Next Generation of Electronic Patient Record: Moving from Information to Knowledge-based

Lau, Adela
School of Nursing, The Hong Kong Polytechnic University
Hong Kong, China

Abstract

WHO has defined three standards for classification and terminology used in Healthcare Information Systems: ICD (International Classification of Disease), ICF (International Classification of Functioning, Disability and Health) and ICHI (International Classification of Health Intervention). They are used for clinical and diagnosis coding, classification of the health components of functioning and disability, and classifying procedure codes in medicine respectively. These classifications provide the terminology to describe clinical data and diagnosis. To represent the semantic meaning of e-patient records, WHO launched a project of implementation of ICD-10 plus, ICD-11 draft and ICD-11 Ontology in March of 2007. The new ICD standard guides the classification and representation of knowledge of clinical data. So, what is the next generation of e-patient record? How does the e-patient record move from being information-based to being knowledge-based? What kinds of research questions need to be tackled in the new evolution of e-patient records?

1. Introduction

WHO defined three standards for classification and terminology used in Healthcare Information Systems. ICD is an international classification of disease for clinical and diagnosis coding (World Health Organization[a], 2008). The classification ICF (International Classification of Functioning, Disability and Health) complements ICD, which contains information on diagnosis and health condition, but not on functional status (World Health Organization[b], 2008). ICHI (International Classification of Health Intervention) is for classifying procedure codes in medicine (World Health Organization[c], 2008). The vision of ICD (World Health Organization, 2007) is to assist in public health policy, resource allocation and monitoring outcomes by recording mortality, morbidity and other population health parameters. In addition, ICD aims to support clinical decisions and health system management and to be integrated into routine practice in different settings, including primary care, more specialized clinical care and research.

In order to transfer the e-patient record from an information to a knowledge-based system, the new vision of ICD aims to guide the classification and representation of knowledge of clinical data. It expands the level of detail of classification entities by linking them to

standard description of signs, symptoms and other descriptors of illness (World Health Organization, 2007). Thus, the new version of ICD (10 plus, 11) is appropriate for using electronic health records for knowledge capture and sharing. To represent knowledge adequately, the classification will be built using ontological tools with various domains such as constellations of signs and symptoms, severity and course, as well as genetic and other information. This ontological approach enables standardized information processing and communication by computers in e-health applications, and facilitates knowledge capture and sharing across different healthcare information systems. Therefore, the aims of this paper are to discuss what the next generation of e-patient record might look like, how the e-patient record moves from being information-based to being knowledge-based, and what research questions are to be tackled in the new evolution of the e-patient record.

2. How ICD Standards Facilitate Knowledge Capture and Sharing

As stated in the white paper on ICD (World Health Organization, 2007), ICD-10 Plus is a web application that allows users to enter structured proposals for ICD revision for standardization of the exchange and communication of e-patient records. ICD11 draft aims to define the ICD ontology. The selected expert can use a wiki-like structured joint-authoring tool to define the health/medical terminology (e.g. the name of each entity, relevant inclusion and exclusion terms and a textual description), taxonomy rules (e.g. in what chapter or section in the classification tree, and whether it is a disease, disorder, injury, syndrome, sign, symptom, other), and clinical and/or research rules for diagnosis and place them into the WHO web portal. Expert drafting groups will use terminology/ontology tools such as SNOMED (The International Health Terminology Standards Development Organisation, 2008) and/or any other terminology (NANDA International, 2007; National Cancer Institute, 2008) to identify core constructs and concepts of ICD11. A taxonomic review, clarification and comment on the proposed ontology will be carried out by WHO experts, scientific peer review and the public afterward. Thus, ICD11 facilitates creating knowledge linkages and algorithms for symptom-diagnosis or diagnosis-treatment decision support. Since ICD11 standardizes the health/clinical/medical terminology and medical records so that the patient data can be represented and exchanged in semantic manner, it supports and facilitates knowledge capture, creation and sharing in health/nursing/ medical diagnosis and treatment.

3. Next Generation of E-patient Record

The next generation of e-patient record can be divided into four layers (see figure 1 below). The data and transaction layer has the traditional healthcare transaction information systems, such as e-patient record and medical insurance claim systems for storing and archiving the patient's personal profile, insurance profile, clinical data and transaction data. Thus, this layer is designed for data input and is used by the clinical professional such as the nurse, physician and accounting manager for their daily activities.

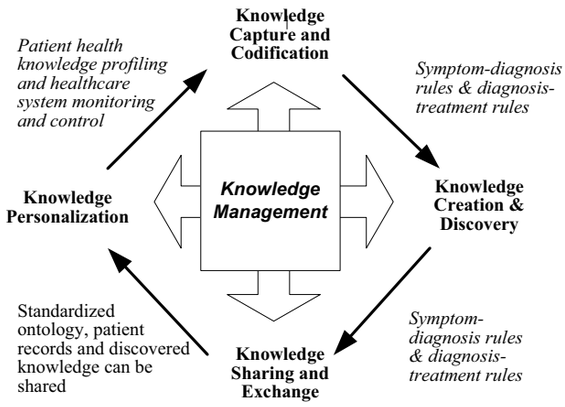

Fig. 1. The information architecture of the next generation of e-patient record

On top of the data and transaction layer, the ontology layer provides the health/clinical/medical ontological tools such as ICD11 for ontology management and ontology-based patient record management. Ontology management provides the services of co-authoring, mapping and exchanging the ontologies from different sources. The defined ontology is stored in ontology databases. Ontology-based patient record management parses and processes the ontology from the ontology databases for implementing the ontology-based patient records. In addition, this layer provides a patient record mapping service to map different record standards and formats of healthcare information systems for patient record exchange.

The information layer on top of the ontological layer provides the service of health/clinical/medical information retrieval and reporting. Healthcare management and policy makers can retrieve the information and report on population health, healthcare outcomes, and administration plans. This enables the healthcare management and policy maker to better plan infection control and disaster prevention, healthcare initiatives, and healthcare resources allocation and scheduling.

On top of the information layer, the knowledge layer provides the services of medical intelligence, personalized patient record management and health monitoring and alerts. By using the symptom-diagnosis and diagnosis-treatment rules defined in the ontology, medical knowledge and a knowledge base can be created for decision support. In addition, since all e-patient records are stored in semantic manner using computing power and artificial intelligence, similar cases and medical rules can be discovered. This facilitates the development of a case-based, rule-based or expert-based clinical/medical intelligence system. Further, the symptoms, diseases and treatment from different cases can be related and evaluated to generate a clinical/medical outcome assessment. Most importantly, the patient's health profile can be personalized and evaluated by relating the patient's medical records with the signs and symptoms, symptoms with diagnosis, diagnosis with disease,

and disease with treatment knowledge. As a result, the patient's health can be monitored and alerted. In addition, the captured rules can be used to generate a health/medical knowledge map or knowledge base. By using the health/medical knowledge map and patient records, population health status and distribution can be captured so that infection and disease control can be exercised. Lastly, by reviewing the healthcare system and the health of the population, health professional knowledge capital and assets can be measured and planned.

4. Transforming E-patient Record from Information-based into Knowledge-based

In the past few years, researchers have studied how to develop and integrate the medical ontologies (Charlet et al., 2006; Jon et al., 2007; Lee et al., 2006; Meton et al., 2006) and apply them to medical knowledge management (Dieng-Kuntz et al., 2006; Haung & Chen, 2007; Shah et al., 2007). Thus, the next generation of e-patient records will transfer from being information-based to being knowledge-based (see figure 2 below). All the health/clinical/medical ontologies are standardized and mapped. The health/clinical/medical knowledge such as symptom-diagnosis rules, diagnosis-treatment rules, etc., is captured and codified. By using the patient records data and ontological representation and rules, new health/clinical/medical knowledge can be created and discovered. The ontology, patient records and new health/clinical/medical knowledge are shared and exchanged over the virtual integrated platform so that patient health knowledge profiling and healthcare system monitoring and control can be exercised.

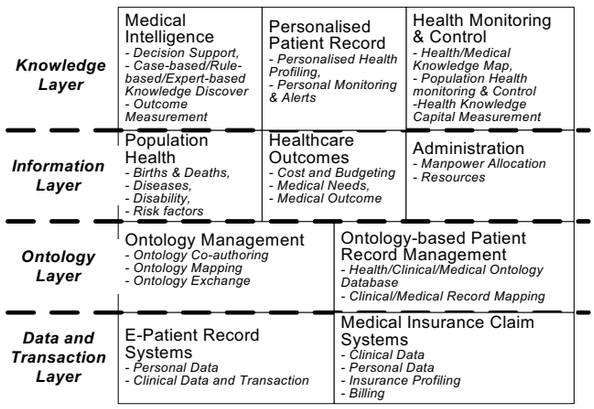

Fig. 2. Transformation from information-based to knowledge-based records in the next generation of e-patient record

In summary, the next generation of e-patient record has the new features of semantic patient record management, health/clinical/medical knowledge representation, integrated ontology-based e-patient record, virtual medical knowledge collaboration, sharing and exchange, medical, clinical and healthcare reporting, monitoring and forecasting, intelligent

medical knowledge repository, personalized health knowledge management, and healthcare system knowledge management and capital measurement.

Research Questions to be Tackled in Next Generation of E-patient Record

Therefore, the research questions to be tackled in the next generation of e-patient records include (but are not limited to):

- How to apply wiki-features and technologies to develop a co-authoring platform for ontology creation and sharing?
- How semantic web representation language and technologies represent the semantic meaning of the e-patient record?
- How to construct a knowledge map of medical symptoms, diagnosis and treatment as a knowledge base?
- What knowledge can be discovered from the symptom-diagnosis rules and diagnosis-treatment rules of medical ontologies and e-patient records?
- Research on the algorithms of ontology-based text mining to discover knowledge, such as symptom-diagnosis, diagnosis-treatment, etc., from e-patient records.
- How to map different clinical/medical ontologies such as ICD10, SNOMED, NCI ontology, Gene Ontology, MGED Ontology, MedDRA, VANDFRT, LOINC, and GALEN across different healthcare information systems?
- What web services and semantic web technologies are to be used for virtual patient record exchange and sharing?
- How to apply web/knowledge management technologies for personalizing patient records and profiles?
- How to apply data and text mining techniques for health monitoring and alerts?

5. Conclusions

The next generation of e-patient record standardizes the health/clinical/medical terminology. All the patient data can be represented in a semantic manner so that it facilitates knowledge capture, creation and sharing in health/nursing/medical diagnosis and treatment. The research questions to be tackled for the next generation of e-patient records cover the research topics of ontology knowledge representation and co-authoring, the ontology engineering process, social network analysis, knowledge repositories, text mining, knowledge discovery and knowledge intellectual capital measurement.

6. References

Charlet, J.; Bachimont, B. & Jaulent, Marie-Christine. (2006). Building medical ontologies by terminology extraction from texts: An experiment for the intensive care units. *Computers in Biology and Medicine*, Vol. 36, No. 7-8, (Jul-Aug 2006) pp.857-870.

Dieng-Kuntz, R.; Minier, D.; Ruzicka, M.; Corby, F.; Corby, O. & Alamarguy, L. (2006). Building and using a medical ontology for knowledge management and cooperative work in a health care network. *Computers in Biology and Medicine*, Vol. 36, No. 7-8, (Jul-Aug 2006), pp.871-892.

Huang, M.J. & Chen, M.Y. (2007). Integrated design of the intelligent web-based Chinese Medical Diagnostic System (CMDS) - Systematic development for digestive health. *Expert Systems with Applications*, Vol. 32, No. 2, Pp.658-673.

Jon, P.; Wang, Y.F. & Budd, P. (2007). An automated system for conversion of clinical notes into SNOMED clinical terminology. *ACM International Conference Proceeding Series*; Vol. 249, (Jan 2007) , pp.219–226.

Lee, Y.Y.; Supekar, K. & Geller, J. (2006). Ontology integration: Experience with medical terminologies. *Computers in Biology and Medicine*, Vol. 36, No. 7-8, (Jul-Aug 2006) pp.893-919.

Melton, G.B.; Parsons, S.; Morrison, F.P.; Rothschild, A.S.; Markatou, M. & Hripcsak, G. (2006). Inter-patient distance metrics using SNOMED CT defining relationships. *Journal of Biomedical Informatics*, Vol. 39, No. 6, (Dec 2006), pp.697-705.

NANDA International. "Nursing Diagnoses: Definitions & Classification", 2007. NANDI-I. Avaliable at http://www.nanda.org [Access 3rd Mar 2008].

National Cancer Institute. "Cancer Topics", 2007. Avaliable at http://www.cancer.gov/cancertopics [Access 3rd Mar 2008].

Shah, N.H.; Rubin, D.L.; Espinosa, I.; Montgomery, K. & Musen, M.A. (2007). Annotation and query of tissue microarray data using the NCI Thesaurus, *BMC Bioinformatics*, (Aug 2007), pp.296 – 303. [Access 3rd Mar 2008].

The International Health Terminology Standards Development Organisation. "Systematized Nomenclature of Medicine", last updated in 2008. Avaliable at http://www.snomed.org/ [Access 1st Apr 2008].

World Health Organization. "Production of ICD-11: The overall revision process. WHO White Paper", Mar 2007. Avaliable at http://www.who.int/classifications/icd/ICDRevision/en/index.html [Access 2rd Apr 2008].

World Health Organization[a]. "International classification of disease", last updated in 2008. Avaliable at http://www.who.int/classifications/icd/en/ [Access 4th Apr 2008].

World Health Organization[b]. "International Classification of Functioning, Disability and Health", last updated in 2008. Avaliable at http://www.who.int/classifications/icf/en/ [Access 4th Apr 2008].

World Health Organization[c]. "International Classification of Health Interventions", last updated in 2008. Avaliable at http://www.who.int/classifications/ichi/en/ Access 4th Apr 2008].

Advances in Computer Science and IT

Edited by D M Akbar Hussain

ISBN 978-953-7619-51-0
Hard cover, 420 pages
Publisher InTech
Published online 01, December, 2009
Published in print edition December, 2009

The book presents some very interesting and excellent articles for this divergent title. The 22 chapters presented here cover core topics of computer science such as visualization of large databases, security, ontology, user interface, graphs, object oriented software developments, and on the engineering side filtering, motion dynamics, adaptive fuzzy logic, and hyper static mechanical systems. It also covers topics which are combination of computer science and engineering such as meta computing, future mobiles, colour image analysis, relative representation and recognition, and neural networks. The book will serve a unique purpose through these multi-disciplined topics to share different but interesting views on each of these topics.

How to reference

In order to correctly reference this scholarly work, feel free to copy and paste the following:

Lau Adela (2009). Next Generation of Electronic Patient Record: Moving from Information to Knowledge-based, Advances in Computer Science and IT, D M Akbar Hussain (Ed.), ISBN: 978-953-7619-51-0, InTech, Available from: http://www.intechopen.com/books/advances-in-computer-science-and-it/next-generation-of-electronic-patient-record-moving-from-information-to-knowledge-based

INTECH
open science | open minds

InTech Europe
University Campus STeP Ri
Slavka Krautzeka 83/A
51000 Rijeka, Croatia
Phone: +385 (51) 770 447
Fax: +385 (51) 686 166
www.intechopen.com

InTech China
Unit 405, Office Block, Hotel Equatorial Shanghai
No.65, Yan An Road (West), Shanghai, 200040, China
中国上海市延安西路65号上海国际贵都大饭店办公楼405单元
Phone: +86-21-62489820
Fax: +86-21-62489821

IntechOpen