Digital Health and the Challenge of Interoperability

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Power of Information

The improved understanding of the whole healthcare and wellbeing pathway for individuals depends on the power of healthcare information, being made readily available and easily interpretable by both humans and machines.
Motivation for Interoperability

towards an enhanced integrated care approach
The Challenge of Interoperability

Health Information Exchange

Source: https://himsshie.pbworks.com/w/page/4775490/HIEDefinition

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Representing Healthcare Knowledge

- The foundation of interoperability lies with a shared understanding of data representation and concepts between systems:
  - It is necessary to establish both syntactic (model-based) and semantic interoperability to represent knowledge in a computable form.
The Concept of Interoperability I

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E-mail: randyg@norwich.net

"Hello, Bob? It's your father again.
I have another question about my new computer.
Can I tape a movie from cable TV then fax it from
my VCR to my CD-ROM then E-mail it to my
brother's cellular phone so he can make a
copy on his neighbor's camcorder?"
Main Entry: interopera-bility
: ability of a system ... to use the parts or equipment of another system
Source: Merriam-Webster web site

interoperability
: ability of two or more systems or components to exchange information and to *predictably* use the information that has been exchanged.

Semantic interoperability
Syntactic interoperability (interchange)

Source: Charles Mead, CaBIG
Importance of interoperability

- **The Goal:** healthcare and patient-related information enrichment
- **The Challenge:** Developing a user understandable, computable and extensible knowledge representation scheme for capturing healthcare concepts and information (knowledge)
- **Patient-Centric World:** From EHR to PHR
Interoperability at Different Levels

Application level:
- EHR: presentation, functionality
- Continuous Pathway of Care: presentation, functionality
- PHR: presentation, functionality

Logical level:
- EHR: clinical content, terminology, model
- Continuous Pathway of Care: clinical content, terminology, model
- PHR: clinical content, terminology, model

Technical level:
- EHR: format & storage, transmission
- Continuous Pathway of Care: format & storage, transmission
- PHR: format & storage, transmission

Integrated Care Interoperability
Semantic interoperability
Technical interoperability

Reproduced from the Antilope Project ALT model

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Technical (Syntactic) Interoperability

MSH | ^~\& | ADT1 | MCM | LABADT | MCM | 198808181126 | SECURITY | ADT ^ A01 | MSG00001- | P | 2.4
Evn | A01 | 198808181123
PID | | | PATID1234 ^ 5 ^ M11 | | JONES ^ WILLIAM ^ A ^ III | | 19610615 | M | | C
PV1 | | I | 2000 ^ 2012 ^ 01 | | | | 004777 ^ LEBAUER ^ SIDNEY ^ J. | | | | SUR | | | | ADM | A0
AL1 | | | ^ PENICILLIN | | PRODUCES HIVES ^ RASH ^ LOSS OF APPETITE
DG1 | 001 | I9 | 1550 | MAL NEO LIVER, PRIMARY | 19880501103005 | F
PR1 | 2234 | M11 | 111 ^ CODE151 | COMMON PROCEDURES | 198809081123

Segments identify the type of information that appears in the message. This HL7 message contains the following segments:

MSH message header
Evn event type
PID patient identification
PV1 patient visit information
AL1 patient allergy information
DG1 diagnosis
PR1 procedures

Composites/fields contain information related to the patient encounter or event.

Source: http://www.altova.com/HL7_technology_primer.html
Standards Development Organizations and associated groups are engaged in activities to develop and implement standards for elements of both syntactic and semantic interoperability, e.g.

- Health Level Seven International (HL7) – clinical information systems standards
  - and others such as DICOM, ISO, W3C, etc.
- Integrating the Healthcare Enterprise (IHE) – shaping the integration of standards by facilitating the concept of sharing information in the healthcare enterprise.
- Clinical Data Interchange Standards Consortium (CDISC) providing standards to support the acquisition, exchange, submission and archive of clinical research data and metadata
An Example from the Clinical Care Perspective

• The screening for hearing loss in newborns before hospital discharge is now considered a standard of health care in the United States and is referred to as Early Hearing Detection and Intervention (EHDI)

• Sponsored by CDC - an ambitious program that can potentially capture the whole of the newborn population

• Establishes bi-directional information exchange between clinical care and public health in a relatively simple and feasible way by using HL7 standards and IHE implementation approaches
Semantic Interoperability
Containers of clinical content “dialect” and meaning is needed
Informatics Tower of Babel: The Grand challenge

- Common Semantics?
- Each part of the health community speaks its own scientific “dialect” (e.g. lab values, genetic profile, clinical data)
- Lack of consensus on common standards and terms
- Recently, convergence of terminology-base standardisation efforts
- Enterprise vocabulary services: ontology-based to drive mappings between various terminologies
- Avoiding the informatics “Tower of Babel” problem (coined by caBIG project)
# Aspects of “Terminological” Systems

<table>
<thead>
<tr>
<th>Enterprise-level Vocabulary Services Efforts</th>
<th>Terminology-based standardisation efforts</th>
<th>Practitioner-based technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Language independence</td>
<td>Language Dependence</td>
<td>Language Dependence</td>
</tr>
<tr>
<td>Ontology</td>
<td>Terminology</td>
<td>Natural Language/structured language (epistemology based)</td>
</tr>
</tbody>
</table>

- **Model of the domain:**
  - Taxonomy, relationships & constraints
  - Expert domain Representation
  - Unique preferred terms
  - Well defined of terms
  - Pragmatic Representation of domain
  - Clinical use and dissemination
  - The “Tower of Babel” effect
Example Project: TRANSFoRm I

TRANSFoRm

- Translational Research and Patient Safety in Europe
- 5-year project (2010-2015)
- EU funding
- 21 partners
- 10 EU member states
- Aims to deliver a digital infrastructure that facilitates the reuse of primary care electronic Health Records (eHR) data to improve both patient safety and the conduct and volume of clinical research in Europe
### Example project: TRANSFoRm II

#### Tools For GPs And Researchers

<table>
<thead>
<tr>
<th>Data Quality Browser</th>
<th>Query Workbench</th>
<th>Study Designer</th>
<th>Study Manager</th>
<th>Diagnostic Support</th>
<th>Data Mining &amp; Analytics</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Enables assessment of data quality in EHR systems and repositories for inclusion in research studies</td>
<td>• Assists with the identification of eligible patients for research studies • Assists with query formulation &amp; execution</td>
<td>• Design of eligibility rules, protocol, Common Data Elements (CDE), electronic Case Report Forms (eCRF) and study timelines</td>
<td>• Recruitment and randomisation of eligible patients • Assist with storing patient consent • Capture and reporting of adverse effects • Capture of Patient-Reported Outcomes</td>
<td>• Interactive patient-specific advice at the moment of consultation • Triggering of diagnostic support for GPs • Warehouses derived Clinical Prediction Rules in a semantically-enabled store</td>
<td>• Collaborative tools for validation and improvement of generated clinical evidence • Visual insight into derived decision support models</td>
</tr>
</tbody>
</table>

#### Core Technologies

<table>
<thead>
<tr>
<th>Data Provenance</th>
<th>Semantic Integration</th>
<th>Security Framework</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Provenance information capture, analysis and presentation from the provenance service • Enables auditability and accountability across all tools</td>
<td>• Simplified data access to various and heterogeneous data sources based on a view relevant to the Primary Care field • Integrated Vocabulary Services for searching and retrieving clinical vocabulary concepts and associated content</td>
<td>• Lightweight Shibboleth based infrastructure plugs into local authentication services • Study based user roles and permissions</td>
</tr>
</tbody>
</table>
The TRANSFoRm Integrated Vocabulary Service is designed to allow end users to search and retrieve clinical vocabulary concepts and associated content:

- a web interface and a web service API
- the service uses the LexEVS (version 5.1 and 6.0) technology to access a backend UMLS vocabulary database
- the service uses direct Java Database Connectivity (JDBC) to access other vocabulary databases (e.g. Read Codes V2, ICPC2)
UMLS as the basis of terminology cross mappings
Example Terminological Mappings

- Read Codes (RCDv2) and International Classification of Primary Care (ICPC2) corpus of terms and their associated mappings – created to cater for the initial need of the existence of specific primary care oriented terminologies.
- The UK NHS Connecting for Health Terminology Centre - mappings from Read Codes version 2 to SNOMED CT.
- The Read Codes v2 database in Transform VS is set up based on this mapping so that Read Codes 2 concepts can be linked to a UMLS search. Similar approach for ICPC2.
- ICPC2-ICD10 Thesaurus and mappings - Transition Project @ University of Amsterdam
- The TRANSFoRm team has updating the ICPC2-ICD 10 mapping and Thesaurus
A screenshot of the vocabulary service web-based interface

Source vocabularies:

<table>
<thead>
<tr>
<th>Source</th>
<th>Language</th>
<th>Code</th>
<th>Text</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICD10</td>
<td>ENG</td>
<td>E11</td>
<td>Non-insulin-dependent diabetes mellitus</td>
</tr>
<tr>
<td>ICPC2ENQ</td>
<td>ENG</td>
<td>T90</td>
<td>Diabetes non-insulin dependent diabetes</td>
</tr>
<tr>
<td>ICPC2CD10ENG</td>
<td>ENG</td>
<td>MTHU003788</td>
<td>adult-onset; diabetes</td>
</tr>
<tr>
<td>ICPC2CD10ENG</td>
<td>ENG</td>
<td>MTHU022956</td>
<td>diabetes; maturity-onset</td>
</tr>
<tr>
<td>ICPC2CD10ENG</td>
<td>ENG</td>
<td>MTHU022816</td>
<td>diabetes; NIDDM</td>
</tr>
<tr>
<td>ICPC2CD10ENG</td>
<td>ENG</td>
<td>MTHU022816</td>
<td>diabetes; non-insulin-dependent diabetes</td>
</tr>
<tr>
<td>ICPC2CD10ENG</td>
<td>ENG</td>
<td>MTHU022817</td>
<td>diabetes; nonketotic</td>
</tr>
<tr>
<td>ICPC2CD10ENG</td>
<td>ENG</td>
<td>MTHU022833</td>
<td>diabetes; type II</td>
</tr>
<tr>
<td>ICPC2CD10ENG</td>
<td>ENG</td>
<td>MTHU047774</td>
<td>maturity-onset; diabetes</td>
</tr>
<tr>
<td>ICPC2CD10ENG</td>
<td>ENG</td>
<td>MTHU052916</td>
<td>NIDDM; diabetes</td>
</tr>
<tr>
<td>ICPC2CD10ENG</td>
<td>ENG</td>
<td>MTHU063299</td>
<td>non-insulin-dependent; diabetes</td>
</tr>
</tbody>
</table>

Language: English

Finnish
French
German
Hebrew
Hungarian
Italian
Japanese
Korean
Latvian
Norwegian
Portuguese
Russian
Croatian
Spanish
Example: Selecting an Event Type
Select Diagnosis Codes
Add Concept to Diagnosis

Add Concept to Diagnosis
Models of How Clinical Content is Organised

The Clinical Data Information Model (CDIM) of the EU FP7 TRANSFoRm project

Data item

Measurement datum

Systolic measurement
Lab measurement
Pulse rate measurement

Clinical finding -> Phys Exam
Clinical finding -> Lab finding
Diagnosis
Prognosis

length -> human height
Mass -> dose
phenotype -> gender
pressure -> diastolic pressure

Document -> Rx
Directive -> Act -> Rx item
Directive -> Condition -> Rule
Label -> Measurement unit -> Unit label

Chemical -> Form -> Product
Molecular -> DNA -> SNP
Object -> Human -> Patient

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Current Challenges

- International or European “terminological” systems
- Challenge of multilingual systems in Europe
- Importance of appropriate existing “terminological” systems
- Politics, Ethics, Tradition – specialty specific, Social organization – e.g. NHS/Primary-care, Standardization
- Different use of data at the national — Clinical care, secondary use, research, etc.
- Issues of implementation
- Issues of user acceptance
- Can these be used in patient-centric integrated care paradigm?
Summary

• The impact of digital technology and information can be transformative for healthcare.

• Digitally-enabled healthcare provides the way forward: The benefits to individuals and society are multiple. People’s health journeys are better understood and appropriate lifestyle choices can be better tailored and promoted to the individual:
  
  • linked **electronic records** to support the delivery of care;
  
  • **harnessing data** to support research and real-time public health **decision making**;
  
  • **integrated decision support systems** which aim to maximize effectiveness and patient safety;
  
  • tools for delivering **remote monitoring** and **self-management**
  
• **Interoperability**: an opportunity and challenge
Thank You

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