



eHealth in Thailand: INTEROPERABILITY AND HEALTH INFORMATION STANDARDS

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PREFACE

This report was developed by Thai Health Information Standards Development Center (THIS), affiliated agency of Health Systems Research Institute (HSRI), Ministry of Public Health, Thailand. The information in this document represents the experiences of THIS on research and development of health data standards in Thailand. It is also designed to help the readers to understand the rationale behind, to share experience in developing health data standards, and to assure that the work processes and data needs in health information exchanges are well understood by readers. The target audiences of this report are health IT and healthcare professionals, health policy makers and people who are interested in health information systems and eHealth. The overall goal of this effort is to share knowledge and facilitate interoperability, health data standardization of health information system development with the ultimate aim of strengthening health systems.

The report consists of five main parts. The first part is the general knowledge about eHealth, interoperability and health information standards. The second part describes health information standards development in Thailand and the Thai Health Information Standards Development Center (THIS). The following two parts depict the development of TMT and the study of LOINC in Thailand. The final part is the conclusions and recommendations of health data standards development.

Boonchai Kijsanayotin MD. PhD.
May 2016

EXECUTIVE SUMMARY

Interoperability of different health information systems is one of the major challenges for countries to develop functional, integrated and effective health information systems. It is evident that the lack of uniform data standards will lead to information fragmentation. Interoperability of information systems needs the whole stack of standards which include content, syntactic, semantic and security standards.

This report provided fundamental knowledge of health information standards and interoperability and also explored and reviewed the development, adoption and use of health data standards in Thailand. Thailand has developed, adopted and implemented some health data standards such as the citizen ID system, the health provider facility ID system, standard data sets for reporting and insurance reimbursement systems, and the International Classification of Diseases (ICD). However, the current standards are not adequate. To support information exchange of administrative and clinical data, and Electronic Health Record (EHR), Thailand needs more health data standards. The demands of containing healthcare cost by the government led to the development of health data standards that can identify healthcare resources and analyze their utilization. Thai Health Information Standard Development Center (THIS), responds to the demands by researching and developing two semantic standards, the Thai Medicines Terminology (TMT) and Logical Observation Identifiers Names and Codes (LOINC). The development of TMT and the adoption of LOINC aim to facilitate the EHR interoperability in Thailand. The standards that can support both administrative functions and also health information exchange for clinical and quality of care. TMT is currently implemented in Thai insurance reimbursement information systems and the government e-procurement information system. LOINC, a widely use international standard, has been studied for the plausibility of adopting the standard in Thai healthcare service context. The study shows that LOINC can be used and should be adopted in Thailand.



Though health informatics professionals in Thailand have encouraged the adoption of health data standards, there are barriers such as a lack of human resources in health informatics, lack of awareness and unfamiliarity with the potential benefits of using standards and terminologies in healthcare among high level policy makers and healthcare professionals. With these barriers in mind, we recommend the following steps for the development of health information standards in Thailand:

- Governance and leadership of national eHealth systems are essential and critical for the country to achieve interoperability through health data standards.
- Incentives and mandates from the governing body that has authority are important to the adoption of standards.
- Standards maintenance process is a necessary component of successful implementation of every standard.
- Advocacy on the potential benefits from using data standards as well as communication between the organizations and the users are of importance.
- Human resource in health informatics is an important component and building capacity for them is essential.

Key words: eHealth, Electronic Health Record, Health Information Systems, Interoperability, LOINC, Standards, Thailand, TMT



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ABBREVIATIONS AND ACRONYMS

ADB	Asian Development Bank
AeHIN	Asia eHealth Information Network
CDA	Clinical Document Architecture
CPOE	Computerized Provider Order Entry
CSMBS	Civil Servant Medical Beneficiary Scheme
DICOM	Digital Imaging and Communications in Medicine
EHR	Electronic Health Record
FDA	Food and Drug Administration
FSN	Fully Specified Name
HIE	Health Information Exchange
HIS	Health Information System
HL7	Health Level 7
HSRI	Health Systems Research Institute
Health IT	Health Information Technology
ICT	Information and Communications Technology
IHTSDO	International Health Terminology Standards Development Organization
LOINC	Logical Observation Identifiers Names and Codes
M&E	Monitor and Evaluation
MICT	Ministry of Information and Communication Technology
MOPH	Ministry of Public Health
RELMA	Regenstrief LOINC Mapping Assistant

ABBREVIATIONS AND ACRONYMS (CONT.)

SEAR	South East Asia Region
SNOMED CT	Systematized Nomenclature of Medicine Clinical Terms
THIS	Thai Health Information Standards Development Center
TMT	Thai Medicines Terminology
ToR	Terms of Reference
WCO	WHO Country Office
WHO	World Health Organization

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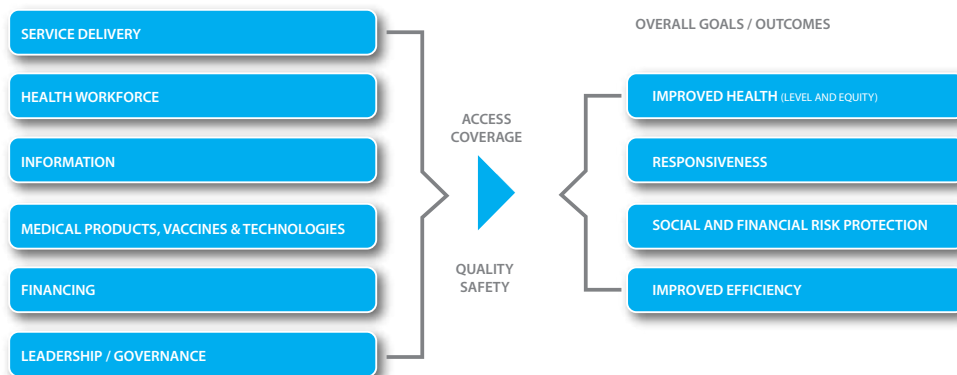
INTRODUCTION

Information is one of the essential six building blocks of a health system.⁽¹⁾ [Figure 1] In today digital era, health information technology (HIT) and health information systems (HIS) are amalgamated into a single entity. The health sector in Thailand, similar to many countries, embraces HIT to support operation and management of health care delivery, public health and personal health. Effective integrated HIS requires different information systems to interoperate. Interoperability can be defined as the ability of two or more systems to exchange and use information. Health information standards provide a common language enabling interoperability between systems and/or devices. However, lack of interoperability and health data standards is one of the big challenges in Thai health information systems development. [2]

Figure 1 : Health Information Systems (HIS) is one of the six essential components of health systems

THE WHO HEALTH SYSTEM FRAMEWORK

SYSTEM BUILDING BLOCKS



THE SIX BUILDING BLOCKS OF A HEALTH SYSTEM: AIMS AND DESIRABLE ATTRIBUTES

- Good **health services** are those which **deliver** effective, safe, quality personal and non-personal health interventions to those who need them, when and where needed, waste of resources.
- A well-performing **health workforce** is one which works in ways that are responsive, fair and efficient to achieve the best health outcomes possible, given available resources and circumstances. I.e. There are sufficient numbers and mix of staff, fairly distributed; they are competent, responsive and productive.
- A well-functioning **health information system** is one that ensures the production, analysis, dissemination and use of reliable and timely information on health determinants, health systems performance and health status.
- A well-functioning health system ensures equitable access to essential **medical products, vaccines and technologies** of assure quality, safety, efficacy and cost-effectiveness, and their scientifically sound and cost-effective use.
- A good **health financing** system raises adequate funds for health, in ways that ensure people can use needed services, and are protected from financial catastrophe or impoverishment associated with having to pay for them.
- **Leadership and governance** involves ensuring strategic policy frameworks exist and are combined with effective oversight, coalition-building, the provision of appropriate regulations and incentives, attention to system-design, and accountability.

This report, **Interoperability and Health Information Standards in Thailand**, describes interoperability, health data standards, the need for health data standards and the development of the standards in Thailand. The report covers following topics:

- eHealth: an overview
- Interoperability and Health Information Standards
- An overview of Thai Health Information Standards Development Center
- Health Information Standards in Thailand: the situation
- Thai Medicines Terminology
- LOINC adoption in Thailand
- Conclusions and recommendations

eHEALTH: AN OVERVIEW

Current century, Information and Communication Technology (ICT) plays a very important role in every aspect of human life. The ICT has been changing education, economic development, rural development and healthcare. World Health Organization (WHO) defines eHealth as the use of ICT for health.⁽³⁾ The European Commission refers eHealth to ICT tools and services that can improve prevention, diagnosis, treatment, monitoring and management. ⁽⁴⁾ The use of ICT in health and healthcare has enormous potential to increase healthcare efficiency, improve quality of life and reduce the soaring health expenditure.⁽⁵⁾ While eHealth has been a prominent topic in healthcare for the past years, the use of ICT in health is lagged behind compared to other industries such as telecommunications, banking, trading and retail merchandising. Healthcare industry has been slow in adopting new technologies. The realization of the eHealth benefits is slow.⁽⁵⁾

In 2005, at the 58th World Health Assembly (WHA), the WHA 58.28 resolution recognized the important of ICT in health. The resolution urged member countries to draw a long-term strategic plan for developing and implementing eHealth services, develop eHealth infrastructure and build closer collaborate between public and private sectors on eHealth.⁽⁶⁾ Since then, many countries have been working on utilizing ICT to improve national health information systems, but they also have been facing several challenges to build effective and functional eHealth. One big implementation challenge is the development of interoperable eHealth systems and lack of national health information standards. In 2013, WHA 66.24 resolution urged member states to draw up a road map for implementation of eHealth and health data standards at national and sub-national levels and to develop policies and legislative mechanisms linked to an overall national eHealth strategy in order to ensure compliance in the adoption of eHealth and health data standards.⁽⁷⁾ In fact, WHO resolution WHA 66.24 focuses on improving quality of health information on the Internet and recognizes the necessity to ensure secure online management of health data, and to increase the trust in eHealth tools and health services. Moreover, the International Telecommunication Union (ITU) stated that

the advancements in eHealth will be only accomplished through ICT standards efforts that facilitate interoperability among systems and devices, provide unqualified privacy and security, address the unique needs of the developing world, and leverage existing ubiquitous technologies such as social media applications and mobile devices. In 2012, WHO and ITU, working together, published the National eHealth Strategy toolkits in responding to the needs of countries, at every level of development, who seek to adapt and employ eHealth.[8]

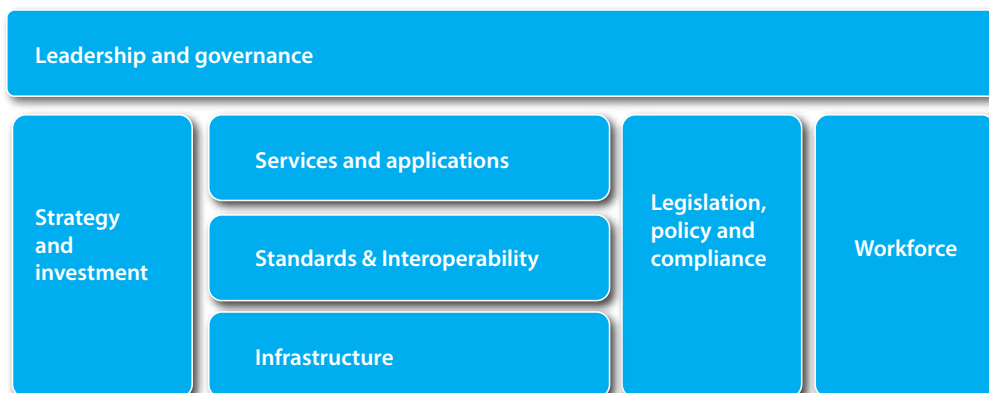
eHEALTH COMPONENTS

The WHO-ITU National eHealth Strategy toolkit identifies important seven building blocks or components that must be in place to realize the national eHealth vision. [Figure 2] The seven components are:

- leadership and governance
- strategy and investment
- legislation policy and compliance
- workforce
- infrastructure
- services and applications
- standards and interoperability.

One of the seven components is interoperability and health data standards. Interoperability of various health information systems and health data standards are essential for comprehensive and integrated health information which is primal for effective decision making of all health-related stakeholders from policy-makers, healthcare providers to general public.

Figure 2 : eHealth components (WHO-ITU Model)

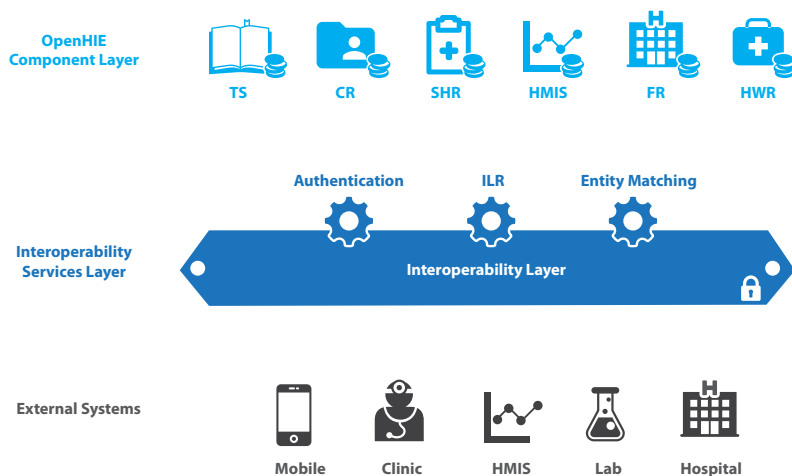


In general, the integrated information needed at point of healthcare services are who received services, provided by who, where, and what type of services have been provided. The health information exchange (HIE) is an enabler of the health information integration. (9) HIE refers to the technologies, standards, and governance that enables the exchange of data between the information systems of various health care stakeholders. (10) HIE is defined as the electronic transfer of clinical and/or administrative information across diverse and often competing health care organizations. In practice, the term HIE is often used both as a verb and a noun. As a verb, HIE refers to movement of data or information electronically among stakeholders in the health care sector. HIE as a noun, it refers to an organization, usually a legal corporation, which facilitates information exchange (the verb form) within a network of facilities, community, state, or region. (11) Figure 3 shows architectural model of HIE, presented by the OpenHIE group, which is an enabler of the health information integration. (9) The OpenHIE architecture demonstrates the importance of the interoperability and standardization to identify people, providers and types of medical services to ensure that the same meaning of medical concepts is interpret the same by different applications.

The OpenHIE architecture supports interoperability by creating a framework that maximally leverages health information standards, enables flexible implementation by country partners, and supports interchangeability of individual components. The external systems are a diverse group of actors (diverse information systems) that leverage the health information exchange to improve the quality of care by using higher quality and more timely data to support their activities. These systems include mobile messaging tools (SMS/IVR), electronic medical records, laboratory or stock management systems, and monitoring and evaluation tools.

The Interoperability Service Layer (IL) is the component that enables easier interoperability between disparate information systems by connecting the infrastructure services and client applications together. An interoperability layer receives transactions from external systems and coordinates interaction between components of the HIE and provides common core functions to simplify the interoperability between systems.

Figure 3 : The HIE architecture or the eHealth blueprint



The OpenHIE component layer composes of several shared assets of the system. The Terminology Services (TS) component provides a centralized source for the HIE's standards and definitions, including terminologies, ontologies, dictionaries, code systems, and value sets. Other HIE components can use these standards and definitions to normalize clinical data and achieve consistent aggregation and reporting. The Client Registry (CR) supports the unique identification and management of patient identities. In order for the details of what specifically happens during a health service event to be understood universally, each client or patient needs to be represented in a standard way. A Shared Health Record (SHR) enables the collection and storage of electronic health information about individual patients in a centralized repository which is capable of being shared across different healthcare settings. The Health Management Information System (HMIS) component – stores and redistributes population level information normalized through the exchange. The Facility Registry (FR) serves as the authority for maintaining the unique identities of locations where health services are provided. This is the service that manages a master facility list dataset. The Health Worker Registry (HWR) serves as the authority for maintaining the unique identities of health workers within a country.

INTEROPERABILITY AND HEALTH INFORMATION STANDARDS

1. INTEROPERABILITY

Health information should be seamlessly shared among medical devices and enterprise systems to optimize healthcare and meaningfully used to serve healthcare delivery system, personal health and health of the population. The information should meet the requirement of both healthcare services and public health functions and such information should be comprehensive, integrated and good quality. In addition, patient health information should be exchanged between providers, authorized agencies, and should be available to the right people at the right time and at the right place, the HIE. To achieve HIE, different health information systems, both inside and outside of the organization must be interoperable. Interoperability is important to patient care as patient's vital data can be shared among stakeholders which will lead to less medical errors, unnecessary tests and more efficient decision making.

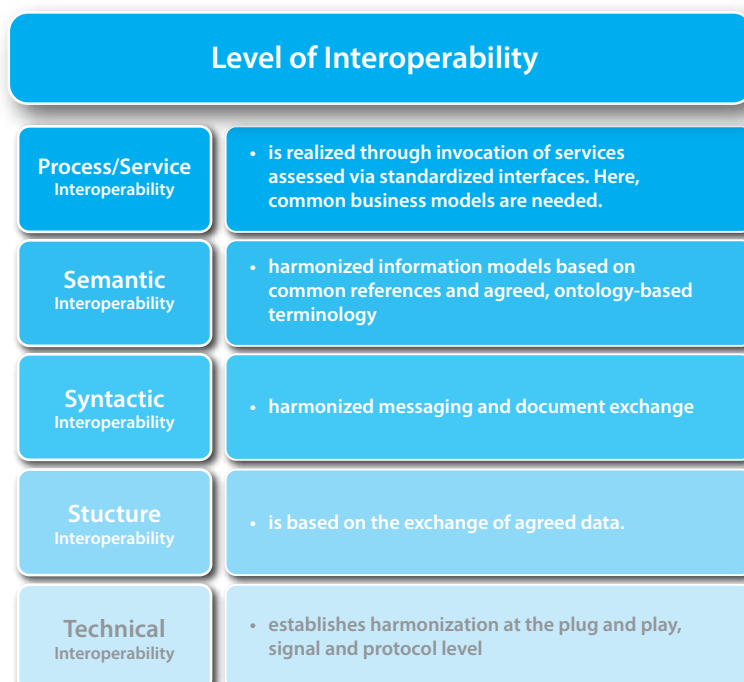
Health Information Management Systems Society (HIMSS) stated that interoperability describes the extent to which systems and devices can exchange data, and interpret that shared data. For two systems to be interoperable, they must be able to exchange data and subsequently present that data, such that it can be understood and used by a user. (12) The Institute of Electrical and Electronics Engineers (IEEE) defines interoperability as the ability of a system or a product to work with other systems or products without special effort on the part of the customer. (13) Another definition from ISO/IEC 2382-01 for interoperability is "the capability to communicate, execute programs, or transfer data among various functional units in a manner that requires the user to have little or no knowledge of the unique characteristics of those units".

In healthcare, interoperability is the ability of different information technology systems and software applications to communicate, to exchange data accurately, effectively, and consistently, and to use the information that has been exchanged.(12) To say that two or more information systems are interoperable, it is not only the ability to exchange information, but they also have to be able to use the exchanged information. Interoperability requires standards to ensure data being shared in the health systems is available and retains the same meaning and context throughout different processes of clinical care. Interoperability is made possible by the implementation of standards.

2. LEVEL OF INTEROPERABILITY

There are multiple levels of interoperability. From the basic level that the systems can only exchange message without knowing the meaning of the message, for example that a person who only know English receives an email written in Thai, to the highest level of interoperability that the disparate systems not only understand the messages, but also work together seamlessly with common business model. Figure 4 describes the multiple levels of interoperability, the first level is technical interoperability which refers to ability to moves data from system A to system B, neutralizing the effects of distance. Technical interoperability is a domain independent. It does not know or care about the meaning of what is exchanged. The structure interoperability means the systems can exchange message based on agreed data set. It is the standardization of data content. Syntactic interoperability is the interoperability level that various systems adopt the same standards of syntax or format of the exchanged messages. Semantic interoperability ensures that sender and recipient understand the same data in the same way and allows computers to

Figure 4 : Levels of interoperability



share, understand, interpret, and use data without ambiguity. Semantic interoperability usually involves the use of codes and identifiers which are based on common references and agreed terminology. Process interoperability is achieved when human beings share a common understanding across a network, business systems interoperate, and work processes are coordinated.(14,15) Following this section, we will focus on three levels of interoperability the structure, syntactic and semantic interoperability.

3. STANDARDS

Standard is a definition, set of rules or guidelines, format, or document that establishes uniform engineering or technical specifications, criteria, methods, processes or practices. In addition, it has to be approved by a recognized standards development organization (SDO), or have been accepted by the industry.(16) eHealth Initiative (eHI) defines standards as a well-defined approach that supports as a business process, has been agreed upon by a group of experts and has been publicly vetted.

Standards are basically universally agreed upon ways to handle data to ensure interoperability. Standard can also be described as a group of guidelines concerning the essential requirements that a certain process, product or service must be met in order to meet quality objectives. Standards allow data to be shared across systems and across stakeholders regardless of the application. In fact, standards are the foundations of interoperability; it is not possible to build interoperable systems without them. Standardization is a process of agreeing the standards, which represent the common language allowing the exchange of data between disparate data systems. The goals of standardization include achieving comparability, compatibility and interoperability between independent systems, ensure data compatibility and to reduce duplication of effort and redundancies.(15)

4. WHY DO WE NEED STANDARDS?

The issue of health data standard and interoperability is not trivial. Many health IT projects, regardless of the size, in many countries failed as health IT services and applications are not interoperable. Information exchange is difficult to achieve in healthcare system due to absence of standards. In fact, studies indicated that lack of standards create a barrier for people to effectively collaborate because their information systems are not interoperable and makes it difficult to share or interpret data across systems.

For different systems to integrate health information, the information needs to be transferred from one system to another through interfaces. The formula $\frac{N^2 - N}{2}$ demonstrates that interfaces needed to connect N systems increases exponentially.(15) For example, in general hospital IT environment, there are around hundred applications. If the numbers of system increase, the numbers of interface will also increase. The number of interfaces that need to be communicated between those systems is almost 5000 interfaces [Figure 5].

Figure 5 : Number of interfaces needed for the interoperability of systems without standards

Number of Interfaces needed for the interoperability of systems without standards

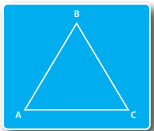
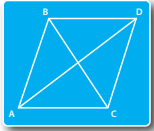
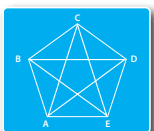
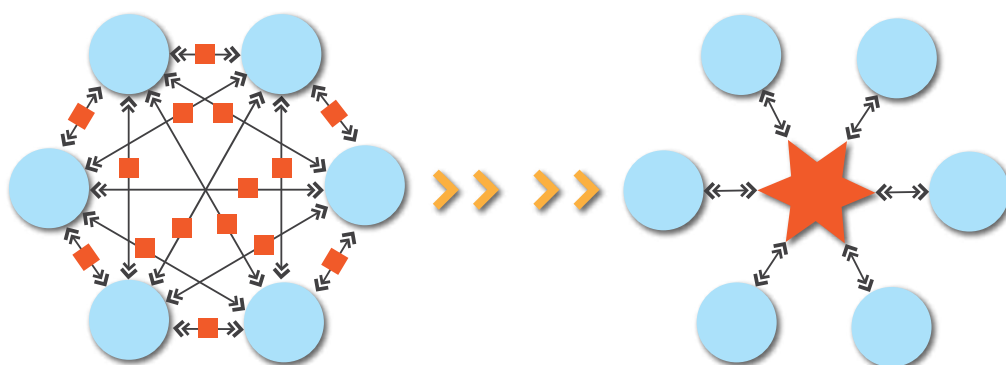
	2 systems, 1 interface
	3 systems, 3 interfaces
	4 systems, 6 interfaces
	5 systems, 10 interfaces
100 systems	100 systems, 4950 interfaces

Figure 6 : The benefits of the implementation of standards

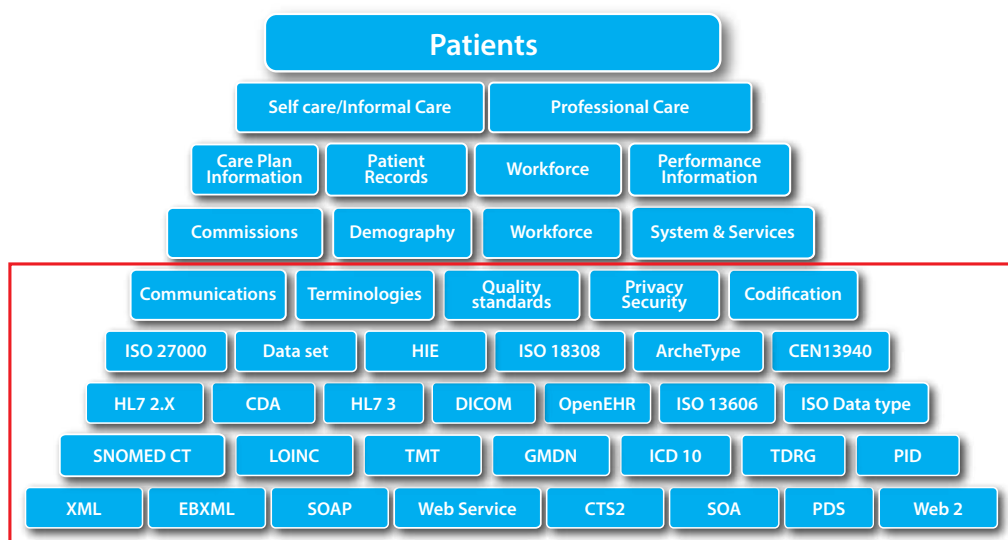


The star in the center of the right figure replaces the 15 separate specifications described in the left figure (Figure 6). The diagram describes the fact that if standards are not deployed, how much waste of time, resources and efforts we have to spend.⁽¹⁵⁾ The benefit of standards is it enables interoperability and may also allow innovation based on common foundation.

5. CATEGORIZING DIFFERENT STANDARDS

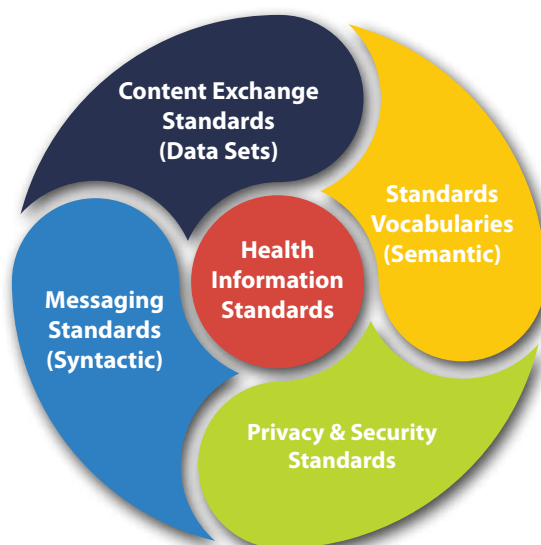
There are many types and level of health information standards. Figure 7 shows the landscape of the standards that are needed to serve systems interoperability. In health care, we need different type of health data standards to support system interoperability. In order to share data across healthcare institutions, exchanged data must hold similar data elements, use similar terminology, and use an agreed messaging format.

Figure 7 : Health information standards landscape



From Figure 7, the lower five stacks are the different type of standards that is needed for HIE. We can simplify numbers of health information standards by categorizing them into four major groups (Figure 8): the content exchange standards, semantic or vocabularies standards, syntactic or messaging standards, and privacy and security standards.

Figure 8 : Categories of health information standards



1. **Content exchange standards or standards data set** is the agreed content of services or functions that parties have agreed to exchange, e.g. data set for billing, data set for Continuity of Care Document (CCD).
2. **Semantic standard or standard vocabularies** are the standards of meanings. Sometimes, a term may mean different things, representing different concepts for example the term “cold” in one circumstance means a respiratory infection disease and in another circumstance means the feeling when people are exposed to low temperatures. Sometimes different terms may represent the same concept, for example: the terms “heart attack” and “myocardial infarction” represent the same meaning as “death of cardiac muscle”. As a result, we need standardized ways to represent concepts. There are several coding systems that represent the meaning in several aspects in medicine. The samples of semantic standards are patient identifier, provider identifier, ICD, SNOMED CT, and LOINC. They have different objectives, and are all important in HIE. Internationally, there is a range of core semantic standards used to represent clinical findings, diseases, clinical laboratory and clinical observations. The following are some important examples:
 - International Classification of Diseases (ICD) system [17] is the classification of diseases and related health problems. Its main objective is the disease statistical report and epidemiological purpose or administrative reimbursement as well as the standard diagnostic tool for epidemiology, health management and clinical purpose. ICD is developed and maintained by the WHO headquartered in Geneva, Switzerland.
 - Logical Observation Identifiers Names and Codes (LOINC)[18] is a standard which is used for identifying laboratory and clinical observations. The LOINC database, developed and maintained by Regenstrief Institute Inc. Indianapolis USA., provides a set of universal names and identification codes for identifying laboratory and clinical test results.

- Systematized Nomenclature of Medicine Clinical Terms (SNOMED CT) (15,19) is a detail clinical terminology, maintained and distributed by the International Health Terminology Standards Development Organization (IHTSDO), the non-for profit organization based in Copenhagen, Denmark. SNOMED CT is considered to be the most comprehensive, multilingual healthcare terminology in the world. It was created as a result of the merger of Systematized Nomenclature of Medicine Reference Terminology (SNOMED RT) and National Health Service (NHS) Clinical Terms Version 3. SNOMED CT provides the core general terminology and contains more than 300,000 active concepts with unique meanings and formal logic-based definitions organized into hierarchies. SNOMED CT is being used around the world in several domains such as academic research; standards for the promotion of eCommerce in the German Health Care System (eCG), hospitals; Electronic Health Record (EHR) Implementation using Cerner Millennium, Corporate Electronic Health Record etc.
- The Diagnosis-Related Group (DRG)(20), a case mix system, is a statistical system of classifying a hospital's acute care patients into groups, which is used for prospective payment system.

3. **Syntactic or messaging standards** are the agreed formats for the grammar of the message. The most popular messaging standards are Health Level 7 (HL7) V2.x. standard. The standard, developed and maintained by HL7 organization(15,21), primarily defines specifications for exchange of health informatics data between healthcare IT applications. The Digital Imaging and Communication (DICOM) is a standard for handling, storing, printing and transmitting information in medical imaging.

4. **Security and privacy standards** include rules and regulations to keep patient information secured. The examples include Public Key Infrastructure (PKI), Secure Sockets Layer (SSL) and Digital Signature which is a system for creating storage and distribution of digital certificates, which are used to verify the particular public key, which belongs to a certain entity.

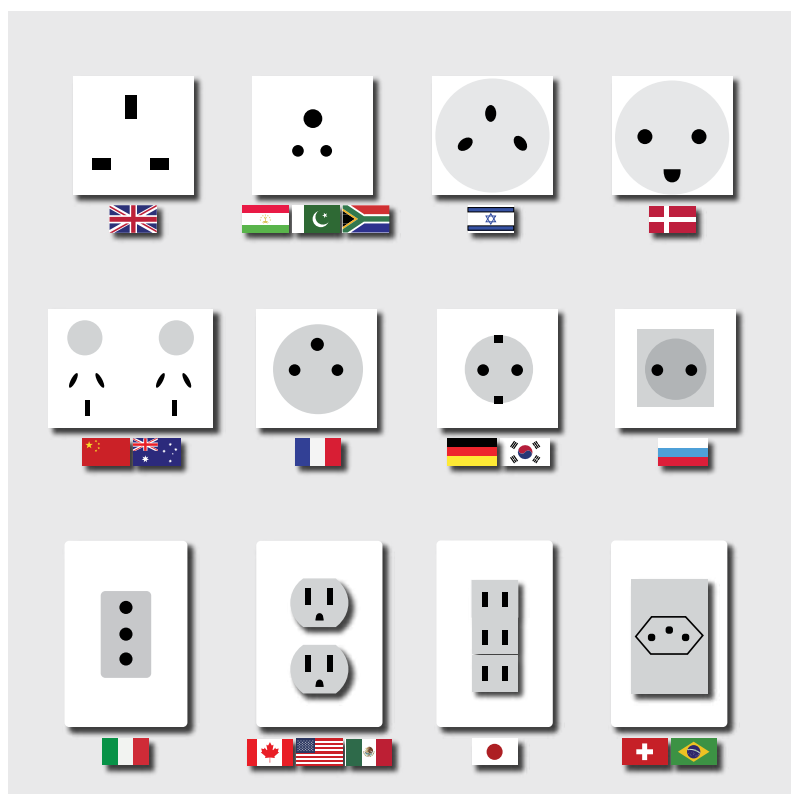
6.IMPLEMENTING INTEROPERABILITY AND STANDARDS IS HARD

Having interoperability and doing the standardization are easier said than to implement. The worldwide use of electric socket is supposed to be one standard but in the real world, it is not. Figure 9 shows a variety of electric plugs and sockets that are currently used in various countries. Imagine how convenient and effective if only one standard is adopted across the world.

Health information standards are complex. Many standards are needed to make different systems interoperate. Although there are many international standards developed and ready for implementation, countries need capacity to know which standards to choose, how to use and customize the standards to suit the country context. Health Information standard implementation takes time and investment, and the interoperability benefit will not prevail until the majority adopt the standards. Unfortunately, this capacity and

investment are usually lacking in the Lower and Middle Income Countries (LMICs). The commitment from all stakeholders, the development and establishment of good governing body, and having a clear roadmap for which standards to use/implement to be interoperable in healthcare system are also of importance. There is no silver bullet or the best answer of how LMICs should do to make the system interoperable and to implement health information standards.

Figure 9 : Variety of electric plugs and sockets



However, having knowledge of the country eHealth current situation, learning from other country experiences and working together among LMICs through networking will help. In Asia, a group of health IT/eHealth professionals from South and Southeast Asia countries have formed an Health IT/eHealth peer to peer and learning network, called Asia eHealth Information Network (AeHIN).[22] The AeHIN composes of members from Ministry of Health, academe, non-governmental organization and international development partners such as WHO, Asian Development Bank (ADB), United Nations Children's Emergency Fund (UNICEF), Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ) etc. It promotes better use of ICT to achieve better health through peer-to-peer assistance and knowledge sharing and learning through a regional approach. The network works on eHealth governance, enterprise architecture, and standards and interoperability within and across countries.

AN OVERVIEW OF THAI HEALTH INFORMATION STANDARDS DEVELOPMENT CENTER (THIS)

Health System Research Institute (HSRI), an autonomous state agency under the auspices of Ministry of Public Health (MoPH). Its mission is to research and develop health systems knowledge in Thailand, recognizes the challenges of national HIS and HIT development in Thai health systems. Recent research on HIS/eHealth situation in Thailand(2) shows that the country inadequately developed health information standards. In addition, there were other factors hindering the development of integrated HIS in Thailand which includes:

- The lack of a central/fundamental mechanism to determine standards and policies for national health information
- The lack of personnel in the development of health information systems and health information standards.
- The lack of awareness on the need for and benefits of national health data standards

In order to address those challenges, the executive board of HSRI, chaired by the Minister of MoPH, concluded a resolution in April 2012 to research the development of standards for health information systems. On July 31, 2012, THIS was established under HSRI.[23]

THAI HEALTH INFORMATION STANDARDS DEVELOPMENT CENTER (THIS)

THIS is an organization affiliated with HSRI. The center was established to research and develop health information standards toward the aim of achieving interoperability across health information systems in Thailand. The vision, mission and objectives of THIS are described as follows:

Vision: Thailand has national health information standards which enable seamless health information exchanges for better health care of Thai people. The standards are accepted and adopted by all Thai health system stakeholders and are compatible with international standards.

Mission: To develop and facilitate the development of Thailand health information standards in order to achieve health information systems interoperability with the ultimate goal of better health care.

Objectives:

- To develop and facilitate the development of national standards of health information system, that can be exchanged at all levels
- To develop standard health information systems guidelines for the stakeholders
- To encourage and support the knowledge creation and knowledge management and continuous development of human resources in Biomedical and Health Informatics and Health Information Systems
- To establish and expand knowledge network of HIS, HIT and eHealth with stakeholders at both domestic and international level.

THAILAND HEALTH INFORMATION STANDARDS DEVELOPMENT

1.THE SITUATION IN 2013

At the national level, the Thai Ministry of Interior (Mol) has developed and implemented a computerized civil registration system including components for individual citizen and household identifying systems since 1982. Every individual citizen is assigned a unique identification number which is known as the 13-digit number. The citizen ID has been used to identify an individual when the person transacts with both public and private organizations including healthcare organizations.(24) The Ministry of Public Health in Thailand has developed, adopted and implemented several health data standards. Most of these standards serve administrative purposes. We had adopted ICD 10 since its inception, more than a decade ago, and modified and extended the WHO ICD 10 international to ICD 10 TM (Thai Modification).(25) The main use is for public health reports and reimbursements. The ICD10 -TM and ICD9-CM (Clinical Modification) are used for coding diagnosis and health service intervention respectively. DRG has been developed since 1992 as a financing tool for prospective payment systems. It progressively evolved and has been widely used for acute care in-patient reimbursement since 2002. (20) The Ministry of Public Health also developed and maintained health facility registry and identification code (health facility IDs).(25)

There are two national health minimal standard data set which are developed for administrative purposes. They are 1) standard data set for health insurance, known as the 12-file data set and 2) standard data set for health center, known as the 18-file data set. They are used mainly for health insurance payments and healthcare activities reports respectively.(2,26) [Table 1]

Table 1 : Thailand health data standards in 2013

Standard Type	National Standards
Core data set standards	Minimal data sets for insurance process, Health center activities reports
Semantic standards	ICD 10 TM, ICD 9 CM Citizen IDs, Facility IDs
Syntactic standards	-
Security and privacy standards	-

2. CURRENT DEVELOPMENT

Informed by the study of current available health data standards and the country needs of integrated interoperable health information systems (2), THIS has proposed the health data standards development plan that the country should take. The plan aims to support and enable both administrative (insurance reimbursement and population health report) and clinical (healthcare services) information exchange. Standard data set for patient health summary to serve information exchange in the transition of healthcare services is considered the priority. As for semantic standards, THIS identified the country's urgent need for developing medicine terminology standards and clinical laboratory data standards because information about drug and laboratory investigation utilization provides a large value for both clinical care and healthcare expenditure management. In addition, THIS also proposed that standard clinical terminology, SNOMED CT, which is more expressive than ICD and essential for clinical care, should be studied and considered for implementation in the near future.

Since there is no syntactic data standards adopted at the national level, a selected international syntactic data standard is proposed. They are HL7 messaging standard, HL7 CDA standard and DICOM standard. Ministry of Information and Communication Technology (MICT) is the center of the security and privacy data standards development in Thailand. THIS has been actively involved and participated in the development with the ministry. [Table 2]

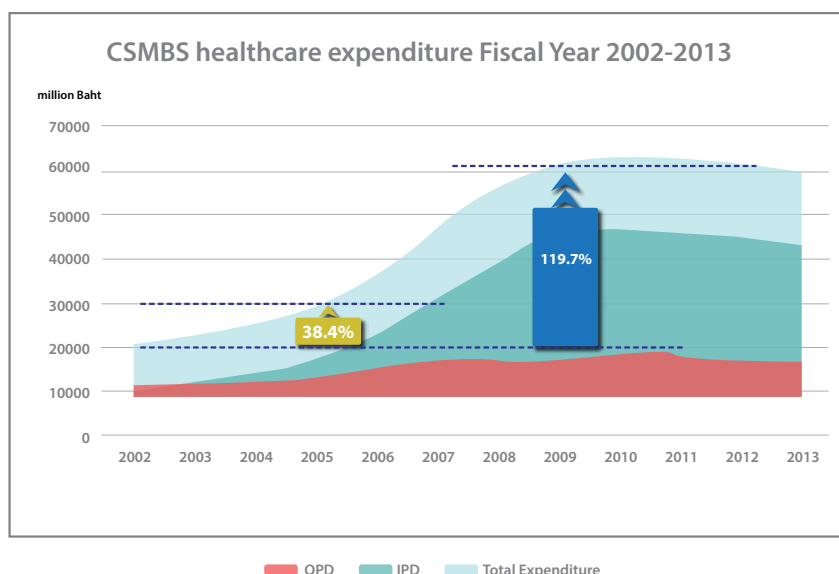
Table 2: Health data and information standards which THIS proposed that Thailand should develop in its five years plan

Standard Type	National Standards
Core data set standards	Patient healthcare summary
Semantic standards	Medicines Terminology Standard : TMT Laboratory standard : LOINC SNOMED CT
Syntactic standards	HL7 Messaging, HL 7 CDA DICOM
Security and privacy standards	(Follow MICT standards)

In 2013, THIS started the development of a national drug code project in response to the request from the Comptroller General's Department (CGD), Ministry of Finance (MoF). The CGD is responsible for the Civil Servant Medical Beneficiary Insurance Scheme (CSMBS) which covers around 4.5 million beneficiaries who are governmental officers and their immediate family members.(27) The insurance scheme faces rapidly increasing healthcare costs. [Figure 10] The cost data shows that almost 80% of out-patient healthcare services expenditure is from drug utilization.(28) The CGD needs a Monitor and Evaluation (M&E) mechanism especially information regarding drug utilization in

order to contain the budget costs. However, there is no national coding standard for drugs that can track the detailed drug utilization by healthcare providers. As a result, THIS was funded by the CGD to research and develop national drug coding system for M&E. This led to the development of the TMT.

Figure 10 : Rapid increasing of Civil Servant Medical Benefit Scheme (CSMBS) expenditure in the past 10 years



OPD= Out-Patient Department service expenditure, IPD = In-Patient Department service expenditure

THAI MEDICINES TERMINOLOGY (TMT)

Thailand did not have national drug coding system which can be used to serve multiple purposes, such as: clinical care functions, drug utilization, drug monitoring, drug interaction, and especially healthcare service reimbursement for Thai three main insurance schemes. The government recognized the situation which lead to forming of a committee to develop a national drug coding system in 2013.[29] The committee assigned THIS to be a secretariat in working group. The working group consisted of physicians, pharmacists, health/biomedical informaticians and computer engineers. The working group studied and reviewed the current drug coding systems in Thailand and drug terminologies used in other developed countries.[30]

THIS has set up principles for health information standards development, which are;

1. Develop health information standards that can be used with many functions in the healthcare systems.

2. Take into account Thai healthcare context in the standards development process.
3. Don't reinvent the wheel; the standards should be built on a country's previous works.
4. Comply with international standards.

There are several drug or coding systems being used and proposed for use in Thai healthcare systems. The drug product registration numbers, created by Thai Food and Drug Administration (FDA) MoPH, is mainly used for controlling and monitoring drug trading. Another MOPH's drug coding system, called "24-digit drug code", was developed by a group of public hospital pharmacists in MOPH. The 24-digit drug code was designed to identify pharmaceutical products for the purpose of drug inventory and utilization management in MOPH hospitals.[31] However, it carries several limitations. The major weaknesses of 24-digit drug code, mentioned in the "Desiderata for Controlled Medical Vocabularies", [32] are 1) the code system cannot uniquely identify pharmaceutical products, 2) the drug terms are not standardized, and 3) the identifier contains meaning which lead to increase in digit when the additional information are needed.

Global Standard 1 (GS1) Thailand, under the Federation of Thai Industries and the LogHealth, healthcare supply chain excellence center in Mahidol University, proposed that the Global Trade Identification Number (GTIN) should be used to identify pharmaceutical products for the Thai healthcare community.[33,34] The GTIN is a unique 14-digit number used to identify trade items, products, or services. Although, the GS1 is one of the popular international standards, its main use is in logistic and supply chain management.[35] Currently, the utilization of GTINs in healthcare is still evolving. However, GS1 scope does not include some essential pharmaceutical information e.g. active ingredient, dosage form, and strength, which are important for the use in clinical care settings.

The drug terminologies from five developed countries were studied. They are Australian Medicines Terminology (AMT) in Australia,[36] Dictionary of Medicines and Devices (dm+d) in the United Kingdom,[37] National Drug Code, and RxNorm in the United State of America,[38, 39] Hong Kong Medication Terminology Table (HKMTT) in Hong Kong, and Singapore Drug Dictionary (SDD) in Singapore. The AMT, dm+d, HKMTT and SDD are SNOMED CT extension, which are used for identification their pharmaceutical product. Furthermore, the SNOMED CT, a concept-based terminology, is the desirable terminology for exchange of clinical information and good for administrative information systems.

As mention above, THIS developed the national drug coding system called TMT. The concept-based terminology model is applied for TMT development. TMT is not only designed for reimbursement and administrative purposes, but also can be used in multi-dimension such as, drug inventory and logistics, drug prescription and dispensing, and drug interaction etc. Using TMT for drug identification and drug information exchange in clinical information systems and EHR is the ultimate goal.

1. WHAT IS TMT?

TMT is Thai national drug codes and descriptions of medicinal products (both generic and trade products) that are used in Thai healthcare systems. The development of TMT follows international standard, SNOMED CT concept model. TMT is a uniquely and unambiguously code and medicinal product term. It uses a set of medicinal products property which includes active ingredients (substances), dosage form, strength, unit of use, product package and manufacturer. It also contains information about the relationships between the properties. TMT consistently identifies brand and generic medicinal products.

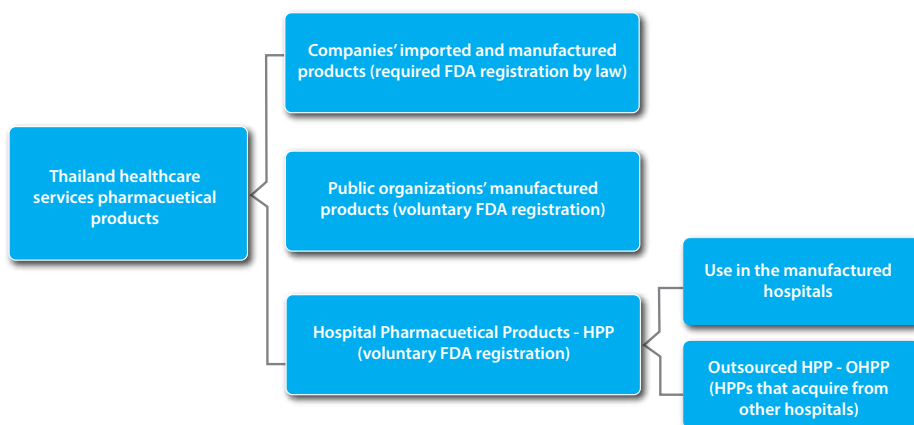
The key objective of TMT is to provide a consistent identification and naming of medicines which can support medicines management and activity across Thailand's healthcare system. TMT is primarily designed to enable interoperability between applications and computers by providing a set of codes and standard descriptions of medicines.

2. THE SCOPE OF TMT

TMT intends to cover all pharmaceutical products that are available in the market for treating patient in Thai healthcare services. the pharmaceutical products can be categorized into two groups that follow Thai FDA registration [Figure 11],

1. Pharmaceutical products that are required by law to register with Thai FDA. Medicinal products which are manufactured and imported by pharmaceutical companies to be traded and used in Thailand.
2. Pharmaceutical products that do not require by law to register with Thai FDA. Medicinal products which are manufactured by the Government Pharmaceutical Organization (GPO), the Defense Pharmaceutical Factory, the Thai Red Cross Society and hospitals (for internal use) are exempted from registration.

Figure 11 : TMT covers pharmaceutical products for human use in Thailand healthcare services



TMT standardizes terms and attributes describe pharmaceutical products and its related-concepts. The terms and attributes are:

1. Active ingredient: Use WHO International Nonproprietary Names (INN)[40] for standardizing active ingredient terms.
2. Dosage form: Use European Directorate for the Quality of Medicine & Health Care (EDQM) [41] for standardizing terms of dosage form.
3. Strength and unit of measure: These two attributes follow the SNOMED CT standard.
4. Manufacture: Manufacturer names and codes are derived from Thai FDA products' registry and the MOPH's healthcare facility's registry.

There is a wide range of knowledge about medicines that is not included in this medicines terminology. These information are provided by other knowledge resources, which can be linked to TMT. The examples of information that can be retrieved which are not under the scope of TMT include, but are not limited to:

- Adverse effects
- Cautionary and advisory label recommendations
- Contraindications
- Counselling instructions
- Dose checking
- Drug: Allergy interactions
- Drug: Drug interactions
- Drug: Food interactions
- Indications
- Normal dose ranges
- Physiological equivalence
- Precautions for use
- Storage or supply chain related information

3. TMT MODEL

TMT is a concept-based terminology. It follows the general desiderata for controlled vocabularies which was described in the paper "Desiderata for Controlled Medical Vocabularies in the Twenty-First Century" [32] The desiderata are:

- **Vocabulary Content:** The terminology needs to be comprehensive in terms of both domain coverage (concepts) and human-readable terms (descriptions and synonyms).
- **Concept Orientation:** Each concept has one meaning (non-vagueness), and only one meaning (non-ambiguity)
- **Concept Permanence:** Once a concept is created its meaning is persistent. However, a concept may be marked as retired if its meaning is found to be ambiguous, redundant, or incorrect.
- **Nonsemantic Concept Identifiers:** Each concept has a unique identifier, which should be meaningless.
- **Polyhierarchy:** The clinical concepts are naturally multidimensional, need more than one super-type (parent) concept.

- **Formal Definitions:** The definitions need to be structured and controlled. The means of classifying a concept is independent of the means of identifying it.
- **Rejection of “Not Elsewhere Classified” Terms:** No one or more catch-all categories for concepts not covered.
- **Multiple Granularities:** Different users require different levels of granularity. Different levels of granularity are needed for defining concepts, navigation, decision support, and reporting.
- **Multiple Consistent Views:** When a concept has multiple hierarchical parents, the view of that concept should not depend on whether it was reached by following the hierarchy from a particular parent.
- **Context Representation:** Information is usually recorded in a particular context and cannot be interpreted without that understanding. The context needs to be computer process able. One approach is to provide a means of recording context explicitly within the terminology.
- **Graceful Evolution:** Terminologies change over time. Care is needed to design the whole structure to support graceful evolution of concepts, terms, and relationships.
- **Recognize Redundancy:** When terminologies change, it is important to recognize explicitly that some components will become redundant.

The TMT model is composed of eight notable concepts (levels) and each concept represents and serves for different purposes.[Figure 12] Each concept is identified by a TMTID (TMT code), which is a unique number without any meaning attached to any part of the code. The definition of the notable concepts is shown in Table 3. Furthermore, each concept are linked to other concepts in different levels by relationships which allow users to work effectively for different purposes, for example; drug prescribing, drug dispensing, and drug utilization analysis.

The concept item composes of standard and unique descriptionn called Fully Specified Name (FSN) and its identifier, the TMTID. TMTID is a set of numeric digits which has two parts. The first part is a serial number which has no meaning. The second part, the last digit, is the check digit¹. The “Verhoeff check” algorithm is used to generate the check digit (between 0-9).[42] Figure 13 shows a sample pharmaceutical product FSNs, TMTIDs and relationship of TMT notable concepts.

¹ A check digit is a form of redundancy check used for error detection on identification numbers (e.g. bank account numbers) which have been input manually. It is analogous to a binary parity bit used to check for errors in computer-generated data. It consists of a single digit (sometimes more than one) computed by an algorithm from the other digits (or letters) in the sequence input.[From: https://en.wikipedia.org/wiki/Check_digit Access: January 23, 2016]

Table 3: Eight notable concepts of the TMT model

Concept	Description
Substance (SUBS)	SUBS represents active ingredient.
Virtual Therapeutic Moiety (VTM)	VTM represents one or combination of active ingredients used to produce medicine.
Generic Product (GP)	GP is a subtype of VTM that contain VTM with additional information of strength and dosage form.
Trade Product (TP)	TP is a subtype of GP that contain GP with additional information of trade name and manufacturer.
Generic Product Use (GPU)	GPU is a subtype of GP that contain GP with additional information of unit of use and product content.
Trade Product Use (TPU)	TPU is a subtype of TP and GPU.
Generic Product Pack (GPP)	GPP is a subtype of GP that contain GPU with additional information of pack size and pack unit.
Trade Product Pack (TPP)	TPP is a subtype of TPU and GPP.

Figure 12 : Relationships between concepts in Thai Medicines Terminology (TMT) data model

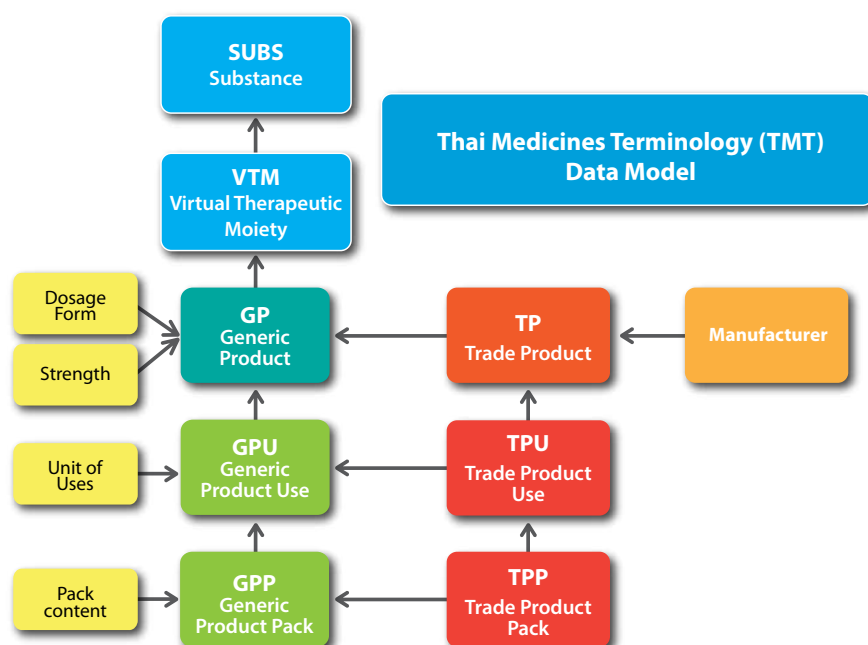
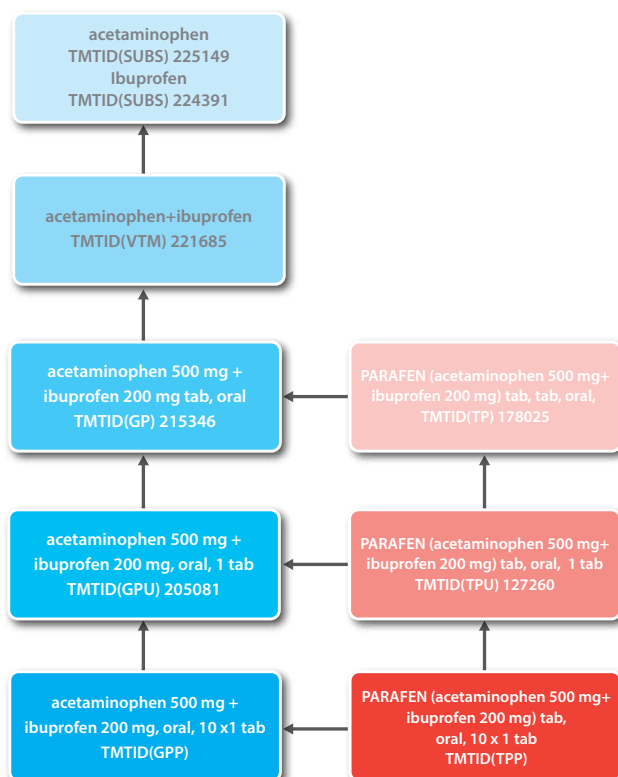


Figure 13 : Sample showing the relationship of TMT notable concepts, TMTIDs and FSNs of a trade product



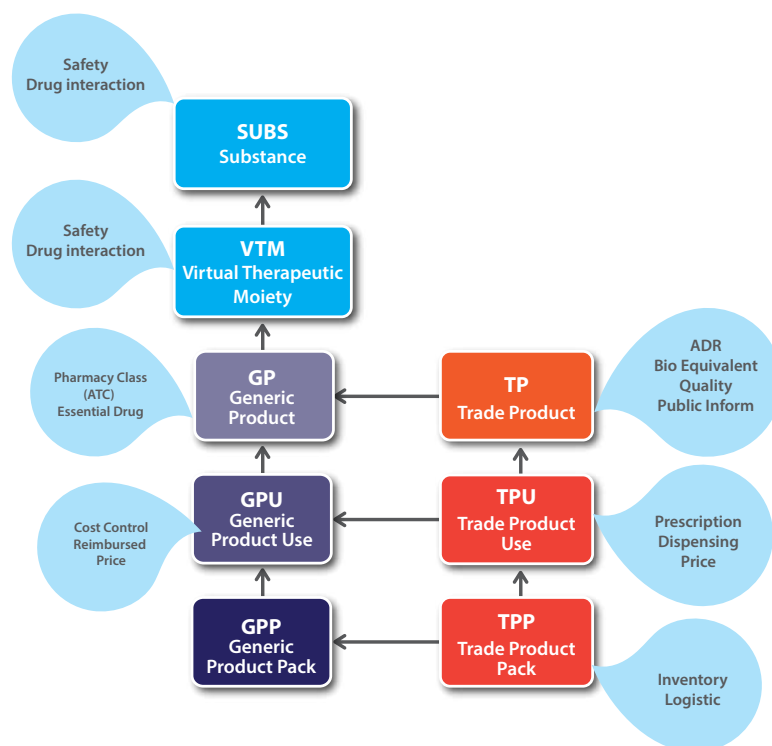
4. BENEFIT OF TMT

TMT follows the methodology and references that SNOMED CT used. By using international terminology standards, TMT is benefit for the pharmacy information exchange in Thailand and other countries that use SNOMED CT in their health information systems.

TMT is designed to be used across health information systems and applications to achieve semantic interoperability. [Figure 14]

- TMT can be used in pharmacy management information systems such as drug prescription, drug dispensing, drug administration, adverse drug reaction, and drug inventory.
- TMT can be used to support clinical and management decision support system.
- TMT helps the interoperability in different Electronic Medical Records (EMR) within and between organizations.

Figure 14 : TMT is designed to be used across clinical and administrative information systems



5. MAINTENANCE AND INFORMATION SERVICES OF THE TMT

Standards are not static. They need maintenance mechanisms to keep up with changes that happen over time. The cycle of updating standards depends on how fast the information change. As informed by Thai FDA internal reports, every month there are around a hundred new drugs registered and a hundred registered products are no longer valid; TMT is updated twice a month. We release an update on the first and the third Monday monthly.[43] The main purpose of the regular maintenance is to ensure all the TMT codes and terms are up-to-date and reliable. We get the new registered drugs and outdated registered drugs information from Thai FDA every month and receive request for TMTID of new products from pharmaceutical companies and hospitals every day.

TMT maintenance services accept requests from stakeholders and provides question and answer services via phone calls and email on working day. In addition, we send out TMT update notification emails to TMT users who are registered for the services. We publish the new release at the THIS website (http://this.or.th/tmt_download.php) and it is free of charge. Email and social media like Facebook are used to receive feedback and exchange knowledge among users and developers.

6. THE ADOPTION OF THE TMT

Currently, TMT is used mostly in healthcare information systems. Healthcare insurance schemes and healthcare providers are adopting TMT in their electronic claim information systems. The newly implemented electronic governmental procurement system (eGP) adopts TMT for specifying generic and trade pharmaceutical products in the government centralized e-procurement information system.^[44]

TMT is designated to be the coding standard of pharmaceutical products that health care providers have to use when they submit electronic claim data to the Comptroller General Department's CSMBS reimbursement system. Every outpatient CSMBS prescriptions, which are reimbursed by Fee for Service (FFS) payment model, have to encode the sale drug items with the TMT code. With this implementation, CGD has information about the utilization and price of each individual drug which in the past was not known. Previously, health providers submitted only total amount of each prescription charge.

The eGP information systems, which operates under the CGD, has mandated all government buyers that purchase medicinal products with e-bidding process. The buyer have to specify the products they wanted to buy using the GPU code. Each GPU has many trade product codes, the TPU code link to it. Each specific trade product of the sellers has one TPU code. With this implementation, the CGD will be able to analyze the amount and price of each drug that is purchased by government buyers across the country.

In March 2015, the Electronic Transactions Commission, Ministry of Information and Communication Technology of Thailand declared that TMT is the national drug terminology standard for electronic transaction in health sector. The commission encourages all parties, both public and private, to use TMT in their healthcare service and healthcare business electronic transaction.^[45]

TMT is designed to support not only administrative information systems, but also clinical information systems such as Computerized Provider Order Entry (CPOE) systems, medication management systems and has potential to be used in clinical decision support systems. However, it is still in the early phase of implementing TMT in such systems.

7. TMT AND OTHER INTERNATIONAL DRUG CODING SYSTEMS

7.1. ATC and TMT

Anatomical Therapeutic Chemical (ATC) is the medicinal product classification system which is to serve as a tool for drug utilization research in order to improve quality of drug use. It was developed and maintained by WHO Collaborating Centre (WHOCC) for Drug Statistics Methodology, Norwegian Institute of Public Health. WHO recommended ATC

for use in pharmacy related information systems such as drug utilization and analysis of drugs adverse among patient groups. ATC classifies medicinal products using three dimensions: anatomical (organ systems), therapeutic quality and chemical quality of the drug.(46) However, ATC code cannot uniquely identify medicinal products at both generic and trade level. The ATC is included in some international drug catalogs e.g. Martindale, European Drug Index, Australia drug catalogs. TMT can maximize the analysis of drug utilization by integrating data with ATC. When TMT is mapped to ATC code, it allows the TMT concept to recognize ATC information to improve healthcare utilization analysis. THIS provides the mapping file of TMT to ATC.

7.2. GS-1 standard and TMT

GS-1 standard is a global standard to identify the trade product for product traceability in supply chains. GS-1 provides and controls the GTIN and barcode of trade products and services. Though GS-1 standard can recognize the product in the supply chain workflow because some essential pharmaceutical information are not available. by tracking GTIN, it cannot be served in clinical workflow because some essential pharmaceutical information are not available. Data about medicinal products in GS-1 system is focused on the data needed for supply chain processes e.g. drug manufacturing lot number, product expiry date, drug storing temperature etc. (35) Linking GTIN with TMT will serve in both supply chain and clinical processes. TMT can be mapped to GTIN at product pack level which allow traceability between drug supply chain process and drug use in clinical workflow. The linkage can improve the precision and accuracy of information chains through the drug cycle. However, these characteristics are still under study research and development platform to interoperate between TMT and GTIN.

7.3. SNOMED CT and TMT

SNOMED CT is a standardized clinical terminology for the electronic exchange of clinical health information. SNOMED CT is the most comprehensive and precise clinical health terminology in the world, owned and distributed around the world by IHTSDO. (19) Medicinal product terminologies are represented in the substance and biological/ pharmaceutical product hierarchies out of 19 SNOMED CT hierarchies. Medicinal product concepts are specified at the GP. TMT extends medicinal product concepts to the level of trade products, which are used in the Thai healthcare service. TMT can be considered a local SNOMED CT extension of pharmacy terminology subset.

LOGICAL OBSERVATION IDENTIFIERS NAMES AND CODES (LOINC) IN THAILAND

1. GENERAL INFORMATION ABOUT LOINC

LOINC is a terminology standard that has been developed by The Regenstrief Institute, Indianapolis in the United States of America. It is a universal names and codes system for encoding clinical observation and medical laboratory and is broadly used in more than 160 countries with no license fee.[18]

LOINC facilitates exchange and pooling of results such as blood hemoglobin, serum potassium, or vital signs, for clinical care, outcomes management, and research from multiple sites. When hospitals, health organizations, pharmaceutical manufacturers, researchers, and public health departments receive such messages, they can automatically file the results in to their medical records, research, and/or public health systems correctly. By using LOINC, different Laboratory Information Systems (LIS) can be interoperated.

LOINC version 2.52 released on July 2015 contains 76,266 terms, which can be divided into four categories as shown in Table 4.

Table 4: Four categories of LOINC terms and codes

Class type	Example class
Laboratory	Laboratory section e.g. chemistry, hematology, serology, microbiology, toxicology
Clinical	Clinical observation section e.g. vital signs, hemodynamic, intake/output, EKG, obstetric ultrasound, cardiac echo
Attachment	Claim attachments includes the clinical and administrative information often necessary to adjudicate claims for ambulance, rehabilitation, or emergency room services
Survey	Survey instruments

LOINC consists of two parts, namely, code and name. The LOINC codes are serial numbers with a check digit. The LOINC name refers to a single test item, which includes six core name parts (axes). The six core name parts are shown in Table 5.

Table 5: LOINC six core name parts

Axis	Sub part	Example
Component	Principal name of analyte	Glucose, Calcium
	Information about challenge	1H post 100 g glucose PO
	Standardization or adjustment	Adjusted to pH 7.4
Property		Mass, Number, Volume, Mass Concentration, Substance Concentration
Time		Point in time vs. time interval
System	Sample	Blood, Urine, CSF, Tissue
	Super system (indicate the source of sample that doesn't collect from patient directly)	Blood from blood product unit, Blood from donor, Cord blood from fetus
Scale		Nominal, Ordinal, Quantitative, Narrative
Method		EIA, Culture, Probe (where necessary)

Each LOINC name contains at least five axes except method, which is only required when necessary. LOINC FSN is a unique name to specify laboratory and clinical observation. It can be written by using six axes of LOINC including Component, Property, Time, System, Scale, and Method and each axis is separated by a colon (:). In addition, LOINC provides the human readable term, LOINC Long Common Name, as FSN cannot be read easily by healthcare personnel. The examples of LOINC FSN, and Long Common Name are shown in Table 6.

Table 6: Examples of LOINC terms

LOINC	NAME	Description
2160-0	LOINC FSN	Creatinine : MCnc : Pt : Ser/Plas : Qn
	LOINC Long Common Name	Creatinine [Mass/Volume] in Serum or Plasma
718-7	LOINC FSN	Hemoglobin : MCnc : Pt : Bld : Qn
	LOINC Long Common Name	Hemoglobin [Mass/Volume] in Blood
5803-2	LOINC FSN	pH : LsCnc : Pt : Urine : Qn : Test strip
	LOINC Long Common Name	pH of Urine by Test strip

The advantages of LOINC are as follows:

- Well-designed; LOINC is designed to uniquely identify laboratory and clinical observation.
- Coverage; LOINC contains 76,266 terms covering more than 95% of laboratory tests worldwide.
- Widely acceptable; more than 160 countries use LOINC in their healthcare systems.
- Maintenance; the Regenstrief Institute develops, maintains, and updates LOINC twice a year.
- Free of charge; LOINC materials are registered under United States trademarks of Regenstrief Institute, Inc.

Regenstrief Institute has provided a tool called Regenstrief LOINC Mapping Assistant (RELMA) for mapping between local laboratory and clinical observation tests to LOINC terms.^[47] The RELMA facilitates users to convert their local test into LOINC and allows their systems to interoperate with other systems while supporting international standards such as HL7 and SNOMED CT.

2. FEASIBILITY OF ADOPTING LOINC FOR THAILAND HEALTHCARE SYSTEM

Thailand does not have national standard terms and a coding system to identify clinical investigations such as clinical laboratory tests. Each hospital uses their own local codes to identify their laboratory test in hospital information systems. There is investigation test list, composed of; test name, code, and price announced by CGD, which is commonly known as “CGD laboratory test list”. It is used for the CSMBS reimbursement system at national level. However, it cannot be used in clinical care context because the terms are not standardized, non-comprehensive and less specific for patient care. THIS had identified this gap and started to explore the possibility of adopting LOINC for both clinical and administrative use in Thai healthcare information systems in 2012.^[48]

In 2014, we studied a clinical laboratory test lists from selected hospitals and two large institutes. The hospitals are university hospitals which provide super tertiary healthcare services (Chulalongkorn University Hospital, Siriraj hospital and Ramathibodi hospitals, Mahidol University), hospitals in Buriram province, which provide primary and secondary healthcare services. The two institutes are Department of Medical Sciences, Ministry of Public Health (DMSC), which provide special laboratory test services, and CGD. Our assumption is the lists should cover all the laboratory tests available in Thailand thus represent all levels of healthcare.

Researchers from THIS mapped the Thai local laboratory test items from the above facilities with LOINC (version 2.48) using RELMA program (version 6.6) released on June 2014. The mapping results are categorized into three types^[49,50] :

- One-to-one map: one local laboratory test can be mapped with one LOINC code.
- One-to-many map: one local laboratory test can be mapped with more than one LOINC code.
- Unmapped: no appropriate LOINC code for local laboratory test.

The mapping type in each institution varied depending on the data structure stored in their LIS. The percentage coverage of LOINC is shown in Table 7.

The mapping results of laboratory test lists from multiple healthcare institutions suggested that LOINC covers local tests ranging from 50.44% to 95.99%. Most of the mapping types are one-to-many because LOINC is more precise in indicating the laboratory test than the local codes.

Overall, around 50% to 96% of the local laboratory tests can be mapped to LOINC codes. The mapped results revealed the substantial disparity of available tests and comprehensiveness of laboratory details among the healthcare institutes. The high percentage of mapped results indicates that LOINC standard is feasible for use in the Thai healthcare setting.

Table 7 : Mapping results of local test in different institutes

INSTITUTE	MAPPING TYPE			
	one-to-one	one-to-many	unmapped	total
Siriraj Hospital	649 (37.32%)	415 (23.86%)	675 (38.82%)	1,739 (100.00%)
Ramathibodi Hospital	5,263 (36.47%)	2,016 (13.97%)	7,154 (49.56%)	14,433 (100.00%)
Chulalongkorn Hospital	144 (37.21%)	219 (56.59%)	24 (6.20%)	387 (100.00%)
DMSC	38 (24.52%)	91 (58.71%)	26 (16.77%)	155 (100.00%)
CGD	75 (12.52%)	500 (83.47%)	24 (4.01%)	599 (100.00%)
Buriram province Hospitals	160 (26.89%)	404 (67.90%)	31 (5.21%)	595 (100.00%)

As mentioned previously, the mapping type can be classified into three categories: one-to-one, one-to-many and unmapped. One-to-one mapping specifies the local laboratory test having necessary details (six axes) for the mapper to identify the LOINC code. The example is shown in Table 8.

Table 8 : Examples of one-to-one mapping

LOCAL TEST NAME	LOINC	INSTITUT LOINC LONG COMMON NAME
PRC	51879-5	Transfuse packed erythrocytes units [#]
Lipase (LPS)	3040-3	Lipase [Enzymatic activity/volume] in Serum or Plasma

One-to-many mapping specifies that LOINC has higher granularity than local laboratory test, i.e., LOINC code contains six elements of laboratory details while local tests only contain 2-5 elements in specifying unique lab tests. One-to-many mapping example is shown in Table 9.

Table 9 : Examples of one-to-many mapping

LOCAL TEST NAME	LOINC	LOINC LONG COMMON NAME
RH. (D) Typing- Tube Method	1305-2	D Ag [Presence] in Blood
	978-7	D Ag [Presence] on Red Blood Cells
	976-1	D Ag [Presence] on Red Blood Cells from Blood product unit
	977-9	D Ag [Presence] on Red Blood Cells from donor
Specific gravity	53326-5	Specific gravity of Urine by Automated test strip
	5810-7	Specific gravity of Urine by Refractometry
	50562-8	Specific gravity of Urine by Refractometry automated
	5811-5	Specific gravity of Urine by Test strip

For the unmapped result, it specifies that local laboratory test does not match with any LOINC code. The unmapped test can be categorized into four certain types

- Not enough laboratory detail; the tests that do not have enough information of axes for mapping with LOINC Code
- Not a laboratory test; the local (test) names in LIS are not laboratory tests
- Out of scope of LOINC; the tests that are not under LOINC scope
- Cannot find in LOINC; the tests that do not exist in LOINC database, but within LOINC scope mentioned in LOINC guidebook.

The example of each unmapped types are shown in Table 10.

More than half of unmapped tests fell into the following two categories: “not a laboratory group” and “out of LOINC scope”. This is because the hospitals’ LIS was designed to include those local (test) names for their routine work flow, but the names were not laboratory tests.

Table 10 : Examples of unmapped mapping type

TYPE	LOCAL CODE	LOCAL TEST NAME
Not enough laboratory detail	650373	Fungus culture ; Left
	653A05	KOH Right upper anterior arm
Not a laboratory test	550505	Specimen problem
	700000	Send to wrong lab
Out of scope of LOINC	T010	Biopsy (2-5cm)
	38002	Biopsy 2-5 cm 1 bottle
Cannot find in LOINC	250071	CBC + Malaria profile in EDTA blood
	801040	Carbamate in Gastric Lavage

CONCLUSIONS AND RECOMMENDATIONS

This report has attempted to provide fundamental knowledge of health information standards and interoperability and also to explore and review the development, adoption and use of health information standards in Thailand. Interoperability of different health information systems is one of the major challenges for countries to develop functional, integrated and effective health information systems.[8] It is evident that the lack of uniform data standards will lead to information fragmentation. Interoperability of information systems needs the whole stack of standards which include content, syntactic, semantic and security standards.

Thailand has developed, adopted and implemented some health data standards such as the citizen ID system, the health provider facility ID system, standard data sets for reporting and insurance reimbursement systems, and the ICD. However, the current standards are not adequate. To support information exchange of administrative and clinical data, and EHR, Thailand needs more health data standards. The demands of containing healthcare costs by the government lead to the development of health data standards that can identify healthcare resources and analyze their utilization. THIS responds to the demands by researching and developing semantic data standards, the TMT and LOINC, which can support the administrative functions and also health information exchange for clinical and quality of care. Thai Medicines Terminology is the concept-base terminology which can be considered as SNOMED CT extension of the pharmaceutical products in Thailand. TMT is currently implemented in insurance reimbursement information systems and the government e-procurement information system. LOINC, a widely use international standard, has been studied to explore the plausibility for adopting the standard in Thai healthcare service context. The study shows that LOINC can be used and should be adopted in Thailand. The development of TMT and adoption of LOINC will facilitate electronic health record interoperability in Thailand.

Though health informatics professionals in Thailand have encouraged the adoption of health data standards, there are barriers such as lack of human resources in health informatics, and lack of awareness and unfamiliarity with the potential benefits of using standards and terminologies in healthcare among high level policy makers and healthcare professionals. With these barriers in mind, we recommend the following steps for the development of health information standards in Thailand:

- Governance and leadership of national eHealth systems are essential and critical for country to achieve interoperability through health data standards.
- Incentives and mandates from the governing body that has authority are important to the adoption of standards.
- Standards maintenance process is a necessary component of successful implementation of every standard.
- Advocacy on the potential benefits from using data standards as well as communication between the organizations and the users are of importance.
- Human resource in health informatics is an important component and building capacity for them is essential.

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NOTES

This image shows a full page of white paper with horizontal dashed lines, typical of primary school handwriting practice paper. The lines are evenly spaced and run across the entire width of the page. There are no margins, text, or other markings present.

“**eHealth in Thailand: interoperability and health information standards** represents the experiences of THIS on research and development of health data standards in Thailand. It is also designed to help the readers to understand the rationale behind, to share experience in developing health data standards, and to assure that the work processes and data needs in health information exchanges are well understood. The target audiences of this report are health IT and healthcare professionals, health policy makers and people who are interested in health information systems and eHealth.”



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