# Analysis of HL7 EHRS Functional Model and Suggested Applications in China

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### Abstract

*HL7 electronic health record system (EHRS) functional model is an international standard which gives scientific instructions for EHRS design and implementation. It has the features of technological irrelevancy, requirement hierarchy and functional comprehensiveness. It is composed of overarching, care provision, care provision support, administrative support, population health support, record infrastructure and trusted infrastructure. This paper describes the functionalities of each section in detail. To apply this functional model, the history of Chinese health information system construction is reviewed and the weakness is analyzed as a basis. Then this paper gives suggestions on the construction of health information system in China: to enhance the functionality of healthcare systems, to enhance the information network function of regional health information network (RHIN), and to redesign the trust architecture of RHIN.*

### Keywords:

Electronic Health Records; Models, Theoretical; Suggestion

## Introduction

An Electronic Health Record (EHR) is a repository of information regarding the health status of a subject of care in computer processable form. Electronic Health Record System (EHRS) is a set of components that form the mechanism by which electronic health records are created, used, stored and retrieved, including people, data, rules and procedures, processing and storage devices, and communication and support facilities [1]. EHRS functional model (EHRS FM) defines a standard functionality list that presents in an EHRS [2]. As a core model, it determines the main functionality framework that an EHRS should have. At present, China is on the process of constructing interoperable population health information networks [3]. It is essential to get theoretical instructions from the EHRS FM. In this paper, we introduce the history and principles of HL7 (Health Level 7) EHRS FM, and describes the main content of HL7 EHRS FM Release 2 (R2) in detail. Then we review the history of Chinese health information system construction and analyze the weakness of this construction mode. Further, we give suggestions on applying EHRS FM to improve the health information system construction in China.

## HL7 EHRS FM

### History of HL7 EHRS FM

The research of HL7 EHRS FM can be traced back to April, 2003. It was sponsored by HL7 workgroup. In July 2004, it was approved as a draft standard for trial use. The HL7 EHRS FM R1 was released in February 2007 and became the ANSI standard. The HL7 EHRS FM R1.1 was released in November

2009 and was accepted as an international standard ISO/HL7 10781 [4]. In April 2014, the HL7 EHRS FM R2 was released. Compared with the previous edition, this edition made fundamental change by proposing an entirely new architecture of EHRS FM. It became the ISO standard in 2015 [5].

### Principles of HL7 EHRS FM

The principles of HL7 EHRS FM can be summarized as technologically irrelevancy, requirement hierarchy, and functional comprehensiveness.

#### Technologically Irrelevancy

With the development of information technology, new technologies emerge continously. The functionalities of EHRS are constantly implemented by new technology, but the functionality framework of EHRS is relatively stable. Therefore, one principle of EHRS FM is to separate the functional framework from its implementation. The technologically irrelevancy is realized by defining the scope and content of EHRS functionalities instead of the technological details of EHRS.

#### Requirement Hierarchy

Owing to the diversification of EHRS, the actual EHRS conforms to a specific functional profile which is a subset of the EHRS functional model. The conformance criteria have two levels: the required criteria and optional criteria. The required criteria are expressed by mandantory word *shall.* The optional criteria can be devided into two sub-levels. Suggested criteria are expressed by word *should.* Permit criteria are expressed by word *may.* Requirement hierarchy bring about the flexibility of EHRS FM. It can meet the needs of various application situations and adapt to various development stages of EHRS.

#### Functional Comprehensiveness

Unlike the functional model of common information systems, HL7 EHRS FM greatly extends the scope of EHRS functionalities. Especially in the arena of information network archietecture and trust architectue. It embodies the functional comprehensiveness of EHRS.

### Description of HL7 EHRS FM R2

Figure 1 shows the general structure of HL7 EHRS FM R2. It consists of 7 sections, which are Overarching (OV), Care Provision (CP), Care Provision Support (CPS), Administrative Support (AS), Population Health Support (POP), Record Infrastructure (RI) and Trusted Infrastructure (TI). Each section contains functionality list described by ID, type, name, statement, description and conformance criteria.
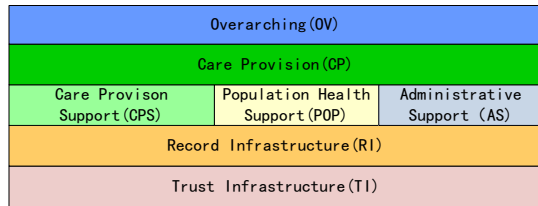
*Figure 1–The General Structure of HL7 EHRS FM R2*

### Overarching (OV)

The Overarching section contains conformance criteria that apply to all EHRS. There are 2 functionalities and 33 conformance criteria in this section, including health record report and output, record lifecycle manamgement, security management , terminology service and system management.

### Care Provision (CP)

This section contains functionalities and conformance criteria required to provide direct care to a specific patient and practice of healthcare. Organized in general flow of an encounter, these functionalities can be used as EHR supporting functionalities to various healthcare systems. There are 41 functionalities and 494 conformance criteria organized in 9 categories, which are managing clinical history, rendering externally-sourced information, managing clinical documentation, managing orders, managing results, managing medication/immunization/treatment administration, managing future care, managing patient education & communication, and managing care coordination and reporting.

### Care Provision Support (CPS)

This section contains functionalities that support the provision of care. It has 76 functionalities and 559 conformance criteria. They are classified into 10 categories as record management, supporting externally-sourced clinical documents, supporting clinical documentation, supporting orders, supporting for results, supporting treatment administration, supporting future care, supporting patient education and communication, supporting care coordination and reporting, and managing user help.

### Administration Support (AS)

The Administration Support section includes functionalities that provide support for the management of the clinical practice and give assistance to the administrative and financial operations, such as resource management, workflow, and communication with patients and healthcare providers. It also provides support for managing non-clinical administrative information on patients and providers. It has 55 functionalities and 249 conformance criteria. They are categorized as provider information management, patient demographics and location management and synchronization, personal health record (PHR) interaction management, communication management, clinical workflow tasking management, resource availability management, encounter/episode of care management, information access for supplemental use, and administrative transaction management.

### Population Health Support (POP)

This section includes functionalities for supporting public health management and disease prevention and control. It focuses on special group of people, such as chronical disease group, women, and children. These functionalities can support data aggregation for medical research, public health promotion, and improving the quality of care. Besides, this section also includes functionalities about protecting patient privacy and supporting patient consents for the secondary uses of medical records. There are 18 functionalities and 108 conformance criteria in this section. They belong to 10 categories: support for health maintenance/preventative care/wellness, support for population-based epidemiological investigation, support for notification and response, support for monitoring response notifications regarding a specific patient's health, support for donor management, measurement/analysis/research and reports, public health related updates, de-identified data request management, support for consistent healthcare management of patient groups or populations, and managing population health study related identifiers.

### Record Infrastructure (RI)

This section consists of functionalities about record management. It can be implemented within the architecture of a single system or across tightly-coupled systems. There are 37 functionalities (including subfunctionalities) and 186 conformance criteria organized in 3 categories, including record lifecycle and lifespan, record synchronization and record archive and restore.

### Trust Infrastructure (TI)

This section consists of functionalities related to EHRS trust infrastructure. These functionalities are fundamental to system operations, security, efficiency, data integrition, privacy/confidentiality and interoperability with other systems. There are 93 functionalities and 681 conformance criteria organized in 9 categories, including security, audit, registry and directory services, standard terminology and terminology services, standards-based interoperability, business rules management, workflow management, database backup and recovery, and system and performance management.

### Review of Chinese Health System Development

The Chinese government regard information technology as an important part of modern medicine. Health system construction is an essential part of health reform in China. The development of Chinese health information system can be divided into three stages, which are shown as below [6].

### Stage 1 - Application of Computer Software

This stage is featured as the application of single computer software, such as finance management and medicine management. In this period, computer software is used to replace artifical operation. It is independent and the power of information technology is not sufficiently revealed.

### Stage 2 - Construction of business systems

This stage is featured as the construction of various healthcare systems, such as hospital information system (HIS), community healthcare system, physical examination system, disease prevention and control system, and public health system. These systems realize the automatic process of information and increase work efficiency. Designed separately, they have simple data integration capability, and can only meet the needs of business activities.

### Stage 3 - Construction of Regional Health Information Network

In this stage, the Chinese government began to develop regional health information network (RHIN) based on EHR [7]. The goal of RHIN construction is to break up the barriers of isolated systems, integrate existing healthcare systems, realize the interoperability and coordination, promote the exchanging and deep mining/analysis of EHR data. Currently, China will build 4 levels of RHINs, which are the national RHIN, provincial RHIN, municipal RHIN and county RHIN [8]. The RHINs are based on EHR and take the responsibilities of the center of health data exchange and application.

**Weakness Analysis on Chinese Health System Construction**

For a long time, Chinese health system construction has been driven by pure information technology and investment. It can only meet the needs of a specific domain. This construction mode lacks of top-level design and theorical instructions, leading to a large number of isolated systems. To solve these problems, RHINs are built to create an infrastructure where health information can be shared, exchanged and analyzed. But a thorough integration is needed. That is, to apply HL7 EHRS FM to Chinese RHIN construction.

**Suggestions on Applying HL7 EHRS FM in China**

Broadly speaking, there are three suggestions on applying EHRS FM in China. They are shown as follows.

**Enhancing the Functionalities of Chinese Healthcare Systems by Means of the EHRS FM**

In the architecture of RHIN, the healthcare systems can only play a role of data provider. Their business functionalities are not enhanced by EHR. This leads to the functional stuffless of these systems. For example, a doctor cannot get the clinical history of patient when making a diagnosis. Therefore, it is needed to extend care provision, care provision support and administration support functionalities to hospital information systems and community healthcare systems. Meanwhile, it is needed to extend population health support functionalities to disease prevention and control/public health system. Table 1 gives the functionality list that can be applied to Chinese healthcare systems. It is noted that the existing functionalities of healthcare systems are not included.

*Table 1 – Functionalities Applied to Chinese Healthcare Systems*

| Healthcare systems | Applied Functionalities |
|---|---|
| Hospital Information System | Management of demographics, clinical history , external- source data, workflow, business rules, patient privacy, correspondence, doctor, finance and administration |
| Disease Prevention and Control/Public Health System | Health risk notification, epidemiological investigation, donor management, health assessment , process improvement, healthcare management |
| Community Healthcare System | Future care management, Patient education support |

**Enhancing the Information Network Functionalities of RHIN**

In China, the RHINs play a role of EHR data integration and exchange. But the systems to be connected are limited to HIS, disease prevention and control/public health system and community healthcare sytem. Only limited data types are supported by RHIN, such as structured data, documents and images. Compared with the EHRS FM R2, RHIN should extend the systems to be interfaced, such as physical examination systems or personal health record (PHR) systems. Secondly, the data types should also be extended to be compatible with medical instrument generated data. As an archive management center, the RHIN has EHR lifecycle manamement functionalities, such as creating archive, arranging archive, migrating archive, merge/split archive, final archive and archive maintenance. These archive functionalities should be extended as well. Table 2 shows the information network functionalities to be enhanced for RHIN in China.

*Table 2 – Information network functionalities to be enhanced for RHIN in China*

| Functional Type | Functionalities to be Enhanced |
|---|---|
| Data Collection and Integration | Collect clinical documents, externally-sourced data, emergency medical system originated data, externally-sourced clinical images, patient-originated data |
| Record Synchoronization | Structured-document exchange, registry and directory services, complete logical record exchange |
| Record Lifecycle and Lifespan Management | Originate, manage, retain, amend, translate, verify, access , output ,disclose, transmit , receive, de-identify/ re-identify, pseudomynize, extract,archive/restore,destroy/identify, deprecate/retract, re-activate, merge/unmerge, link/unlink record entries |
| Record Archive and Restore | Archive record entries from online data structures to near-line or off-line data structures, restore record entries |

**Redesigning the Trust Architecture of RHIN**

The traditional concept of information secruity only contains security and audit. But the new trust infrastructure of HL7 EHRS FM R2 greatly extends this concept. It integrates system management functionalities, such as database backup and recovery and system and performance management. The registry and directory services, standard terminology and terminology services, standards-based interoperability, business rules management, and workflow management are also integrated into the new trust architecture. In China, security design is an important part of RHIN [9]. The security architecture of RHIN includes identity protection, identity authentication, identity management, access control, information encryption, digital signature, anonymization and security audit. Compared with HL7 EHRS FM R2, the security architectre of RHIN is not sufficient in registry and directory services, standard terminology and terminology services, and standards-based interoperability functionalities. Therefore, it needs to be redesigned according to the new trust infrastructure. The new trust architecture is shown in Table 3.

*Table 3 – New Trust Infrastructure of RHIN in China*

| Functional Type | FunctionalityName |
|---|---|
| Security | Entity authentication, entity authorization, entity access control, patient access management, non-repudiation, secure data exchange, secure data routing, patient privacy and confidentiality, system operation measurements, service availability, trusted information exchange environment |
| Audit | Audit triggers, audit log management, audit notification and review |
| Registry and Directory Service | Registry services, directory services |
| Standard Terminology and Terminology Services | Standard terminology and terminology models, maintenance and versioning of standard terminologies, terminology mapping |
| Standards-Based Interoperability | Application, structured message, and structured document interchange standards, interchange standards versioning and maintenance, standards-based application integration, interchange agreements, system integration |
| Other Functionalities | Business rules management, workflow management, database backup and recovery, system management operations and performance |

## Conclusions

HL7 EHRS FM R2 is the latest advancement in EHRS functionality design. This version contains several new ideas. China should learn from this advanced international standard to improve the functionality design of health systems and promote the construction and development of RHINs in China.

## Acknowledgements

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