[1] **Eko Prasetyo Nugroho**

[2] **Maria Kartawidjaja**

[3] **Lukas**

Healthcare Integrated Information System in Indonesia

Journal of Electrical Systems

Abstract: - The United States (US), leads the world in medical science and technology. Lead by clear definitions in almost all sectors of clinical research, training and governance practices. Likewise, the pharmaceutical and medical device (medical equipment) manufacturers are considered one of the leading in the world. Therefore, many of the definitions and rules have also been adopted into global regulations by the world health organization, the World Health Organization (WHO). Currently, these rules have been implemented into the health information system (HIS), which further rapidly being adopted and used in many countries. Nowadays, health facilities (HF) around the world have used HIS, which are basic or have reached an advanced level. This paper will describe how the development of HIS and applied products from utilization of information technology (IT) in Indonesia, along with the opportunities and challenges in the future.

Keywords: healthcare, integrated information system, applied science.

1. INTRODUCTION

21st century, is a new era for stakeholders of health care industry in the world. For decades of 20th century, the application and utilization of IT potentiality has much less use in the health care rather than any other sectors. According to the United States Department of Commerce statistics for 1999, the health sector was ranked 53rd in investing in IT for the enhancement of its capabilities and services. [1] So that a change of view to cultivate and take advantage from IT capability has started in the beginning of this century. HIS, which is part of IT, medical equipment manufacturing, and healthcare procedures, has been radically and revolutionarily reformed.

In HIS environment, numerous concepts, procedures and data architecture designs have been standardized and published by WHO. This standardization functions to establish uniformity in data formats and ways of communicating between HIS which made by IT companies. Medical record documents, disease classifications, action classifications, photo and video recording quality are some of the important information that has been standardized.

HIS has the potential to contributing to improving the overall quality of health services. There are at least six important trends that are ongoing, [2] which is:

Trend 1: Change from paper-based to computer-based systems - This change has resulted in recording patient information, medical records and archiving of health facilities operational documents, which were previously created and stored on paper, now stored as digital data on computer devices. This capability certainly increases productivity and starts a "paperless" culture.

Trend 2: Information on a local to global scale - Initially the information produced was only used and researched within a departmental unit, e.g. radiology department, paediatric department. Currently, information is used across departments and begins to be processed across organizations.

Trend 3: Professional health services to patient-centred health services - HIS was initially only made and commercialized to health facilities or health professionals (health workers). However, nowadays, many HIS are made specifically for patient use, for example: personal health record applications, exercise recording applications, doctor consultation scheduling applications.

Trend 4: Data for patient to data for research - Medical records, and photo and video recordings of medical devices were initially made for the use of patient only. Now the data is collected and processed as research materials or for education.

Trend 5: Technical orientation to strategic orientation - HIS was initially built to meet the operational needs of health care organizations, for example the Hospital Management Information System (HMIS), which is used to support the operational of a hospital. In line with the government's strategic needs, in this case the Ministry of

[1,3] Cognitive Engineering Research Group (CERG)

Sekolah Tinggi Ilmu Komunikasi dan Sekretari Tarakanita, 1ekoset2001@gmail.com, 3lukas@atmajaya.ac.id

[2] Electrical Engineering Department, Faculty of Engineering, Universitas Katolik Indonesia Atma Jaya

Jl. Jend Sudirman No. 51, Jakarta 12930, maria.kw@atmajaya.ac.id

Health (MoH), HMIS applications are starting to be linked to the MoH's information system, so that data is centralized and can be processed to produce strategic policies.
Trend 6: numeric data format to complex data format - Processed data is also increasingly complex. A simple HIS only generates a numeric data format. However, the evolution of technology makes HIS able to generate imaging data formats.

2. CONCEPT

The six trends previously described are a continuous effect of the transformations on the defined definition of health care quality and four-level model of health care system framework. The originator of this transformation is the Institute of Medicine (IOM), a non-profit healthcare and non-governmental organization founded in 1970 in the United States. This organization works to provide input, suggestions and answers that are objective and scientifically balanced to problems in the health care sector to the United States government. IOM's vision in this transformation is to transform the outlook of healthcare into a patient-centred healthcare system.

In terms of quality of health care, IOM identifies six interrelated dimensions of health quality for the health care system to improve. The six dimensions are safe, effective, patient-centred, timely, efficient, and equitable which are described as follows: [1]
Safe - avoiding injuries to patients from the care given to help them
Effective - providing services according to scientific knowledge only to those who can experience the benefits
Patient-Centred - provides respectful and responsive care services according to patient preferences, needs and conditions, and ensures medical decisions and actions are appropriate to the patient's condition.
Timely - reduces waiting times and the possibility of delays that are detrimental to patients when receiving services.
Efficient - avoiding waste in any form, including ideas and energy.
Equitable - providing care services according to established standards regardless of gender, ethnicity, religion, geographic location, and socioeconomic status.
When considering how IT and other communication tools can be used to support realizing IOM's vision of achieving a patient-centred healthcare system, we must understand the four-level model of health care system. IOM has adapted Ferlie and Shortell's [1] four-tiered model (see Figure 1) to clarify the structure and dynamics of the health care system. A brief description of each level of the model is as follows:

The Individual Patient

The main focus of the overall framework is centred on this level. The needs and preferences of the patient should be the determining factors in a patient-centred health care system. The patient's role is expected to be more active by being able to deliver these needs and preferences accurately. For this reason, HIS is expected to be able to provide the availability of information from all services, the development of the patient's health condition and the ability to organize costs that arise during treatment. It is hoped that the process of delivering the availability of this information can be done free of charge. These things are expected to increase the quality, efficiency and effectiveness of services.

The starting point for starting a change in the “patient-centred” perspective in providing health care is to change the perspective of medical practitioners (MDs) who regard patients and their relatives as “partners”. In practice, these "partners" help incorporate their needs and preferences which are then converted into a treatment process. Therefore, the responsibilities of the "partners" in each treatment case will be different. HIS is expected to be easily accessible by "partners".

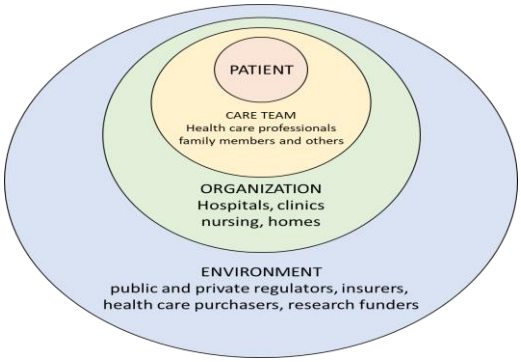

Figure 1. Four-Level Model of The Health Care System [1]

The Care Team

The second level, is the care team, consisting of health workers and patient relatives who collectively provide direct care to patients. This team is the smallest unit that, if possible, also plays a role in standardizing care services. However, in practice, most health services are currently not provided by groups or teams.

The roles and needs of each MDs will change in line with the needs of the patient. The increase in knowledge and development of medical specialties, and the burden of quality of care will indirectly weaken the autonomy of physicians and require them to start working together as a unit of care team.

The Organization

Health facilities that have legal entities are part of this third level. Health facilities provide infrastructure services and health care resources that support the work and development of a professional care team. Health facilities have a major influence in providing the overall working climate and culture in the community. This organization has scope in decision-making, service operations and administrative processes to coordinate various service activities and supporting units at once. The organizational level is also where large investments are allocated for complex HIS and health infrastructure.

Generally, at this level there will be challenges in communication and cooperation with third parties such as procurement of consumables for health services, licensing coordination, accreditation and audits with the government, and financing cooperation with insurance parties. As a result, health facilities are under great pressure to complete a lot of administrative work with less labour regarding to maintain good financial balance. Therefore, organizations have to use other IT software in the form of Enterprise Resource Planning (ERP). [3]

The Political and Economic Environment

The final level of the health care framework is the economic and political environment that influences the structure and performance of the organization and levels below it. This level includes government regulations, standardization of national and international agencies, and payment methods / norms in society. Every time there is a change in policy, socialization is needed in advance so as not to cause polemics between parties in society. Private sector stakeholders also have influence at this level, for example health insurers, or large-scale manufacturing companies with thousands of employees.

The influence of this environment also causes the features or business processes that exist in HIS and ERP to change. An example is the influence of the government's social health security (SHS) policy. In this policy, each HIS and ERP application used at the organizational level must be connected to the SHS application so that these applications can communicate and synchronize a number of data such as patient data, the number of subsidized medicines, and costs arising from SHS patient service.

Based on the above concept, this provision becomes the new benchmark for standard operating procedures (SOP) for health facilities. Change management policies are required to be established and implemented. The HIS and ERP applications for health facilities are also required to be adjusted before they can be used by stakeholders. In the next section, we will discuss the HIS and ERP application modules that are in accordance with this concept.

3. HEALTH INFORMATION SYSTEM AND ENTERPRISE RESOURCE PLANNING MODULES

HIS is an application that focuses on patient health services. This application has an important function in the operational centre of every part of the organization. To see the complexity that is perfectly integrated, we need to refer to the use of HIS in hospitals (see Figure 2). The HIS Hospital business process starts from the outpatient, emergency or pharmacy module where this section serves as the initial recipient of patients or their relatives. After this module, the next process can move to another module according to the patient's needs. Health facilities other than hospitals have the same flow except for independent laboratory health facilities where patient admission is immediately accepted in the laboratory module. This patient-accepting module process flow is characterized by that patients do not need to show special identification or reference letters before registering for services.

ERP is an application that focuses on the business administration of an organization. The application has an important role for the operation of a legal entity that has many employees. ERP commonly contains five main modules, namely Finance, Accounting, Inventory, Purchasing and Sales. However, because of specific need for health facilities, ERP is equipped with several additional modules, which is Human Resource, Customer Relationship Management, and Management. The Inventory module just changes its name to Asset Management.

Then, the sales module is eliminated, all sales transaction recording functions are adopted by the Outpatient, Emergency, Pharmacy and Laboratory modules.

The HIS and ERP applications in their manufacture are equipped with many features so that in the future they can easily adapt to customer's information needs. Manufacturers of HIS and ERP applications in facilitating management generally install modular capabilities, so that in implementation, even though all applications are installed, they can be configured to work according to the modules used only. This also benefits customers because it makes it easier for customers to upgrade applications when the customer's business is growing, for example, customers develop from independent practice to clinic or from clinic to hospital. Other mandatory features include Application Programming Interface (API) and Data Import / Export. API functions to facilitate communication and synchronization between the HIS / ERP application and other applications. Meanwhile, the Import / Export Data feature makes it easy for customers to easily enter or output large amounts of data.

In their implementation, HIS and ERP are accompanied by various other information systems that function as supporting infrastructure both in helping to produce input data, presenting output data and processing data. The next section will describe some of the IT capabilities which are then utilized into information systems.

Healthcare Information System and Enterprise Resource Planning								
	Module Name	Hospital	Clinic	Home Care	Home	Laboratory	Pharmacy	MD Private
HIS	Outpatient	V	V	V	V	X	X	V
	Inpatient	V	V	X	V	X	X	X
	Emergency	V	V	X	V	X	X	X
	Laboratory	V	V	X	X	V	X	X
	Radiology	V	V	X	X	X	X	X
	Pathology	V	X	X	X	X	X	X
	Medical Record	V	V	V	X	X	X	X
	Pharmacy	V	V	V	X	X	V	X
	Nutrient Department	V	X	X	V	X	X	X
	Blood Bank	V	X	X	X	X	X	X
	laundry & Sterilized Service	V	V	X	V	V	X	X
	Insurance	V	V	V	V	V	V	V
ERP	Finance	V	V	V	V	V	V	V
	Accounting	V	V	V	V	V	V	V
	Purchasing	V	V	V	V	V	V	X
	Human Resource	V	V	V	V	V	V	X
	Customer Relationship Management	V	V	V	X	V	V	X
	Management	V	V	V	V	V	V	X
	Asset Management	V	V	V	V	V	V	X

Figure 2. Table of HIS and ERP Modules

4. PROMINENT INFORMATION TECHNOLOGY

Currently, there are three technologies that have researched and utilized massively in producing new innovations which provide solutions of the problems in the health sector. Those three technologies are Cloud Computing (CC) [4] [5], Artificial Intelligence (AI) [6] and the Internet of Things (IoT). [7] In practice, they are mutually integrated into a single information system.

The presence of CC that provides an architectural approach to produce a flexible IT infrastructure, changes many people's behaviours. We can easily build IT resources to meet the requirements of carrying out business processes which then produce a number of structured or unstructured data. This business process not only uses CC, but sometimes also uses IoT or AI capabilities. All data generated from this business process are then collected. This flexible ability makes CC can accommodate enormous amounts of data so that it becomes big data.

AI makes machines have cognitive abilities as if they were human. Machine learning (ML), which is part of the AI group, gives machines the ability to learn and update decision making for the better. This makes the general public often confuse AI with robots. AI and robots are two different technologies.

Meanwhile, IoT is a network of objects, with a clear unique identification, combined with intelligent software, high-tech sensors and connected to the internet. To operate with an accurate accuracy which is acceptable to society, IoT requires 5G network technology, which has a latency accuracy of 1 millisecond, to be able to communicate quickly.

MDs are greatly helped by the presence of this technology. They can more easily and quickly diagnose disease in patients, predict the likelihood of an epidemic that will break out, monitor the patient's condition

anytime and anywhere, accelerate the discovery of new drugs and provide preventive health services to patients [8] [9] [10] [11].

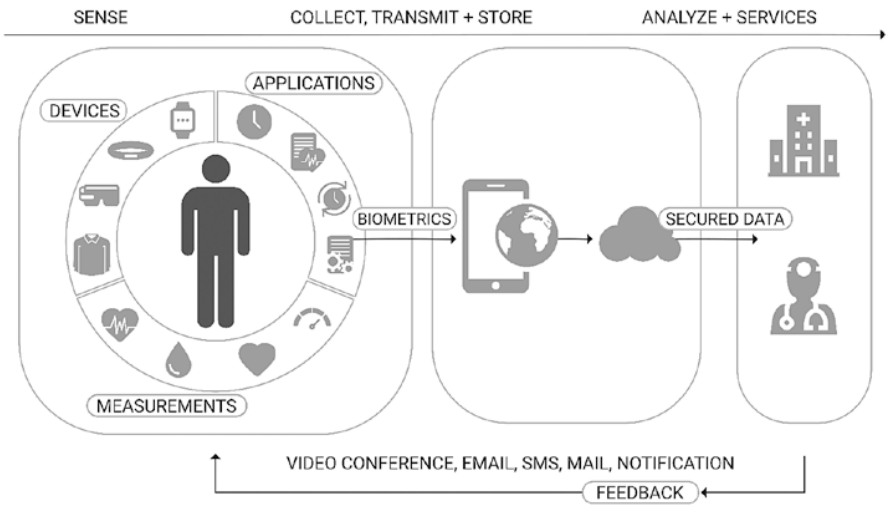

Figure 3. The Example of Integration CC, AI and IoT Diagram

5. STANDARDIZATION

Processes in integrated information systems have to meet standards in order to communicate and collaborate with each other. The following are some of the international standards and their functions:

HL7 version 2 messaging standard [12] - This is a data exchange and communication standard between health information systems developed in the United States and overseas has adopted. 95% of health organizations in the United States and 35 other countries have adopted this standard. HL7 stands for Health Level 7 where level seven references levels in the OSI model.

ICD [13] - Stands for International Classification of Diseases, is a diagnostic tool for epidemiology, health management and clinical related matters. This diagnostic tool is developed and published by WHO. A list of disease classification codes and their treatment measures is in this standard.

DICOM [14] - Is a standard for communication and management of medical imaging information. DICOM stands for Digital Imaging and Communication in Medicine. Copyright and publication of this standard are held by The National Electrical Manufacturers Association (NEMA), a national association of the United States.

6. CONCLUSION

The implementation of HIS - ERP and the application of CC-AI-IoT technology in the health industry have played a very important role in supporting the improvement of the quality of health services. This has a broad impact on every stakeholder. Even though the value of the investment costs incurred is large, these efforts are feasible considering the many process changes that are increasingly cost-saving, effective and efficient. In the short term, it can be seen that human error rates can be reduced, and health care delivery can be more quickly accepted by patients. Patients no longer experience a long queue. The administration process can take place quickly. Improvements in the overall quality of health services will be felt by patients and relatives in the medium term. Likewise, for organizational stakeholders, financial reports will show returns commensurate with the investment costs incurred. In the long term, organizational and environmental stakeholders able to develop research and preventive activities against dangerous disease.

REFERENCES

[1] Proctor P. Reid, W. Dale Compton, Jerome H. Grossman, Gary Fanjiang. 2005. Building a Better Delivery System. Washington: The National Academies Press.
[2] Madison Ngafeeson. 2014. Healthcare Information Systems: Opportunities and Challenges. IGI Global.
[3] Profil Usaha Medixindo Penyedia Solusi Layanan Kesehatan & Teknologi. 2017. Jakarta : PT Data Medika Indonesia.

[4] Katarina Stanoevska-Slabeva, Thomas Wozniak, Santi Ristol. 2010. Grid and Cloud Computing, A Business Perspective on Technology and Applications. Switzerland:Springer
[5] William Aprillius. 2015. Big Data dan Perawatan Kesehatan, Studi Awal Menuju Perawatan Kesehatan Masa Depan. Ultima InfoSys, (VI)1
[6] Ralf T. Kreutzer, Marie Sirrenberg. 2020. Understanding Artificial Intelligence, Fundamental, Use Cases and Methods for a Corporate AI Journey. Switzerland:Springer.
[7] Ammar Rayes, Samer Salam. 2019. Internet of Things From Hype to Reality. Switzerland:Springer
[8] Mark Chang. 2020. Artificial Intelligence for Drug Development, Precision Medicine, and Healthcare. Florida: CRC Press.
[9] Nilmini Wickramasinghe, Freimut Bodendorf. 2020. Delivering Superior Health and Wellness Management with IoT and Analytics. Switzerland: Springer.
[10] Pedro, Ana, Paulo, Nuno. 2020. 5th EAI International Conference on IoT Technologies for HealthCare. Switzerland: Springer.
[11] Arjun Panesar. 2019. Machine Learning and AI for Healthcare. Coventry: Apress.
[12] HL7 International. HL7 Version 2 Product Suite, (http://www.hl7.org/implement/standards/product_brief.cfm?product_id=185, diakses pada 7 November 2020).
[13] World Health Organization. Classification of Diseases (ICD), (https://www.who.int/classifications/icd/en/, diakses pada 7 November 2020).
[14] DICOM. About DICOM: Overview, (https://www.dicomstandard.org/, diakses pada 7 November 2020).