which in Indonesia refers to a Ph.D.

"Homegrown" Software[1]

The type of CPOE/CDS system was classified as homegrown or commercially sold. Homegrown systems were defined as systems developed internally by the clinical entities in which they were being used. Commercially sold systems were products purchased from a software developer that may have been modified for use in a particular clinical setting."

ICD 9 and 10

ICD stands for the International Standard Diagnostic Classification. It is a list of diseases that are classified into various categories in order to enable clinical diagnostics, billing and insurance claim management systems, and determination of mortality and morbidity rates according to WHO standards. Initiated in May 1990 at the 43rd World Health Assembly (ICD 9), the currently revised version (ICD 10) has been used internationally since 1995. The ICD 9 version is still applied in some health centers in Indonesia.[2]

Medication Errors[3]

Any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the health care professional, patient, or consumer. Such events may be related to professional practice, health care products, procedures, and systems, including prescribing; order communication; product labeling, packaging, and nomenclature; compounding; dispensing; distribution; administration; education; monitoring; and use.[4] Some of the factors associated with medication errors include the following:

- Medications with similar names or similar packaging

[1] Wolfstadt, Jesse. et.al. (2008). "The Effect of Computerized Physician Order Entry with Clinical Decision Support on the Rates of Adverse Drug Events: A Systematic Review". Society of General Internal Medicine 23(4):451–8. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2359507/pdf/11606_2008_Article_504.pdf, accessed November 29, 2011

[2] http://www.who.int/classifications/icd/en/. Accessed on October 31, 2011.

[3] Chapter 37. "Medical Administration Safety". http://www.ncbi.nlm.nih.gov/books/NBK2656/#ch37.r4, accessed 20 November 2011)

[4] National Coordinating Council for Medication Error Reporting and Prevention." What is a medication error?"Accessed October 1, 2007]. www.nccmerp.org/aboutMedErrors.html.

- Medications that are not commonly used or prescribed
- Commonly used medications to which many patients are allergic (e.g., antibiotics, opiates, and non-steroidal anti-inflammatory drugs)
- Medications that require testing to ensure proper (i.e., nontoxic) therapeutic levels are maintained (e.g., lithium, warfarin, theophylline, and digoxin)

There are five stages of the medication process: (a) ordering/prescribing, (b) transcribing and verifying, (c) dispensing and delivering, (d) administering, and (e) monitoring and reporting. Of the five stages, ordering/prescribing most often initiates a series of errors resulting in a patient receiving the wrong dose or wrong medication. In this stage, the wrong drug, dose, or route can be ordered, as can drugs to which the patient has known allergies.

Local Area Network (LAN)[5]

LAN is a communications network that serves users within a confined geographical area. The "clients" are the user's workstations typically running Windows, although Mac and Linux clients are also used. The "servers" hold programs and data that are shared by the clients. Servers come in a wide range of sizes from Intel-based servers to mainframes.

MIMS[6]

MIMS is the print and online prescribing database for all healthcare professionals. First published in 1959, MIMS has grown to be the essential choice of prescribing and clinical reference for all healthcare professionals. MIMS incorporates around 200 changes every month, providing news on drug launches and license changes together with clinical guideline updates.

Vulnerable Population

Vulnerable populations are groups of people who are in some way marginalized from mainstream society, by circumstance of poor health, poverty, or minority status. It includes “the uninsured, low-income children, the elderly, the homeless, those with human immunodeficiency virus (HIV), and those with other chronic health conditions, including severe mental illness.”[7] “It may also include rural residents, who often encounter barriers to accessing healthcare services.”[8] According to Wisner et al. (2003), the concept of vulnerability includes “the characteristics of a person or group and their situations that influence their capacity to anticipate, cope with, resist and recover from the impact of natural hazards.”[9]

[5] http://www.pcmag.com/encyclopedia_term/0,2542,t%3DLAN&i%3D45887,00.asp (accessed 20 November 2011)
[6] http://www.mims.co.uk/go/AboutMIMS/ (accessed 20 November 2011)
[7] http://www.ajmc.com/publications/supplement/2006/2006-11-vol12-n13Suppl/Nov06-2390ps348-s352 (accessed 20 November 2011)
[8] Ibid
[9] Wisner, B. et al. 2003. *At Risk: Natural hazards, people’s vulnerability and disasters second edition*. London and New York: Routledge.

Executive Summary

Iatrogenesis is a medical complication resulting from interactions with a health provider, and remains an unsolved global dilemma. The World Health Organization (WHO) predicts one in ten patients worldwide is harmed by diagnostic errors,[10] which manifest themselves in a variety of ways: misdiagnoses of illness; insufficient safeguards in the health system; misunderstandings of patient conditions resulting from miscommunication between providers and patients; and failures by health providers to obtain patients' informed consent before delivering care.

With a population of 240 million people, Indonesia is no stranger to these challenges and lacks the standardized clinical information systems (CIS) in its hospitals- a system that could potentially help physicians to reduce diagnostic and medical errors. In 2000, one study on patient safety conducted by Adi Utarini of University of Gadjah Mada (UGM) showed the occurrence of medical errors across 15 hospitals and 12 health centers in Central Java was at times as high as 88.8%, and resulted in acute respiratory infections, pediatric infections, and treatment errors for antibiotic use. Moreover, the limited availability of literature documenting and analyzing medical and diagnostic errors in Indonesia has exacerbated the complexities of addressing such errors, thereby hindering the development of CIS solutions in Indonesian hospitals. Many current CIS interventions in hospitals are not used optimally to provide decision support mechanisms to physicians to reduce misdiagnoses. More meaningful CIS initiatives must feature the implementation of Clinical Decision Support Systems (CDSS) such as Drug Interaction Alerts, and CDSS supporting features such as Electronic Medical Records (EMR), and Clinical Physicians Order Entry (CPOE) programs. Furthermore, these programs must be built to interoperate effectively with each other, and even across facilities, to ensure that CDSS results in a minimized incidence of errors related to patients' conditions and prescriptions, and follow up care.

However, while Indonesian health informatics experts like Anis Fuad warn "although Electronic Medical Records (EMRs) with Computerized Provider Order Entry (CPOE) can improve accessibility and legibility of information, major improvements of quality and cost of care from the use of health Information Technology (IT) is unlikely without proper implementation and use of CDS (or CDSS)."[11] Indonesian hospitals have yet to undertake significant efforts to incorporate CDSS into operations. Recent attempts

[10] "Recognizing that health care errors affect one in every 10 patients around the world, the WHO's World Alliance for Patient Safety and the Collaborating Centre have packaged nine effective solutions to reduce such errors," said WHO Director-General Dr Margaret Chan. "Implementing these solutions is a way to improve patient safety."(http://www.who.int/mediacentre/news/releases/2007/pr22/en/index.html)

[11] http://healthit.ahrq.gov/images/jun09cdsreview/09_0069_ef.html (Accessed 28 October 2011)

to implement CDSS – or add clinical modules to existing information systems that are mostly digitized billing and administrative tasks - have been hindered at the facility-level by a lack of technical expertise, infrastructure, and post-installation technical support as well as cost constraints. Even for hospitals with the technical capacity to implement drug interaction alerts, the credible drug database required to run the system is often only available at a high cost.

This paper documents the adoption process of three notable CIS/CDSS software programs - Mitrais Medical Suites (MMS), Vesalius, and Electronic Health Record (EHR) - across five Indonesian hospitals located in Bali, Banten, Jakarta, and Central Java Province. Each of the facilities reported on significant lessons learned in the adoption and implementation of CIS/CDSS, particularly in the progress leading to the implementation of drug interaction alerts. Participating institutions included Eka Hospital, a private institution using the Vesalius system for CIS including CPOE, e-prescription and drug interaction alerts; public hospitals Dr. Cipto Mangunkusumo Hospital and RSU Tabanan using, respectively, CPOE and e-prescription with CIS called EHR and MMS as a non-clinical and clinical HIS with drug interaction capacity; public hospital RS Indera, using a limited version of MMS for electronic medical records; and a private institution, RSIA Aisyiyah Klaten, replicating EHR for administrative and billing tasks with plans to adopt drug interaction alert in 2013.

Research findings indicated that key barriers to CIS/CDSS adoption had little to do with funding or poor compliance on data entry requirements or resistance of using the new technology by clinicians, but rather were due to non-software issues such as the lack of adequate internet connection at facilities and Local Area Network (LAN) and the lack of skilled hospital staff who has adequate skills and knowledge in IT and its implications with clinical care. Another primary obstacle to the adoption of CDSS programs is the inherent complexity of efforts driven by a variety of stakeholders – foreign donor agencies like AUSAID, software developers, IT companies, public and private hospitals, and research universities like UGM and Muhammadiyah University of Yogyakarta (UMY). While there are benefits to such partnerships – such as having sufficient technology and health sector expertise to design the appropriate programs - the success of CDSS programs will rest on the ability of partners to work cooperatively to apply their respective skills to building and maintaining an effective system. In addition to the need for stronger partnerships, this study also discovered as an obstacle the insufficient credible drug database in Indonesian CDSS systems, which requires the additional purchase of a drug database or creation by hospitals of individual “homegrown” databases. Only with a full and accessible database can CPOE and EMR systems attain optimal performance in identifying drug allergy and drug interactions alerts, however, this database can be expensive and time-consuming to attain or compile.

Key study recommendations are targeted towards hospital and health facility stakeholders, urging them to conduct an initial assessment of facility needs prior to deciding a CIS/CDSS solution to be adopted, including providing clear specifications and measurement of actual needs such as existing drug

interaction or prescription errors, system interoperability and the availability of skilled human resources as well as recognition of available internet, LAN, and electricity infrastructure. With clear identification of the key areas of improvement, hospital are more able to guide the software developers or the internal IT team to design the most appropriate CIS/CDSS to reduce medication errors and to articulate the duration and scope of technical support. To sustain the adoption of CIS/CDSS, it is also recommended that hospitals conduct pre-and post- installation trainings, considering both IT and clinical perspectives, and aiming to construct a technology-based working culture in which all employees feel comfortable using the system as part of daily operations. Furthermore, collaboration between software and developers of drug databases and pharmaceutical companies is recommended, in order to develop credible and affordable standardized drug databases for the Indonesian health market.

RESEARCH DESIGN

Research Methodology

This paper uses a variety of qualitative study methods within the context of an exploratory multi-case study, in order to document the program model design and theory, activities, growth plans, and user experiences on the initial adoption of the programs. By investigating and documenting patterns and general conditions from the models, researchers derive lessons learned and success stories from the cases. This paper provides recommendations and addresses the implications of the findings for those interested in replicating the models. When limited models were available, the study includes other models from other countries with similar health system climate and context. The exploratory study method is used because 1) limited literature review and available resources on the subject within the study context, 2) no earlier models perceived as similar to the study subjects, 3) the study will be used to identify the best research design, data collection methods, and analysis for future studies, 4) the objects of the study (programs) are exceptionally different from previous ones which existing theories are unable to portray. The research uses a number of data collection methods to collect the information including: triangulation of information, literature reviews, reviews of previously published reports and evaluations on the model or similar models from the past, questionnaires, and interviews.

Triangulation Method

Evidence was collected using a triangulation method or the crosschecking of facts across multiple data sources, such as documentation, direct observation (on-site), participant observation (to capture the insights into personal behaviors and motives), surveys and interviews.

Literature Review

CHMI gathered information about existing and historic studies on methods and approaches regarding the adoption of CDSS and the earlier initiatives leading to the adoption of CDSS in Indonesia. Models included in the literature review were not limited to the field of health sciences, but also to include those in business and social science. The literature reviews were collected from sources including various journals, articles, books, white papers, and case studies.

Questionnaires

The CHMI questionnaire was designed to guide data collectors in collecting information for the case studies across six sections: Program Overview, Model, Impact, Growth Plans, Contextual Factors, and Sources section. Questions were altered, added, or removed based on the situation of the actual interviews. Impromptu questions were asked during the interviews if more specific information was needed.

Interview Procedures

In-person interviews were conducted over a nine-week period between August and October 2011. The interviews were tape recorded with permission and took four to five hours to complete. A verbal consent script was read verbally to the participants and consent was obtained from them prior to administering the questions. See Annex 1 for a full list of interviewees.

Sampling and Study Subjects

The interviews were conducted with four health informatics experts from local universities, employees of a software developer company, staff of three public and two private hospitals. A total sample of forty one interviewees was used and the sampling method applied was convenience sampling. Participants were selected based on the researcher approaching them and subsequently asking for their willingness to participate. At the initial research stage, cold calling was conducted and introduction emails were sent to program funders and implementers. Upon receiving consent from the interviewees, they were invited to a virtual or in-person interview, or for those who could not conduct in-person or virtual interviews, submission of a questionnaire via email.

CHMI Team conducted in-person interviews with six employees of Mitrais and seventeen employees of RS Indera and RSU Tabanan to research about the adoption of MMS-HIS. The interviewees from Mitrais represent top-level managers, Information Technology (IT) specialists and account managers. Meanwhile, the interviewees from RSU Tabanan and RS Indera represent top-level managers, IT professionals, physicians, nurses, pharmacists, and lab technicians. On the adoption of homegrown HIS called “Electronic Health Record (EHR)”, researchers conducted in-person interviews with ten individuals: two interviewees of a public hospital (Dr. Cipto Mangunkusumo Hospital in Jakarta) and eight interviewees of a private hospital (RSIA Aisyiyah in Klaten). The interviewees from Dr. Cipto Mangunkusumo hospital represent Hospital Information System (HIS) specialists, physicians and pharmacists. Meanwhile, the interviewees from RSIA Aisyiyah represent top-level managers, nurses, pharmacists, IT and hospital administration professionals. On the adoption of Vesalius, researchers conducted in-person interviews with four employees of private hospital (Eka Hospital) representing top-level managers, IT specialists, physicians, nurses, and hospital administration professionals. The in-

person interviews were also conducted with four health informatics experts representing academics from the Faculty of Medicines and Public Health of Gadjah Mada University, and Department of Health Informatics of Muhammadiyah University at Yogyakarta.

Piloting the Questionnaires

In August 2011, the questions were piloted through in-person interview with David Magson, CEO of Mitrais in Denpasar, Bali. The purpose of the pilot is to ensure the questions are understood by all categories of interviewees and to test whether some questions should be eliminated or new questions added.

1. BACKGROUND

There are various definitions describing information systems adopted in hospitals and the naming of HIS often varies depending on the vendors and the developers of the system. A medical dictionary, Medconditions.net, defines Hospital Information System (HIS) as an "integrated, computer-assisted systems designed to store, manipulate, and retrieve information concerned with the administrative and clinical aspects of providing medical services within a hospital."[12] In many instances, the clinical function of HIS is referred as Clinical Information System (CIS). In Indonesian hospitals, the non-clinical HIS has gained popularity due its ability to provide solutions in operational related issues such as billing and administration while the use of CIS amongst hospitals in the country remains limited. The specific focus of this study, the CDSS in the form of drug interaction alert, is a decision support system that requires the presence of a complete and accurate CIS in the form of CPOE and EMR in order to function effectively, however clinical information systems in the country are not yet fully functioning, nor even available, in many Indonesian health facilities.

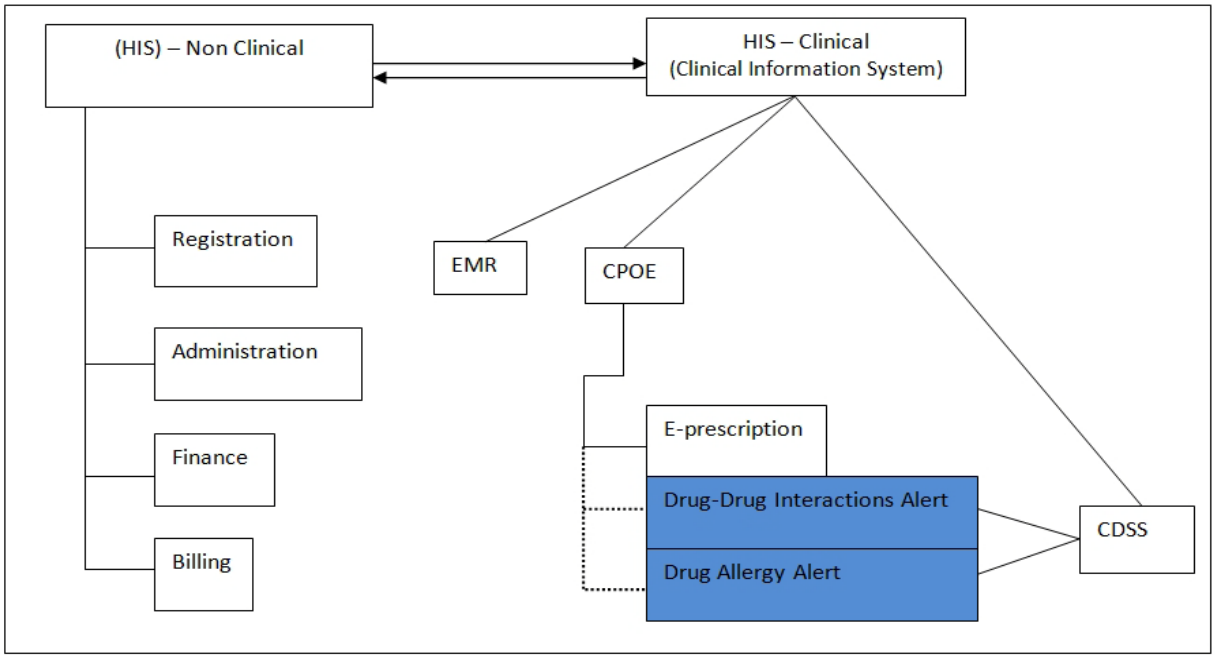

Figure 1: HIS (non-clinical and clinical)

Source : CHMI

[12] Hospital Information System. Dictionary of Medical Conditions Terminology. http://medconditions.net/hospital-information-system.html, accessed November 20, 2011.

1.1 HIS Adoption in Indonesia

Literature on the adoption of HIS in Indonesia is limited, and therefore the research team conducted interviews with Indonesian HIS experts to better understand the first generation of HIS models in the country. dr. Syaiful Fatah of RS Aisyiyah Klaten confirmed that the first HIS adoption in Indonesia was conducted by Fatmawati Hospital in 2007, and consisted of a smart card system that kept patient medical records stored electronically. Another expert, dr. Agus Mutamakin, suggested instead that the earliest adoption of EMR in Indonesia happened at Dr. Cipto Mangunkusumo Hospital in 1995, in the form of a Disk Operating System (DOS)-based EMR system.

It was unclear from the interview whether either system was built to feature clinical or non-clinical functionality, however dr. Guardian Sanjaya of UGM, indicated that the early adoptions of HIS in Indonesia were focused mainly on registration, administration, and billing systems. He added that the intention of the adoption was to cut down on non-clinical costs such as office supplies and to increase the efficiency of administrative staff; not to reduce medical errors in clinical practice.

By 2007, HIS had been adopted by more than 100 out of approximately 1,600 hospitals in Indonesia, but most systems were limited to non-clinical functions, as dr. Sanjaya suggested.[13] Similarly, even the earliest strictly clinical information systems such as Electronic Medical Record (EMR) and Computerized Physicians Order Entry (CPOE) programs were intended not to reduce diagnostic errors, but to promote cost-savings strategies.[14] Only in recent years is there evidence of CIS designed to be not just a cost-saving tool, but also a life-saving tool.

1.2. Development of CDSS

The earliest version of CIS in Indonesia included a physical medical encyclopedia where information related to knowledge in medicine and diseases was recorded. As technology advanced, it became apparent to health practitioners and health scientists who use technology in health care setting that the encyclopedia could be more than just a static knowledge database,[15] and that the knowledge within could become more accessible and useful if systems used artificial intelligence, inference engines, or genetic algorithms. With such modifications, a static CIS could become a Clinical Decision Support System (CDSS): a computer-supported tool that enabled health providers to more quickly and accurately

[13] A. Mohammad B.S., "Petugas Medis Senang Pasien Pun Tenang." *SwaMajalah*, March 1, 2007, accessed November 7, 2011, http://202.59.162.82/swamajalah/sela/details.php?cid=1&id=5615.

[14] Dean F. Sittig et al. *Grand Challenges in Clinical Decision Support*. 2007.

[15] Blum, Bruce I. "Clinical Information System- A Review." *Medical* , 1986, http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1307152/pdf/westjmed00160-0055.pdf.

understand and respond to symptoms and conditions.[16] According to Berner (2009),“ Common features of CDS systems that are designed to provide patient-specific guidance include the knowledge base (e.g., compiled clinical information on diagnoses, drug interactions, and guidelines), a program for combining that knowledge with patient-specific information, and a communication mechanism—in other words, a way of entering patient data (or importing it from the EMR) into the CDS application and providing relevant information (e.g., lists of possible diagnoses, drug interaction alerts, or preventive care reminders) back to the clinician.”[17]

1.3. Supporting System of CDSS

It is documented that CPOE when operated with EMR and a decision support system becomes a more effective system in detecting medication errors, such as in the case of drug counter indication alerts. Only when combined with CDSS can tools like EMR and CPOE become capable of reducing both medical and diagnostic errors, as they minimize glitches in medication and drug orders through automatic entry, avoiding potential misinterpretation of physicians' handwriting or unclear instructions. Both EMR and CPOE supply CDSS with valuable patient information such as medical history and prescription history, which can be matched with the installed medical knowledge in CDSS, to generate accurate and safe results.

Electronic Medical Record (EMR)

Electronic Medical Record is defined as “an application environment composed of the clinical data repository, clinical decision support, controlled medical vocabulary, order entry, computerized provider order entry, pharmacy, and clinical documentation applications. This environment supports the patients' electronic medical record across inpatient and outpatient environments, and is used by healthcare practitioners to document, monitor, and manage health care delivery within a care delivery organization (CDO). The data in the EMR is the legal record of what happened to the patient during their encounter at the CDO and is owned by the CDO."[18]

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[16] Ibid.

[17] Eta S. Berner, Ed.D.,"Clinical Decision Support Systems: State of the Art," *AHRQ Publication* No. 09-0068-EF, June 2009, accessed on October 31, 2011, http://healthit.ahrq.gov/images/jun09cdsreview/09_0069_ef.html

[18] Garets, Dave and Davis, Mike. Electronic Medical Records vs. Electronic Health Records: Yes, There Is a Difference. A HIMSS Analytics White Paper, 2006. Accessed December 1, 2011. Retrievable from http://www.himssanalytics.org/docs/wp_emr_ehr.pdf

Computerized Provider Order Entry (CPOE)

CPOE is defined as "clinical systems that utilize data from the pharmacy, laboratory, radiology and patient monitoring systems to relay the physician's or nurse practitioner's diagnostic and therapeutic plans and alert the provider to any allergy or contraindication that the patient may have so that the order may be immediately revised at the point of entry prior to being forwarded electronically for the targeted medical action."[19]A classic study of inpatient medication errors found that approximately 90% occurred at either the ordering or transcribing stage. These errors can be due to a variety of causes, including poor handwriting, ambiguous abbreviations, or simple lack of knowledge on the part of the ordering clinician."[20] A CPOE system, "at a minimum, ensures standardized, legible, and complete orders and thus has the potential to greatly reduce errors at the ordering and transcribing stages."[21]

CPOE With Decision Support System

When operated with a decision support system such as a drug database, CPOE decision support could provide notifications of: drug-drug interaction, drug allergy, drug dose errors, duplication of order, information of substitute medication and test recommendations.[22] Additionally, CPOE equipped with decision support capability can "monitor patient treatment ensuring, for example, that the right drug is administered to the right patient at the right time, and can issue an alert or reminders and suggest a different course of treatment if a patient's condition changes, if test results are abnormal etc. and provide health professionals with immediate electronic access to their orders and comprehensive views of patient clinical data and lab results."[23]

CIS in the form of CPOE and CDSS help clinicians mainly physicians, nurses, pharmacists, radiology, and laboratory staff in the efforts of reducing medication errors. Additionally, the improvement of patient safety can benefit general population from all socioeconomic levels as the adoption of CIS/CDSS increases in public and private hospitals throughout the country. The adoption of CIS/CDSS in public hospitals can improve the safety of patients from the lowest socioeconomic level through government funded insurance.

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[19] Computerized Physician Order Entry: Costs, Benefits and Challenges, A Case Study Approach, First Consulting Group, 2003.

[20] Computerized Provider Order Entry (CPOE). Agency For Research for Healthcare and Quality. US Department of Health and Human Services. http://psnet.ahrq.gov/primer.aspx?primerID=6, accessed on 20 November 2011.

[21] Ibid

[22] Ibid

[23] Ibid

2. PROGRAM DESCRIPTIONS

Outlined below are the three models of CIS/CDSS documented in this case study, including MMS-HIS implemented at RS Indera and RSU Tabanan in Bali, Vesalius implemented at Eka Hospital in Banten, and homegrown EHR software implemented at two public hospitals, Dr. Cipto Mangunkusumo Hospital in Jakarta and RSIA Aisyiyah Klaten in Central Java. MMS and Vesalius systems are commercial products, while the EHR system was developed internally among stakeholders supporting Dr. Cipto Mangunkusumo Hospital.

2.1. Mitrais Medical Suite (MMS)-Hospital Information System (HIS)

Mitrais is an information technology (IT) company located in the city of Bandung in West Java, Jakarta, and Bali provinces. The company is one of leading providers of customer custom software development both in Indonesia and around the globe. In 2006, it entered the market for medical software industry and constructed Mitrais Medical Suite (MMS), a comprehensive patient-centered system. Since 2009, several hospitals in the three provinces including two public hospitals in Bali - RSU Tabanan and RS Indera - have adopted the MMS-Hospital Information System (HIS). According to Mitrais representative Yuni Sucipto, "MMS-HIS supports CPOE for doctors, nurses and pharmacists to perform online ordering that will help minimize errors and deliver patient safety."[24]

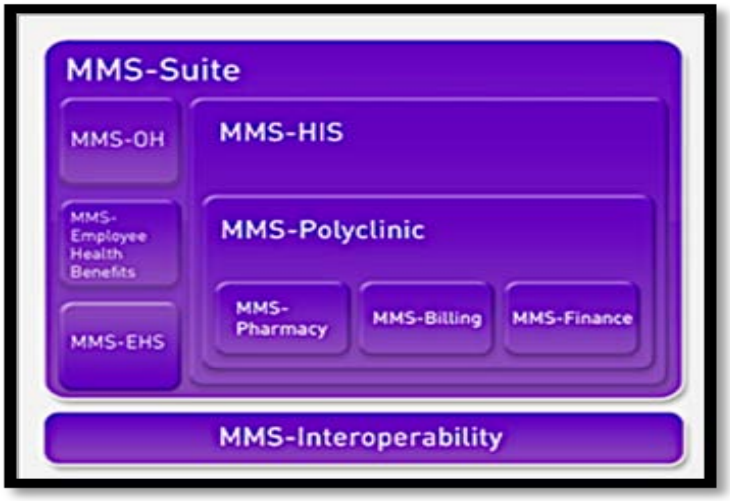

Image 1: MMS-HIS Overview

Source:http://www.mitraismedical.com/solutions/Pages/default.aspx#

This case study focuses on a version of MMS-HIS which includes non-clinical and clinical information functions that support CDSS specifically in the form of drug interaction alerts. Features of MMS-HIS focused upon include EMR, CPOE, and e-prescription services.

Custom Solutions

Mitrais has been delivering customized software solutions to international customers based on Microsoft

[24] Yuni E. Sucipto, interview by Tanti Liesman, Depasar August 3, 2011

technologies since 1998, according to Agus Bintoro, Mitrais Senior Project Manager.[25] Mitrais has "achieved Gold certified partner status within the Microsoft Partner Program for its demonstrated competencies in Mobility Solutions and Custom Development Solutions technologies because of its success in providing its clients with high quality, cost effective software development solutions based on Microsoft NET, SQL Server, and ASP Net."[26] The certification marks the capability of the information system provided by Mitrais to cater to clients who are looking for special types of custom solutions.

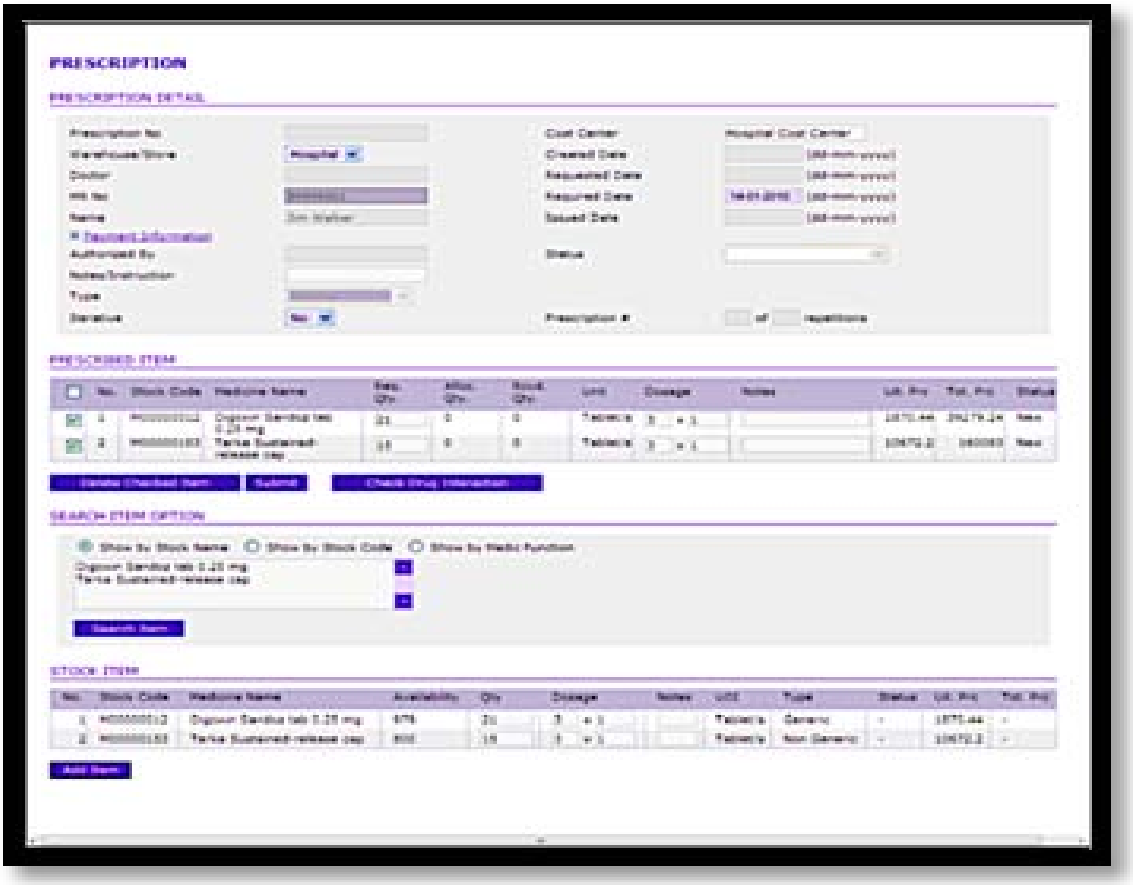

Image 2: MMS-HIS User Interface for CPOE feature of MMS-HIS

Source: © PT Mitrais

Interoperability of the MMS System

MMS products can be purchased independently or integrated into a comprehensive enterprise system suite to fit into the needs of the clients. David Magson, CEO of Mitrais, stated that the "MMS system

[25] "Solutions," accessed on 1 September 2011, http://www.mitraismedical.com/solutions/Pages/default.aspx#

[26] Ibid

provides more flexibility with configuration to specific facility needs and is available at an affordable price even for government hospitals such as Tabanan and Indera."[27]

> *"MMS system provides more flexibility with configuration to specific facility needs and is available at an affordable price even for government hospitals such as Tabanan and Indera,"*
>
> **David Magson, CEO of Mitrais**

Universal Medical Language

The Mitrais system employs SNOMED CT (Systematized Nomenclature of Medicine Clinical Terms), "which enables healthcare professionals worldwide to exchange information in clear and unambiguous terms,"[28] and is "considered to be the most comprehensive multilingual healthcare terminology in the world."[29] According to Mitrais' former Director of Strategic Alliances, Tarasanti Anindyapraba, SNOMED CT "will help ensure standard healthcare terminology is used for each clinical field within each application screen of the Mitrais Medical Suite. It will also help medical professionals to employ standard clinical information in the analysis of patients' data and treatment. Additionally, SNOMED CT can be used as a decision support system. The concepts can act as guidelines for distribution to other software standards."[30] Anindyapraba also added that SNOMED CT "embedded in Electronic Health Record systems works behind the scenes to support the encoding of discrete clinical information in a meaningful way (including the enabling of) the improvements in the quality of data available for health services research, measurement of clinical outcomes also, and improvements in the completeness, accuracy, and consistency of health record documentation. As an affiliate member of the International Health Terminology Standards Development Organization, Mitrais benefits from ongoing specialist input to evaluate and endorse the terminology. It also supports the development of richer computer-aided clinical decision-support systems, such as clinical alert and reminder systems, with the greater detail available."[31]

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[27] David Magson, Interview by Tanti Liesman, Denpasar August 3, 2011

[28] "Mitrais System Speaks Universal Medical Languages", accessed on 1 September 2011, http://www.mitraismedical.com/news/Pages/MITRAISSYSTEMSPEAKSUNIVERSALMEDICALLANGUAGES.aspx

[29] "International Health Terminology Standards Development Organisation." accessed on 22 September 2011, http://www.ihtsdo.org/ IHTSDO is a not-for-profit association that develops and promotes use of SNOMED CT to support safe and effective health information exchange.

[30] "Solutions," accessed on 1 September 2011, http://www.mitraismedical.com/solutions/Pages/default.aspx#

[31] See note 18

Drug Interaction and Allergy Alerts

MMS allows physicians to enter a patient's medical information and diagnosis and to check drug interaction option. For extra safety measure, checking drug interaction can be done in two levels, first by the physician during order entry and second by the pharmacist as the medicine being dispensed. MMS provides "easiness to check: drug-to-drug interaction, drug-to-allergy and drug versus conditions via interoperability with a drug database called Medical Information Management System (MIMS). The system is designed to equip doctors/nurses and pharmacist the easiness (or convenience) to check certain condition with the medicine that will be prescribed by doctors."[32]

Image 3: Physician entering patient information using MMS-HIS CPOE module at RSU Tabanan
Source: CHMI

2.1.1. RSU Tabanan

RSU Tabanan consists of two public hospitals - the first one built in 1953, the latter in 2010. The adoption of MMS-HIS has occurred only at the newer hospital, and began in late 2010. To improve the RSU Tabanan's HIS, part of RSU Tabanan's annual budget was allocated for MMS procurement and maintenance. The decision to adopt CIS/CDSS came from the hospital's top management-namely administrators who sought to improve the health services offered by the hospital for the public including the tourists in Bali. MMS-HIS at RSU Tabanan is used to maintain patient EMRs, however the system's ability to provide drug interaction and allergy alerts is not yet implemented because the hospital's pharmacy database is not yet fully developed. There is a plan to develop a homegrown drug database at RSU Tabanan, and once completed, the drug database will be used with the MMS HIS drug interaction feature via CPOE.

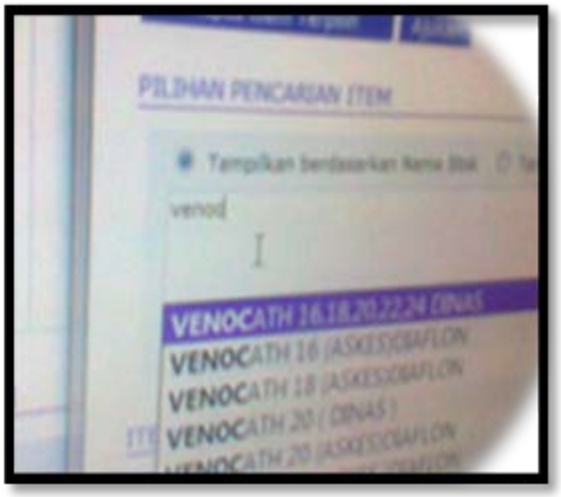


Image 4: Drug search on the pharmacy database of MMS-HIS at Tabanan Hospital
Source: CHMI

[32] Yuni E. Sucipto, email message to Tanti Liesman, October 27, 2011.

2.1.2. MMS-HIS at RS Indera

RS Indera began to receive financial support from AusAID after the 2002 Bali bombings, when the hospital was overwhelmed with ophthalmologic cases. As part of AusAID's donation to the hospital, they also invested in an upgrade to the non-clinical and clinical hospital information systems. But it was not until seven years later that collaboration began between RS Indera and Mitrais, with the adoption of six MMS modules into the AusAID-funded HIS that provided functionality for administration, patient services, medical records, and a medical library developed internally by the hospital. "Although at the current state, the hospital is only adopting the non-clinical functions of the MMS-HIS, additional modules are progressively being added into the information system," said dr. I Made Yuniti, Vice President of RS Indera.[33] In the near future, RS Indera plans to complete the adoption of MMS modules including e-prescription and CPOE and until that time, the hospital continues to upgrade the non-software infrastructures like internet connection and LAN that would support the complete adoption of MMS in the future.

2.2. Vesalius at Eka Hospital

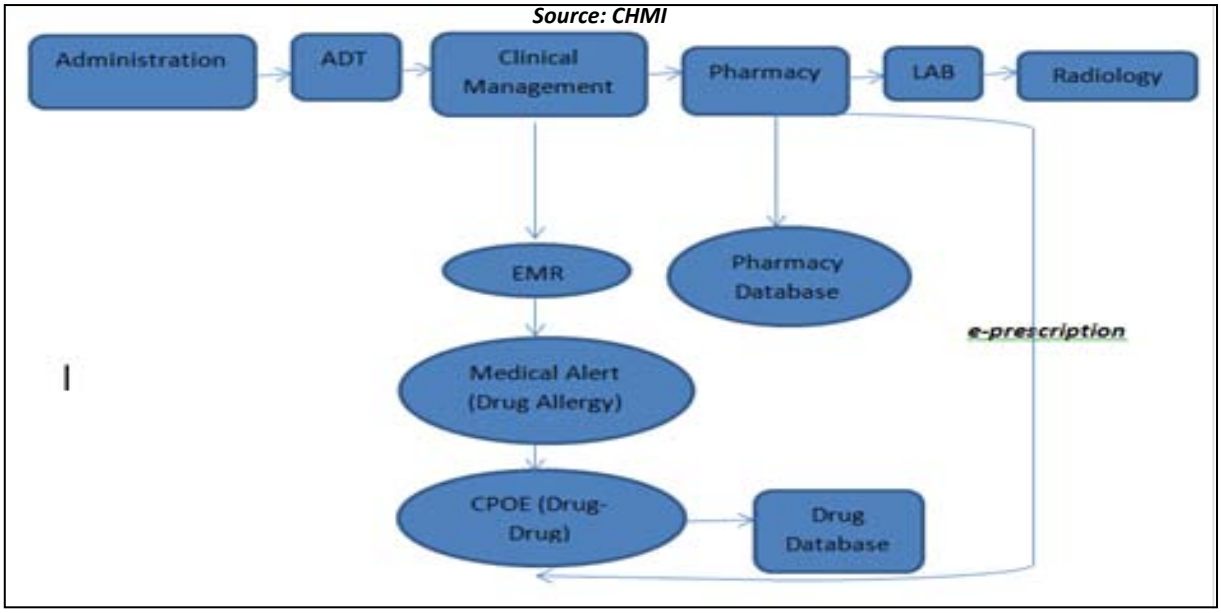
Vesalius, created by software provider Nova MSC, is built to manage clinical and non-clinical HIS, and has been adopted by Indonesian hospitals,[34] including Eka Hospital. The solution offers two web-based modules, namely Vesalius Hospital Information System (V-HIS) and Vesalius Clinical Information System (V-CIS). Both are accessible online or via a facility's intranet. V-HIS collects and processes patient data, and includes several key modules such as patient administration, roster and appointments, and pharmacy tools. V-CIS assists physicians in performing effective decision making and clinical care delivery, and consists of two modules, Physician Support Systems (PSS) and Electronic Medical Records (EMR).[35] Vesalius enables automatic alerts on drug-to-drug or drug-to-allergy interactions, by allowing physicians to order electronic prescriptions that are automatically checked by the computer system against patient medical histories and a knowledge-based engine designed with IF-THEN rules (i.e. 'IF Drug X interacts with Drug Y then alert'). This drug-to-drug interaction alert is supported by a pharmacy drug database that is integrated within the system.

[33] I Made Yuniti, interview by Tanti Liesman, Denpasar, August 1, 2011.

[34] "Our Healthcare Solution Features"accessed on October 19, 2011, http://www.novamsc.com/pdts_health_vesalius.htm,.

[35] "Products", accessed on October 3, 2011, http://www.novahealth.asia/products_his.htm.

Figure 2: Vesalius-Eka Hospital Model



Source: CHMI

2.2.1 Eka Hospital

Eka Hospital is a private hospital located in South Tangerang, Banten Province. Founded in 2008, it is fully equipped with advanced IT equipment and infrastructure, and since its inception, Eka Hospital has used Vesalius software to enhance staff efficiency and quality of health services including enabling alerts for patient allergies and potentially damaging drug interactions based on the information previously documented in medical records. To support the adoption of CIS/CDSS, the hospital hired 14 IT-specific staff members to provide ongoing technical assistance. The IT specialists not only perform troubleshooting software support, but also encourage a shift in working culture towards greater acceptance of the system in everyday operations, as opposed to traditional paper-based data entry processes. If there are needs identified that are unsupported by the existing software, the IT team works with open-source software codes to design new tools to integrate with the Vesalius system.

Eka Hospital adopted both V-HIS and V-CIS, the former intended to support the complete workflow from the time of registration up to billing and patients' discharge, and the latter consisting of an EMR system serving as a repository of individual medical records entered by physicians including patient medical histories, drug allergies, and clinical notes. The V-HIS program enables improved patient administration (knowledge of patient demographics, billing profile, and preferred doctors), Admission, Discharge and Transfer (ADT) services; Roster and appointments; and prescribing and dispensing of drugs. Meanwhile, V-CIS facilitates order entry in a multi-disciplinary environment involving physician, pharmacist, radiologist, laboratory, etc.

Eka Hospital plans to expand the area of the hospital and complete the development of a new building in the near future. The new building will be equipped with Vesalius enabled hospital information systems and linked digitally to the first building.

2.3. "Electronic Health Record" (EHR): A Homegrown Solution

EHR is an open-source hospital information system developed by a team from three separate institutions: Dr. Cipto Mangunkusumo Hospital, UMY, and UGM. Despite its name, the system features not only patient data documentation but also non-clinical and clinical components including CPOE and drug interaction modules, customized regularly to better meet the needs of Dr. Cipto Mangunkusumo Hospital.[36] It is reported that EHR improves the quality of patient care and the efficiency of hospital operations,[37] and is currently adopted by Dr. Cipto Mangunkusumo Hospital, RSIA Aisyiyah Klaten, and Academic Clinic of UGM.

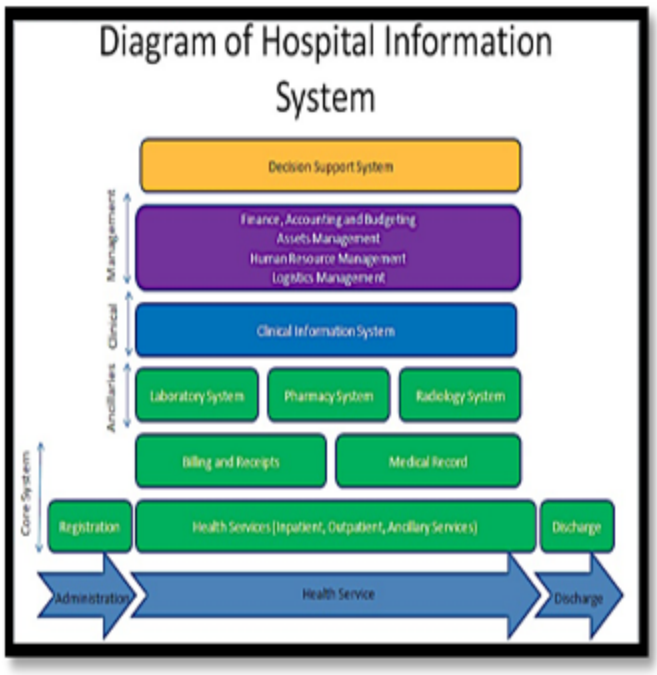


Figure 3: Dr. Cipto Mangunkusumo Hospital "EHR" Model

Source: Dr. Cipto Mangunkusumo Hospital

Image 5: Physician writing e-prescription using EHR

Source: Dr. Cipto Mangunkusumo Hospital

[36] Ash, J., Sittig, D., Campbell, E., Guappone, K., & Dykstra, R. "Some Unintended Consequences of Clinical Decision Support Systems." 2007

[37] Ibid.

2.3.1. Dr. Cipto Mangunkusumo Hospital

Founded in 1896, Dr. Cipto Mangunkusumo Hospital is one of Indonesian oldest hospitals, is based in Jakarta, and acts as the central tertiary referral center in the country. In an earlier adoption of EHR, the hospital was limited to accessing medical records from one station without the availability of LAN connection. In 2006, administrative and billing modules were integrated into EHR system for the entire hospital, along with a new ability for the information to be entered and processed online.

Image 6: Pharmacist confirming e-Prescription

Source: Dr. Cipto Mangunkusumo Hospital

After three years of significant progress of making the EHR connected throughout the hospital and online, the hospital added the inpatient and outpatient CPOE modules that are operated with a homegrown drug database at several departments of the hospital. The CPOE modules helps pharmacists tackle ordering problems resulting from a lack of communication between physicians, such as double prescriptions within the same facility. The drug database model currently consists of 17,000 drugs available in Indonesia, which are classified systematically according to the indication, contraindications, and precautions of each drug. The database is able to provide information associated with drug-to-drug interactions, overriding medications, and possible drug allergies, however, is not yet able to detect errors automatically. At the present moment, the list of medicines in the database is limited to frequently prescribed medicines at Dr. Cipto Mangunkusumo Hospital, and efforts to update the database will likely be challenging due to lack of publications explaining the standardized drug database models in Indonesia, according to dr. Agus Mutamakin. In the implementation of the EHR system, administrators have observed high levels of staff compliance with the system, which is unsurprising because the hospital is a teaching hospital where a majority of the staff are young thus more fluent in and comfortable with technology-enabled data systems. dr.

The CPOE modules at Dr. Cipto Mangunkusumo Hospital helps pharmacists tackle ordering problems resulting from a lack of communication between physicians, such as double prescriptions within the same facility.

Agus Mutamakin, one of the creators of EHR, noted that the development of the product utilized open-source software and was thus a low-cost operation, meaning it has the potential to be scaled up as a model system for other hospitals, notably low-funded facilities, all over Indonesia. The hospital's existing drug database is already scheduled to be scaled up within the facility over the next year, and will be expanded to include standardized and widely used drugs, not only those most frequently prescribed.

2.3.2 Rumah Sakit Ibu dan Anak (RSIA) Aisyiyah Klaten

RSIA Aisyiyah is a private hospital accommodating referrals from smaller maternity clinics in the geographic area of Klaten, Central Java In 2010, RSIA Aisyiah replicated the EHR system pioneered at Dr. Cipto Mangunkusumo Hospital because, according to the Director of RSIA Aisyiyah, dr. Maimun, the hospital's existing non-clinical information system did not have the capacity to support the implementation of e-prescriptions and drug interaction alerts. Early adoption of EHR system consisted of billing and finance modules for outpatient services, and a planned expansion in 2013 will enable CPOE services, as well as a facility-wide data sharing system. It is expected that the hospital's new database can also be linked to the District Health Office (DHO) to be used for health service quality evaluations.

Image 7: Electronic Health Record (EHR)

Source: Dr. Cipto Mangunkusumo Hospital

2.4. Cross-Institutional Comparison

Table 1: Progress of CDSS adoption in five hospitals

Institution	Software Adopted	Features	Next Steps	Support	Non-software Complications
RSU Tabanan	MMS-HIS (non-clinical and clinical) including CPOE and Drug Interaction	CPOE and e-prescription	Development of drug database and implementation of Drug Interaction in the near future	3 IT specialists with 24-hour on-call duty; 20 desktops and 11 laptops for 100 users (who work on shifts)	Weak LAN and internet connections. On-going needs for training and technical support
RS Indera	MMS-HIS (non-clinical and clinical) including CPOE and Drug Interaction	Non-clinical (Registration, Administration, Billing)	Long term plan includes implementation of EMR, CPOE, e-prescription and development of drug database	1 IT specialist and 18 desktops for 16 users. (Regular support by Mitrais now only available for maintenance and on-call support for incidental errors.)	Weak LAN and internet connections linking two hospitals. On-going needs for training and technical support
Dr. Cipto Mangunkusumo Hospital	Homegrown "EHR"(Non-clinical and clinical) including EMR, CPOE, e-prescription, drug interaction and drug allergy.	EMR, CPOE, e-prescription,	Drug Database is being developed	18 IT specialists with 24-hour on-call duty; 1,500 desktops for 1,700 EHR users	Weak LAN and internet connections.

RSIA Aisyiyah	Homegrown "EHR"(Non-clinical and clinical) including EMR, CPOE and e-prescription	Non-clinical	2013 planning to implement EMR, CPOE, e-prescription, Drug Interaction	1 IT specialist who is available during the office hours (7 a.m. to 2 p.m.) from Monday to Saturday. During the off hours, the IT specialist is available on call basis. 14 desktops for 10 EHR users.	Weak LAN and internet connections. On-going needs for training and technical support
Eka Hospital	Vesalius (non-clinical and clinical) including CPOE, e-prescription, and Drug Interaction Alert	EMR, CPOE, e-prescription, Drug Interaction Alert	Expanding the area of the hospital and complete the development of a new building in the near future. The new building will be equipped with Vesalius enabled hospital information systems and linked digitally to the first building	14 on-site IT specialists with 24-hour on-call duty; 300 desktops for 300 users	Small errors such as slow internet connection, transient power outage, however it does not affect the operational of the system

3. BARRIERS TO IMPLEMENTATION

Adopting HIS/CIS systems comes with significant challenges including insufficient human resources support to maintain systems, unintended costs to patients incurred by the system, and high costs of maintaining the systems, notably the drug databases.

3.1. Lack of Health Informatics Expertise

The dearth of Indonesians with sufficient technical expertise in clinical health informatics contributes to the stagnation of adopting hospital information systems, including CDSS.[38] Health informatics expertise requires an understanding of medical and public health needs and systems, as well as a strong technical capacity in software and systems design. What was observed in this case study was that hospitals adopt an information system and end up relying on clinicians who have independently familiarized themselves with such systems, who are then expected to supervise IT staff members to provide solutions for the technical issues of the system. This inevitably becomes a burden on the clinicians, whose core responsibility is to treat patients, and creates dependencies that limit the IT team from progressing on product development or troubleshooting until a solution is articulated by the clinician. In the same sense, when IT staff are expected understand medicine - a job that is not in accordance with their skills and specialties - process become slower and errors more likely.

3.2. Expensive Non-Software Issues

Respondents in both public and private hospitals indicated the need to have on-going post-installation technical support, including support for issues not directly related to the software, but related LAN and internet network functioning, and the quality of on-going training of IT staff. When interviewed about technical issues, respondents from the public hospitals in Bali using MMS-HIS cited slow internet and LAN as problematic in implementation of the

Barriers to Implementation

- ✓ *Lack of Health Informatics expertise*
- ✓ *Cost of on-going post-installation technical support, related to LAN and internet network*
- ✓ *Expensive drug database development and maintenance*
- ✓ *Concerns over the possible increased waiting time for patients caused by doctors filling out the CPOE forms*

[38] Anis Fuad. Interviewed by Tanti Liesman, Nelty Rosanna and Ashra Vina, Yogyakarta. August

program.[39] Staff of RS Indera, RSIA Aisyiyah Klaten and Dr. Cipto Mangunkusumo Hospital responded with similar comments, even though Internet is considerably faster in Jakarta than in Bali.

The support required to solve non-software issues ended up incurring greater costs on the hospitals, both in the case of commercial products and the homegrown EHR system. The research team found that respondents in Bali and Klaten expressed more concerns over the non-software related issues such as internet network, LAN connection, and lack of skilled staff compared to those in Jakarta (Dr. Cipto Mangunkusumo Hospital and Eka Hospital). Respondents in Bali and Klaten stated that they are often required to create back up data on paper due to Internet connection problems.

3.3. Costs to the Patient

Most respondents indicated that compliance amongst doctors in filling out the CPOE is high, reflected by comments from dr. I Wayan at Indera Hospital, who explained, "When the system is ready and if the electronic forms do not take too long to fill out, the other colleagues would be on board with the implementation. I even recommend writing pads so it's faster than having to type the words into the computers.[40] However, most respondents also indicated concerns over the possible increased waiting time for patients caused by doctors filling out the forms, namely the nurses at Indera and RSU Tabanan.[41] [42]

3.4. Credible Drug Database is Expensive and Limited

Most respondents indicated that developing and maintaining a drug database is expensive due to licensing fees on drugs, and time-consuming due to the lengthy effort required to enter all drug information into a central system. Eka Hospital reported experiencing these obstacles, as their drug-to-drug smart database enables the alert functions of possible interactions between prescribed medicines or drug allergies, but adding more drugs to the internal system adding additional costs of paying licensing fees. The availability of credible database remains limited in Indonesia, and until more comprehensive, public drug databases become available (consisting of both widely used generic and patent drugs with affordable licensing fees), there remains obstructively high costs associated with maintaining the database.

[39] Kadek Siswaningsih, Interview by Tanti Liesman and Nelty Rosanna, Denpasar. August 2,2011

[40] dr. I Wayan Primara, Sp.E.N.T, Interview by Tanti Liesman and Nelty Rosanna, Denpasar, August 2, 2011

[41] I Made Endra Hermawan, Interview by Nelty Rosanna and Cynthia Maharani, Tabanan. August 4, 2011

[42] Wayan Suastini, Interview by Nelty Rosanna and Tanti Liesman, Denpasar. August2, 2011

4. NEXT STEP

Development and Upgrade of Drug Database at RSU Tabanan and RSUPNCM

The plan to develop homegrown drug database has been mentioned by some hospital interviewees. The development of pharmacy database has started and on-going at RSU Tabanan. When completed, the drug database will be used with the MMS-HIS drug interaction feature via CPOE. RSUPNCM plans to update their existing drug database to include standardized and widely used drugs.

RSIA Aisyiyah and Indera Hospital gradually adopt clinical information system (EMR, CPOE). In 2010, RSIA Aisyiah has just finished developing a new building to increase their area of coverage. Currently, the hospital management is equipping the new building with non-software infrastructure to support the EMR implementation and digital data sharing with the older building. Once finished, the hospital management plans to include CPOE at both buildings by 2013. In the near future, Indera Hospital plans to complete the adoption of MMS modules including e-prescription and CPOE. At the time being, Indera Hospital continues to upgrade the non-software infrastructures that would support the complete adoption of MMS in the future.

Eka Hospital-expansion of Vesalius to a new building

Availability of funding for HIS development is not a key barrier, since experts and implementers at public hospitals receive funding from government and foreign agencies working with

Eka Hospital plans to expand the area of the hospital and complete the development of a new building in the near future. The new building will be equipped with Vesalius enabled hospital information systems and linked digitally to the first building. They are, as well, planning to keep updated with the technology they are adopting in order to be the leading choices in health care services on national and international levels. And lastly, for a future period plan, they also wish to expand their network, to be able to synchronized the system with other hospitals and activate data sharing.

5. LESSONS LEARNED

5.1. Progress of Adoption

The team interviewed experts representing implementers and researchers of the development of hospital information systems, including CDSS, in Indonesia: dr. Syaiful Fatah, and Winny Setyonugroho

from University of Muhammadiyah Yogyakarta's School of Medicine; and Anis Fuad and dr. Guardian Sandjaya from the UGM. Interviews reveal that CDSS use in hospitals in Indonesia is still in the early adoption phase. As such, the early or middle phase of building essential infrastructure needed for CDSS adoption is still in development. Ultimately, experts are optimistic that full adoption of CDSS at hospitals is imminent, and will progress faster if commitment comes from all stakeholders. Recently, the government has shown support by creating new regulations related to health informatics and this will promote confidence in the adoption process.

5.2. Funding Is Not a Barrier

The Team finds that the availability of funding for HIS development is not a key barrier, since the experts and the implementers at the public hospitals receive funding from the government and foreign agencies working with the government. Anis Fuad, an expert on Health Informatics at UGM, states that sources of funding are not the main barrier to investing in clinical information systems and CDSS. He emphasized how important it is for the government to invest in CDSS adoption at hospitals and how important to collaborate with experts with extensive experience in information and technology, yet know little about health. A similar statement comes from dr. Agus Mutamakin at Dr. Cipto Mangunkusumo Hospital. In addition, the government's requirement of providing accountability in insurance claims related the province health financing scheme, *Jaminan Kesehatan Bali Mandara*, adds more emphasis on making the previous non-clinical system able to analyze clinical diagnostic information such as laboratory results. Similarly, RSIA Aisyiyah and Eka Hospital representing the private hospitals (in smaller city such as Klaten and metropolitan city Jakarta) reported funding the information system (non-clinical for RSIA Aisyiyah and comprehensive system for Eka Hospital) was budgeted into their operations plan.

However, the hospitals that adopted the homegrown software reported higher cost and limited configurability issues are the two main determining factors of the adoption of the open-sourced homegrown software and not the commercial system.

5.3. Adoption Decision

Research findings indicated various factors affecting the decision to adopt the software in public and private hospitals. Respondents from all five hospitals stated that senior management of the hospitals was involved in HIS implementation from the beginning. At the adoption decision stage, several issues were discussed in search of the right information system design to adopt in accordance with the goals set by the hospitals.

Key Initiator of Adoption

Although the final decisions to adopt HIS mostly come from the top management, the respondents reported various initiators of the adoption. At RSU Tabanan, the decision to implement HIS (with clinical functions) came from the hospital's top management – namely, administrators who sought to improve the health services offered by RSU Tabanan for the public, including the tourists, while the top management of RSIA Aisyiyah initiated the idea of replicating the non-clinical function of EHR system of Dr. Cipto Mangunkusumo Hospital as the first step to adopting a comprehensive HIS system. Similarly, Eka Hospital reported top management as the initiator of the adoption of the comprehensive system including the CDSS function in search for ways to reducing diagnosis errors. RS Indera's MMS-HIS adoption was initiated by AusAid and the top management of the hospital as a part of the funded project post-Bali bombing. A team of medical doctors at Dr. Cipto Mangunkusumo Hospital in charge of the electronic medical records provided the initial inputs and ideas about the adoption of HIS to the top management prior to the system adoption. These initiators pushed through the initial ideas into the development of the system (homegrown) and provide the 'blue print' for the purchasing of the commercial system.

At the adoption decision stage, several issues such as software specifications, bridging the old and new system, non-software infrastructures, affordable drug-database licensing, adequate technology training, software and development trials, commercial vs. home-grown were discussed in the search of right information system design to adopt.

Specifications Prior To Purchasing/Development

Research findings indicated the needs of technical assistance from the software developers in helping the hospitals develop specifications prior to selecting and purchasing a system. This includes technical skills and expertise assistance from the software developers to translate the hospital's clinical information system needs into clear specs, especially for hospitals with limited staff skilled in IT. Findings also indicated difficulties of attracting suppliers of HIS with clinical function at the bidding process, which could have been a result of unclear specifications describing the required clinical functions needed for the new systems.

Bridged Systems

The team found that respondents from all five hospitals considered bridging the existing and new systems a key issue when considering adoption. The "purchased software or systems need to allow for integration with the existing [paper-based] systems. In most cases, the system would need the ICD 9 or 10-". However, it would be easier for "new hospitals to adopt a new hospital information system (non-clinical and clinical) than those that have an existing system." Mitrais has been able to assist the two

public hospitals bridge the previous non-clinical system with the MMS-HIS. RSU Tabanan selected MMS-HIS for its capacity to merge the previous non-clinical system (an open-sourced homegrown system) with MMS-HIS (non-clinical and clinical).

Strong Non-Software Infrastructure

Most respondents indicated there are significant technical issues related to non-software issues. Thus, it is critical to discuss associated technical support and assistance at the program design stage. These non-software basic infrastructures include adequate internet connection, intranet network that connects different units, local personal computers, adapters and generators as back-up in case of power outages. The intranet is used to enable data transfer to different units in the hospital. Additionally, intranet is used to access EMR, order prescriptions electronically, and process drug allergy notifications and appropriate drug dosing. If the physicians need to process an adverse drug reaction, they can run the inference engine in CPOE using internet access. Additionally, the internet can facilitate online data-sharing, journal access, software updates and trouble shooting.

Affordable Drug Database Licensing is highly needed

Findings indicate that developing and maintaining drug database requires expertise in the field while the availability of credible database remains limited in Indonesia. Research findings reveal that the respondents from all hospitals reported limited in-house skills to develop their own database. As an example, the homegrown drug database built by Dr. Cipto Mangunkusumo Hospital entails much longer time to develop. Thus, dr. Agus Mutamakin added that the current progress of home grown drug-database in Dr. Cipto Mangunkusumo Hospital is passively able to inform pharmacists of drug allergy based on medical record as well as indicate category of each medicine. However, this list is limited to the frequent prescribed medicines at Dr. Cipto Mangunkusumo Hospital since there is lack of publications on the model of drug database. The Team found the needs for software companies to work with pharmaceutical companies to develop drug database consisting of both widely used generic and patent drugs with affordable licensing fee to provide a comprehensive system for the hospitals.

Deciding the Most Appropriate Solution: Commercial vs. Homegrown Development

Most respondents did not indicate one system is better than the other-commercial or homegrown. Dr. Cipto Mangunkusumo Hospital and RSIA Aisyiyah reported more flexibility in configurability of the system while those that are using the commercial system reported more secure and long-term stability of the system and ready post-installation technical support and training. Homegrown solution allows hospitals alter the system based on their needs, whereas commercial system is developed to meet their basic needs and has restricted customization due to copy rights issue. Further assessments and research should be taken to assess which system should be adopted.

The public hospitals that are using commercial products (MMS-HIS), Indera and Tabanan, selected commercial products over homegrown software development due to several factors including time considerations and lack of skilled technical staff with the expertise needed to support implementation of the system. Furthermore, the Team found that the hospitals with less IT-skilled staff are using commercial products rather than homegrown development. The public hospitals that are using the in-house products, Dr. Cipto Mangunkusumo Hospital and RSIA Aisyiyah Klaten, have skilled staff members available who are mainly medical doctors and IT professionals. In addition, the hospitals using commercial products such as RS Indera, RSU Tabanan and Eka Hospital, indicated that they have high expectations to perform better after adopting such a long term and significant investment as a hospital information system.

Software and System Trials

The team found that all facilities set out to assess the feasibility of HIS products before implementation, whether products were commercial or home grown. Particular attention was paid when facilities were dealing with previous systems or with working cultures that were still new to CIS and CDSS. For example, prior to developing the CPOE, the Dr. Cipto Mangunkusumo Hospital Research and Development Team conducted in-depth interviews and participant observation assessments on current business processes. The research was targeted at the potential users i.e. pharmacists, physicians, radiology, laboratory staff, etc. Simultaneously, the team used a circle development approach to develop, test, and trial the software developed homegrown and to get feedback from potential users. The process was continuous until they found an ideal solution that would work with the current and future business processes.

Adequate Tech Training

Identifying the needed training at the program design stage is the key to ensure long-term implementation of the system adoption. Pre-installation training for users was observed as a key success factor for the CIS/CDSS implementation in hospitals. Most respondents reported that proper training sessions had been conducted in all five hospitals however, repeated trainings seem to be needed as new staff is hired as well to refresh the knowledge of current staff. Dr. Cipto Mangunkusumo Hospital involved IT consultants who provided three months trainings to senior health providers. Mitrais provided on-going trainings for the staff of two hospitals: RS Indera and RSU Tabanan. UMY provided consultations and trainings to the staff at RSIA Aisyiyah Klaten, before and after the installation of the non-clinical information system. The training is on-going as the hospital is adopting the clinical system.

5.4. Government Regulation

The team found there is ambiguity amongst the respondents and the experts on the issue of government policies on CDSS implementation, such as the legality of e-prescriptions. Despite this, none of the responders expressed concerns over the legal risk and costs of using e-signatures and e-prescriptions. When asked about this issue, dr. Agus Mutamakin of Dr. Cipto Mangunkusumo Hospital stated that e-prescription should be legal citing two new regulations on EMR – Health Ministry 269/2008, and UU No. 11 of 2008, that state "electronic signature is a signature that consists of electronic information that is applied, associated or related to other electronic information which is used as a verification or authentication tool." Although on board with the legality of e-prescriptions, Syaiful Fatah mentioned another regulation that states that a prescription is legal only when there is a wet signature from the doctor.

5.5. CPOE and EMR Implementation

The implementation of CPOE at different stages of patient interaction throughout the hospitals may indicate the readiness of the supporting system, staff and IT hardware and software, in adopting CDSS. Eka Hospital has adopted CDSS which includes drug interaction and drug allergy alerts. RSU Tabanan and Dr. Cipto Mangunkusumo Hospital have adopted electronic medical records, CPOE and e-prescription and are currently developing homegrown drug database. While EHR replication at RSIA Aisyiyah at Klaten is limited to the non-clinical function of HIS, the hospital plans to implement CPOE and drug interaction alerts in 2013. Similarly, RS Indera plans to gradually adopt the complete version of MMS include CPOE and drug interaction.

6. RECOMMENDATIONS

6.1. Improve Government Regulations to Encourage Growth

The team interviewed experts representing implementers and researchers of the development of hospital information systems, including CDSS, in Indonesia: dr. Syaiful Fatah and Winny Setyonugroho from University of Muhammadiyah Yogyakarta's School of Medicine; and Anis Fuad and dr. Guardian Sandjaya from the UGM. Local health informatics experts revealed that CDSS use in hospitals in Indonesia is still in early adoption phases, and building essential infrastructure needed for CDSS adoption is still in development.

While experts are optimistic that full adoption of CDSS at hospitals is imminent, it will progress faster if commitment comes from all stakeholders, including the Indonesian government who will need to create and uphold regulations that promote confidence in the CIS adoption process. For example, the government has already created a requirement that health facilities provide sufficient clinical diagnostic

information necessary to file insurance claims – especially with public insurance programs like *Jaminan Kesehatan Bali Mandara* (KKBM). However, the team found there is ambiguity amongst respondents and experts on the issue of government policies on CDSS implementation, such as the legality of e-prescriptions. While dr. Agus Mutamakin cited two new regulations on EMR – Health Ministry 269/2008, and UU No. 11 of 2008 - that state, an "electronic signature is a signature….which is used as a verification or authentication tool,"[43] Syaiful Fatah mentioned another regulation that states that a prescription is legal only when there is a wet signature from the doctor.[44]

6.2. Create a Targeted Investment Strategy

The research team finds that the availability of funding for HIS development is not a key barrier, since experts and the implementers at the public hospitals already receive funding from the Indonesian government and foreign agencies to conduct the work. RSIA Aisyiyah and Eka Hospital reported funding the information system (non-clinical for RSIA Aisyiyah and comprehensive system for Eka Hospital) was already budgeted into their operations plan. However, funding must be targeted appropriately into strategic investments, such as seeking collaboration between the health and technology fields, so that enough individuals with a comprehensive health informatics background are advising the systems, a recommendation coming from Anis Fuad, an expert on Health Informatics at UGM. Research findings indicated there remain high technical needs at the facility level in managing even the existing software and technology infrastructure within a facility, never-mind the design of additional products. There is a great need for software developers can help hospitals develop specifications prior to selecting and purchasing a system, which requires translating the hospitals clinical needs into clear specs, especially for hospitals with limited staff skilled in IT.

It is very important to be specific about program intentions to potential funders, as CHMI research findings found several facilities faced difficulties in attracting suppliers of HIS with clinical function at the bidding process. This was attributed to the fact that the facilities provided unclear specifications describing the required clinical functions needed for the new systems.

6.3. Improve Non-Software Infrastructure

Most interview respondents reported unreliability in non-software infrastructure, such as internet connections, intranet networks that connect different hospital units and generators as back-up energy sources during power outages. Such non-software components are crucial to the functioning of the

[43] Indonesia, Regulation 11/2008 Information and Electronic Transaction.

http://www.lipi.go.id/intra/informasi/1250035982.pdf

[44] See note 8

entire system. The internet, for example, can facilitate online data sharing, journal access, software updates and trouble shooting. Facility intranet networks are perhaps more crucial, as they are used to access EMR, process e-prescription orders, and facilitate drug allergy notifications and appropriate drug dosing.

CHMI research findings revealed some solutions to improving this infrastructure, primarily by increasing cooperation between vendors and hospitals and leveraging knowledge about more reliable systems and back-up mechanisms. For example, RSU Tabanan collaborates with Mitrais to identify potential vendors for the Internet. Finding non-infrastructure vendors was not Mitrais' responsibility as a CDSS provider; however, Mitrais understood that this cooperation was necessary to contribute to the success of CDSS's adoption at RSU Tabanan.

6.4. See Opportunity for CIS Initiation in Many Forms

Development of the initial idea for homegrown system design or a commercial system purchase came from various actors in each facility, and indicates the importance of effective communication across all levels of work. At RSU Tabanan, the decision to implement HIS came from high-level hospital administrators eager to start a brand new program, while the top management of RSIA Aisyiyah saw that adopting a first-step system could be a helpful to having an eventually comprehensive HIS system. At Eka Hospital, management was most interested in the CDSS function as a way to reduce diagnosis errors, while RS Indera's adoption came about as a result of the Bali bombing and subsequent AusAID funding. And at Dr. Cipto Mangunkusumo Hospital, it was physicians, not administrators, who gave the initial idea to adopt HIS to enable more useful EMR. The opportunity for a facility to adopt a CIS system could come from various actors and for different reasons, and does not follow a single trajectory or development of ideas.

6.5. Bridge Systems Effectively

CHMI research found that respondents from all five hospitals considered bridging existing and new systems as a key issue when considering which software to adopt and how to manage the adoption process. The "purchased software or systems need to allow for integration with the existing [paper-based] systems." In the case of the Mitrais software, the company assisted both public hospitals bridging their previous non-clinical system with MMS-HIS. It was also acknowledged that it would be easier for "new hospitals to adopt a new hospital information system (non-clinical and clinical) than those that have an existing system." However this is increasingly not a realistic situation in Indonesia.

6.6. Distinguish Commercial or Homegrown as Best Fit

A variety of feedback was collected on the quality of commercial versus homegrown, or internally developed, software systems. Dr. Cipto Mangunkusumo Hospital and RSIA Aisyiyah reported that with homegrown software there was more flexibility in the customization of the system with the hospital's needs. Alternatively, hospitals using the commercial system reported more secure and long-term stability of the system and higher-quality post-installation technical support and training.[45] It was noted that there are higher costs and issues of limited configurability related to use of homegrown software.

The public hospitals using commercial products -Indera and Tabanan – felt the commercial product came tied with more highly skilled technical staff and expertise required to support implementation of the system,[46] and of the facilities studied in this report, the hospitals with fewer IT-skilled staff more commonly used commercial products instead of homegrown options. Public hospitals using the in-house products - Dr. Cipto Mangunkusumo Hospital and RSIA Aisyiyah Klaten – already have staff members available who are highly skilled in health informatics. It is recommended that all facilities interested in implementing CIS/CDSS should conduct assessments and research to determine which system should be adopted.

6.7. Engage Health Workers Strategically

Interviews revealed a need to include health workers more strategically in design stage of CIS order to ensure long-term compliance with and implementation of the system adoption. It was believed that a system designed with extensive inputs from end users is more likely to succeed in the long run. For example, prior to developing the CPOE, the Dr. Cipto Mangunkusumo Hospital Research and Development Team conducted in-depth interviews and participant observation assessments on current business processes with pharmacists, physicians, nurses, and laboratory staff. The team used a circle development approach to continually develop, test, and trial the software with potential users until they found an ideal solution that worked with the hospital's current and future business processes.

Additionally, it was communicated that health workers must be more involved in pre-installation training of CIS/CDSS in hospitals. Most respondents reported that proper training sessions had been conducted in all five hospitals however, repeated trainings were needed as new staffs were hired after the system was implemented. As positive examples, Dr. Cipto Mangunkusumo Hospital involved IT consultants to provide extensive trainings to senior health providers, who were then responsible for

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[45] Ash, J., Sittig, D., Campbell, E., Guappone, K., & Dykstra, R. *Some Unintended Consequences of Clinical Decision Support Systems*. 2007.

[46] dr. Made Yuniti, Interview by Tanti Liesman and Nelty Rosanna, Denpasar, 2 August 2011.

training any new staff who came on board. Also, Mitrais provided on-going trainings for the staff of RS Indera and RSU Tabanan. Lastly, UMY provided trainings to the staff at RSIA Aisyiyah Klaten before *and* after the installation of the non-clinical information system, and the training is on-going as the hospital begins to adopt the strictly clinical information system.

7. CONCLUSION

The promise of HIS and CIS to develop across Indonesian hospitals is immense, and with it the possibility of minimizing medical and diagnostic errors that would lead to improved health outcomes for all Indonesians who must seek care at the hospital level. While the health market in Indonesia is still in its advent in terms of CIS and CDSS implementation, there have been several notable pioneers in the field, including those documented in this report, from the public and private sectors, employing both commercially producing and homegrown software solutions.

In order to push the movement towards improved HISs forward in Indonesia, it will be necessary to see greater investment from, and cooperation between, state regulators, private and public service providers, technology solution designers, and health system investors. The government must create a regulatory environment conducive to fostering the growth of electronic information processing systems, and those investing in such systems must be aware of the priority needs in the current environment, which is most often on the need for heath informatics experts who can speak both to the needs of the health system and the capabilities of a software program. In order to ensure investments will be worthwhile, it will be necessary for the government and private sector providers to ensure continued improvement in access to and quality and reliability of internet connections and intranet networks. Further, at the facility level, it is important to maintain effective communication across departments and up and down hierarchies, in order to see potential opportunities to justify new CIS investments and design appropriately –bridged additions to existing systems. Facilities should also communicate well to understand the type of software most fitting for their needs, a process that can become most enlightening when the health workers who engage most directly and frequently are engaged in helping to choose the type and design of implemented CIS/CDSS systems.

Annex 1

List of Participants

No	Position	Organization Name	Name	Location	Interview (mm/dd/yy)
1	IT Staff	RS Indera	Adi Pradnyana Wibawa	Denpasar	8/1/2011
2	Pharmacist	Dr. Cipto Mangunkusumo Hospital	Adi Purnawan	Jakarta	10/2/2011
3	Pharmacist	RSU Tabanan	Agata W	Denpasar	8/4/2011
4	Medical Record Staff	RSIA Aisyiyah Klaten	Andi Hartono	Klaten	9/21/2011
5	Lecturer of Health Information Management System	UGM	Anis Fuad, DEA	Yogyakarta	8/16/2011
6	Consultant	Mitrais	Blighia Febty Kurnia, M.Sc.	Denpasar	7/31/2011
7	Chief Executive Officer	Mitrais	David Magson	Denpasar	7/31/2011
8	Hospital Information Specialist	Dr. Cipto Mangunkusumo Hospital	dr. Agus Mutamakin	Jakarta	10/3/2011
9	Cardiologist	Eka Hospital	dr. Daniel Tambudi	Tangerang	10/4/2011
10	Lecturer of Health Information Management System	UGM	dr. Guardian Sanjaya	Yogyakarta	8/15/2011
11	Otolaryngologists	RS Indera	dr. I Wayan Prmara, Sp. E.N.T	Denpasar	8/2/2011
12	Vice Director	RS Indera	dr. Made Yuniti	Denpasar	8/1/2011
13	Director	RSIA Aisyiyah Klaten	dr. Muhammad Maimun	Klaten	9/12/2011

14	General Physician	RSU Tabanan	dr. Ni Made Yuliani	Denpasar	8/4/2011
15	Emergency Room Physician Coordinator	Eka Hospital	dr. Olaf	Tangerang	10/4/2011
16	Head of Informatics Department	UMY	dr. Syaiful Fatah	Yogyakarta	8/15/2011
17	Staff	RS Indera	drg. Nyoman Wiradharma	Denpasar	8/1/2011
18	IT Corporate	Eka Hospital	Hafit Hermawan	Tangerang	10/4/2011
19	Chief Operating Officer	Eka Hospital	Hasan Widjaja, S.Kom	Tangerang	10/4/2011
20	Cashier	RSU Tabanan	I Gusti B. Dharma Yasa	Denpasar	8/4/2011
21	IT Staff	RSU Tabanan	I Gusti Bagus Arya	Denpasar	8/4/2011
22	Staff	RSU Tabanan	I Made Endra Hermawan	Denpasar	8/4/2011
23	Project Manager MIS	Mitrais	I Made Mudita	Denpasar	7/31/2011
24	Head of IT Department	RSU Tabanan	I Nengah Warsa	Denpasar	8/4/2011
25	Administration Staff	RSU Tabanan	I.G.A. Yasmin Agustini	Denpasar	8/4/2011
26	Director	RSU Tabanan	dr. I Gede Wiryana Patra Jaya, M.Kes	Denpasar	8/1/2011
27	Head of Planning	RS Indera	I.B. Kawi	Denpasar	8/1/2011
28	Head of General Affairs	RS Indera	I.G.N. Mertakota	Denpasar	8/1/2011
29	Administration Staff	RS Indera	I.K.T. Alit Sukadana	Denpasar	8/1/2011
30	Head of Administration	RSIA Aisyiyah Klaten	Istiqomah, Amd.	Klaten	9/21/2011
31	Sales Manager	Mitrais	Iwan Setiadi	Denpasar	8/1/2011
32	Chief Technology Officer	Mitrais	Ken McCellan	Denpasar	7/31/2011

33	Administration Staff	RSIA Aisyiyah Klaten	Kukuh Setiyono	Klaten	9/21/2011
34	Emergency Room Staff	RSIA Aisyiyah Klaten	Kus Indang K.D.	Klaten	9/21/2011
35	IT Staff	RSIA Aisyiyah Klaten	Muhammad Arif Efendi, S.Kom.	Klaten	9/21/2011
36	Pharmacist	RSIA Aisyiyah Klaten	Ririn Bekti Purnami	Klaten	9/21/2011
37	Staff	RSU Tabanan	Suarningsih	Denpasar	8/4/2011
38	Cashier	RSIA Aisyiyah Klaten	Tutut Fitriani	Klaten	9/21/2011
39	Emergency Room Staff	RSU Tabanan	Uci Purnama Sari	Denpasar	8/4/2011
40	Lecturer of Medical Informatics	UMY	Winny Setyonugroho, MT	Yogyakarta	8/15/2011
41	Account Manager	Mitrais	Yuni Erika Sucipto	Denpasar	8/1/2011

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