Presentation Outlines

- Interoperability – What it is?
- Level of Interoperability
- Current Standard
- Interoperability: Advantages
- Interoperability: Challenges
- Interoperability: Future
- HIS: Introduction & Issues
- My Current Activities
- Summary
- References
Interoperability – What it is?

“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 [1].”

According to the Healthcare Information and Management Systems Society (HIMSS), “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 by a user.”
Interoperability : Level

- **Basic components of interoperability:**
  - Ability of at least two or more interfaces/software/systems to exchange data. And able to use the exchanged data smoothly.

- **Interoperability can be divided into three levels**

<table>
<thead>
<tr>
<th>Level</th>
<th>Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Foundation</strong></td>
<td>This is basic level. One EPR system receive data from another system but does not need to interpret it;</td>
</tr>
<tr>
<td><strong>Structure</strong></td>
<td>Data can be exchanged between information technology systems and interpreted at the data filed level; Format of data exchange (e.g. the message format standards); OR structural interoperability defines the syntax of the data exchange.</td>
</tr>
<tr>
<td><strong>Semantic</strong></td>
<td>It is the highest level of interoperability; where two or more systems can exchange information and exchanged information can be used;</td>
</tr>
</tbody>
</table>
Interoperability – Advantages

- It will reduce error and increase the efficiency.

- It will **reduce cost** (for non-integrated health care system) and quick implementation.

- This enables data sharing and data can be analysed in different ways as per the requirements.

- Improve patient safety and provide accurate information.
Interoperability – Advantages

- More time to patient(s) – doctor(s) can provide more time to patient care rather than search the patients’ information or data (historical and current).

- Better conversion between the doctors and other departments (e.g. Lab., Radiology, Nurse, Ward, ICU, or other stakeholders)

- Data can be shared smoothly across the Departments, Hospitals, Clinicians etc.
Interoperability – Standard

➢ Health Level Seven (HL7)
  - HL7v2,
  - HL7v3,
  - HL7 FHIR (Fast Healthcare Interoperability Resources)

-Fast (FHIR) as competent standards for electronic exchange of healthcare information; developed by HL7.

-And it is combines the good features of HL7V2 and CDA. It is design based on RESTful web services.

**Interoperability – Standard**

*Hammond, Bailey, Boucher, Spohr, and Whitaker, 2010*: List of common standards development Organization

<table>
<thead>
<tr>
<th>TYPE OF STANDARD</th>
<th>EXAMPLE STANDARDS</th>
<th>SDO CREATING THE STANDARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>General standards</td>
<td>XML, TCP/IP, 802.11, Web services, security, wireless, GPS</td>
<td>W3C, IETF, IEEE, OMG, HL7</td>
</tr>
<tr>
<td>Data components</td>
<td>Reference Information Model (RIM), data elements, data types, terminology, templates, clinical statements, clinical document architecture</td>
<td>HL7, CEN, ISO, openEHR, IHTSDO, LOINC, RxNorm, UMLS, WHO</td>
</tr>
<tr>
<td>Data interchange</td>
<td>Structured and free-form documents, images</td>
<td>HL7, ASTM, DICOM, IEEE 1073, NCPDP, X12N, CEN, ISO</td>
</tr>
<tr>
<td>Knowledge representation</td>
<td>Guidelines and protocols, decision support algorithms</td>
<td>HL7, ASTM</td>
</tr>
<tr>
<td>Electronic health record (EHR)</td>
<td>Functional requirements, EHR models, Continuity of Care Record (CCR), patient summary record, personal health record</td>
<td>HL7, ASTM, openEHR, CEN</td>
</tr>
<tr>
<td>Application level support</td>
<td>Identifiers, resource registries, disease registries, tool sets, conformance requirements, implementation manuals</td>
<td>HIPAA, HL7, ASTM, ISO, CEN</td>
</tr>
</tbody>
</table>
Interoperability – Standard

- **Health Level Seven (HL7)**
  - HL7 V2
  - HL7 V3 (RIM)
  - HL7 CDA (RIM) -- Document
  - HL7 FHIR

- **Grahame Grieve** wrote the initial Strawman version of FHIR between May and August 2011, it was called ‘Resources for Health (RFH)’

- **FHIR is a RESTful API** and it is successful to develop a RESTful architecture, LinkedIn, Twitter etc.
Interoperability – Standard

HL7 Fast Healthcare Interoperability Resources Specification (FHIR®): FHIR is a next generation standard framework.

Some Benefits:
- Multiple implementation libraries, many examples available to kick-start development
- Specification is free for use with no restriction
- Strong foundation in Web Standards:
  - XML, JSON, HTML, Atom, OAuth
- Human Readable format
- Support RESTful architectures, etc.

Targets:
- Clinical and public health laboratories
- Clinical decision support systems vendors
- Lab vendors
- HIS vendors
- Emergency Service Providers
- Medical Image Services Providers
- Health care institutions
- Immunization Registries
- Pharmaceutical vendors, etc.
Interoperability – Standard

Familiarize yourself with the HL7 FHIR

Good Starting Point:
--Click Resources
--Select Patient S

Read:
- Documentation
- Resources
- Operations

This page is part of FHIR STU 3 (v3.0.1) in its permanent home (it will always be available at this URL). It has been superceded by [v4]. For a full list of available versions, see the Directory of published versions.

1.1 Documentation Index

This page provides an index to the key commonly used documentation pages for FHIR.

Framework
- Conformance Rules
- Resource Life Cycles
- References between Resources
- Compartments
- Narrative
- Extensibility

- Formats: XML, JSON, & RDF
- Terminologies (Code Systems, Value Sets)
- FHIRPath
- Version Management
- Change Management & Versioning
- Version History
- Differences to DSTU 2
- Transforms between DSTU 2 and STU 3
- Background
  - Overview: General, Developers

Exchanging Resources
- RESTful API (HTTP)
- Search + Search Param Registry
- Operations
- Documents
- Messaging
- Services

Base Types
- Data Types (Base)
- Metadata Types
- Resource
- DomainResource

- Element
- BackboneElement
- ElementDefinition

- + Dosage (for medications)

Design Patterns

Adopting & Using FHIR
- Profiling FHIR
- Downloads - Schemas, Code, Tools
- Validating Resources
- Mapping Language (tutorial)
- Testing Implementations

Safety & Security
- Security & Security Labels
- Clinical Safety

Implementation Advice
- Guide to Resources
- Variations between Submitted data and Retrieved data
- Managing Resource Identity
- Push vs Pull
- Integrated Examples

Read these for further information
Interoperability – Standard

FHIR

Fast Healthcare Interoperability Resources (FHIR, pronounced “Fir”) defines a set of “Resources” that represent granular clinical concepts. The resources can be managed in isolation, or aggregated into complex documents. Technically, FHIR is designed for the web; the resources are based on simple XML or JSON structures, with an http-based RESTful protocol where each resource has a predictable URL. Where possible, open internet standards are used for data representation.


- The current specification: [http://www.hl7.org/fhir/](http://www.hl7.org/fhir/) (at this development version)
- FHIR Specification Feedback (DSTU 2)
- FHIR Profiles from other Organizations
- Contact Information
- Getting Involved with the FHIR Community
- FHIR Support Page
- Implementation help: [ask questions about FHIR@hl7.org](http://wiki.hl7.org/index.php?title=FHIR)
- Formal Contact point for the project: [infocontact@hl7.org](mailto:infocontact@hl7.org)
- FHIR Chat (Zulip) chat for community expectations
- FHIR Issue Tracker for change requests/changes
- FHIR Project Team Leads (FHIR Care Team) - [Grahame Grieve](http://www.hl7.org/fhir/)
- [List server - project email list](mailto:hl7-fhir@lists.hl7.org)

- Help / Getting Started
  - FHIR Starter - tutorial for FHIR novices
  - FHIR Teaching - sources of FHIR teaching, training, and tutorials
  - FHIR ChattSheet (DSTU 1)
  - FHIR ChattSheet (DSTU 2)
  - FHIR Chatsheet (DSTU 3)
  - FHIR Chatsheet (R4)
  - Help desk FAQs & knowledge-base articles (HL7 members only)
  - FHIR Tools Registry - a list of useful tools for FHIR implementers
  - FHIR for Clinical Users - an introduction to FHIR for non-technical people that will migrate to the specification in the future
  - FHIR User Group
  - FHIR for Consumers
  - FHIR for Clinical Research
  - Social Media on FHIR
  - FHIR blogs - [David Hay](http://www.hl7.org/fhir/), [Erasud Kramer](http://www.hl7.org/fhir/), [Grahame Grieve](http://www.hl7.org/fhir/), [Keith Beene](http://www.hl7.org/fhir/), [Brian Postelthwaite](http://www.hl7.org/fhir/), [John Moulton](http://www.hl7.org/fhir/), [Steve Munkin](http://www.hl7.org/fhir/)
  - [FHIR News](http://www.hl7.org/fhir/)

- How to
  - Balloting and Publishing FHIR content - instructions for work groups
  - FHIR DSTU monitoring - how to monitor DSTU feedback
  - FHIR Ballot Prep - tasks for the next ballot and milestone dates
  - FHIR Build Process - setting up and running the FHIR build process
  - FHR Implementation Guide QA Requirements - for FHIR profiles publication
  - How to create resources (and how to create types)
  - Materials: jForge issue tracker, Source on GitHub
  - For commit privileges, send a request to [lloyd@fhircore.com](mailto:lloyd@fhircore.com)
  - FHIR resources and Implementation Guides proposal for new resources/implementation guides
  - FHIR Profile authoring - creating and maintaining FHIR profiles (see also Profile Testing)
  - FHIR Change requests - process for managing and resolving
  - FHIR jForge Tracker - guidelines for using the jForge tracker, including for ballot reconciliation

- Implementation Guides
  - FHIR Implementation Guides - General considerations for implementation guides
  - IG Publisher Documentation - Guidelines for setting up a new guide
  - FHIR NPM Package Spec - specification for NPM package for Implementation Guides (and see also the FHIR Package Cache documentation) • FHIR IG PackageList doco
  - Old IG Publishing Method - Guidelines for setting up a new guide under old (deprecated, being phased out rapidly) IG infrastructure
  - FHIR Enhancing Implementation (ONC Grant Project)

- Guidelines

- FHIR Infrastructure Work Group
  - FHIR Workflow Project
  - FHIR Structured Data Capture (SDC) Project
  - Governance
    - FHIR Governance Process
    - FHIR Architecture Governance Process
    - FHIR Governance Board (FGB)
    - FHIR Management Group (FMG)
    - Modeling and Methodology (MIM)
    - Work Groups
    - FHIR Ballot Process
    - FHIR Web Server Hosting Record
  - FHIR Product Director Page
  - [FHIR Tracking Sheet](http://wiki.hl7.org/index.php?title=FHIR)
- Agendas
  - Past Working Group Meetings (list of agendas/minutes)
  - MIM agendas
  - FGB Agendas & Minutes
  - FMG Agendas & Minutes

Publicly Available FHIR Servers for testing

Introduction

This page lists FHIR servers that are publicly available for testing. In order to avoid spam etc, the servers are generally password protected. A contact is provided to get a password. BTW: List of publicly available test data (some of these test servers preload some of this data):

- [Base: What is in the specification](http://)
- [Smart on FHIR test data](http://)

Status
Interoperability – Standard

http://www.hl7.org/FHIR/resourcelist.html

Suggested Reading
Interoperability - Standard

HL7 FHIR Resource Content

Turtle Template

```turtle
@prefix fnir: <http://hl7.org/fhir/>
.

[a fnir:name];
  fnir:nodeRole fnir:treeRoot; # if this is the parser root

# from Element: Element.extension
fnir:Resource.id [ id ]; # 0..1 Logical id of this artifact
fnir:Resource.meta [ Meta ]; # 0..1 Metadata about the resource
fnir:Resource.implicitRules [ uri ]; # 0..1 A set of rules under which this content was created
fnir:Resource.language [ code ]; # 0..1 Language of the resource content
```

XML Template

```xml
<?xml version="1.0" encoding="utf-8"?>

<fnir:Resource xmlns:fnir="http://hl7.org/fhir"
  schemaLocation="http://hl7.org/fhir/fhir.xsd">
  <!-- From Element: extension -->
  <[name] xmlns="http://hl7.org/fhir">
    <!-- Logical id of this artifact -->
    <[id] value="[id]"/>
    <!-- Metadata about the resource -->
    <meta/>
    <!-- A set of rules under which this content was created -->
    <[implicitRules] value="[uri]"/>
    <!-- Language of the resource content -->
    <[language] value="[code]"/>
  </[name]>
</fnir:Resource>
```

JSON Template

```json
{
  "resourceType": "[name]",
  "id": "<id>", // Logical id of this artifact
  "meta": { Meta }, // Metadata about the resource
  "implicitRules": "<uri>", // A set of rules under which this content was created
  "language": "<code>" // Language of the resource content
}```
Interoperability – JSON

JSON: JavaScript Object Notation representation describing a person. *(Copied from Wikipedia)*

```json
{
  "firstName": "John",
  "lastName": "Smith",
  "isAlive": true,
  "age": 27,
  "address": {
    "streetAddress": "21 2nd Street",
    "city": "New York",
    "state": "NY",
    "postalCode": "10021-3100"
  },
  "phoneNumbers": [
    {
      "type": "home",
      "number": "212 555-1234"
    },
    {
      "type": "office",
      "number": "646 555-4567"
    },
    {
      "type": "mobile",
      "number": "123 456-7890"
    }
  ],
  "children": [],
  "spouse": null
}
```

Resource Description Framework (RDF)

```
<person>
  <firstName>John</firstName>
  <lastName>Smith</lastName>
  <age>27</age>
  <address>
    <streetAddress>21 2nd Street</streetAddress>
    <city>New York</city>
    <state>NY</state>
    <postalCode>10021</postalCode>
  </address>
  <phoneNumbers>
    <phoneNumber>
      <number>212 555-1234</number>
    </phoneNumber>
    <phoneNumber>
      <number>646 555-4567</number>
    </phoneNumber>
    <phoneNumber>
      <number>123 456-7890</number>
    </phoneNumber>
  </phoneNumbers>
</person>
```
Interoperability – Standard


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Patient resource

This tutorial is designed for FHIR beginners wishing to become familiarised with the basics of FHIR. In this tutorial, we will walk through the basic CRUD operations. CRUD stands for Create, Read, Update & Delete. These are the four main actions that you will use to interact with the FHIR resources within a FHIR server. Understanding these four operations is essential to working with any RESTful service which a FHIR server is an implementation of. REST stands for 'Representational state transfer' and RESTful just means a system that conforms to the constraints of REST. You don't need to know any more about REST at this stage for the tutorial but if you want more on REST take a look at this page, [Representational state transfer (REST)](http://fhir-drills.github.io).

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**Contents**

- Step 1: Setup a Http post client
- Step 2: Getting your first resource from a FHIR server
- Step 3: Updating your resource in the FHIR server
- Step 4: Adding a new resource to the FHIR server
- Step 5: Deleting a resource from the FHIR server
Interoperability – Challenges

- Lack of Standardization: Developing the Electronic Clinical Documents, for instances:
  - Inpatient/Outpatient Discharge Summary,
  - ED Discharge Summary,
  - Inpatient/Outpatient Clinical Letters, Clinical Notes, Appointment etc.

- Non-standard messaging...... formats and lack of standard workflows....

- Lack of Standardization of other Clinical Setting, for instances:
  - NHS Number (MRN, Patient ID, Clinical ID) – required unique single point patient access ID
  - Medication – Standard Electronic Medical Message
  - Inconsistency of GP code, Practice Code, Consultant Code, Diagnostic Coding,
  - Vague Patients, Radiology, Pathology, Scan, Ultrasound, Video Data etc.
Interoperability – Challenges

- Non-standard Data Format *(structure data, unstructured data, linguistic variables)* & Data Quality
- Who generate data – *Human or Machine?*; Source of data, format of data etc

Lack of Standardization Technical Data; for instances:
- Patient’s name, gender, dob, race, ethnicity, religion etc.
- Patient address filed, next of kin information,
- Vital signs, standard care plan fields, laboratory tests and results,
- Medication, medication allergies, Immunization etc.

Real-Time Health Care Information System: What?

Real Time Decision: How?

Big Data: capturing, storing and managing:
- How to process and extract valuable information from huge volume of data within a given timeframe?
Interoperability/Healthcare – Future

- **Artificial Intelligence, Machine Learning, Big Data, Block Chain** are the potential tools - big impact on the future of healthcare delivery system and interoperability.

- **Big Data : Challenges and Opportunities** – it is tough for managing the data. But can be generated new **Knowledge** by **Analysis the data** and can be introduced the new **Wisdom** that can be applied in health care delivery system.

- **Examples :**

Interoperability/Healthcare – Future

- Machine Learning Techniques can be used in various sectors – eg Auto Scheduling the Patient Appointment ....
- AI can be used to better interpret - images, videos, audio data......
- AI can be used to auto mapping the clinical data sets between the EPR and other downstream system and vice versa.
- Big data type can be analysed by AI systems,
- AI System can generate fast and meaningful clinical results, etc.
- AI can be used to early *Detection* and *Diagnosis* of diseases.
Interoperability/Healthcare – Future

• **Machine Learning** can be applied for **predicting and analysis** for various diseases and can also assist to provide the better treatment for life threading diseases - *Heart, Lungs, Cancer, Stroke* etc and treatment etc.

• **AI and Robotics is using in health care – Robotics Healthcare,**

[Read:](https://www.zdnet.com/article/healthcare-tech-ai-apis-and-interoperability/)  
Interoperability – Future

➢ There is a need to work together to develop a common standard for health information.

➢ Required to develop interoperability standards for the health sector. All stakeholder required to support for interoperable structures.

• Health Information Exchange and Interoperability.

• Innovation in Interoperability and Informatics.

• Establishing common Technical Data standardizing : e.g. patient’s gender, dob, vital signs, care plan fields, laboratory tests & results, immunization etc.

• Real-Time Health Care Information System required to enrich interoperability and intelligences system to make a Real-Time Decision.
HIE – Health Information Exchange

How patient should have the ability to access and control over their health information.

- Required strong policy to related to the electronic exchange of HIS. Consent Models

- Consent HIE could be: No Or Yes
  - Yes with Restrictions
  - No with Exception

- Collection of Consent:
  - Web-based capturing form;
  - on paper-based form - required to fill by person;
  - over telephone (required to record the data)

- Required to design and develop: Consent Management System for HIE.
Health Information Exchange (HIE) systems rests in their potential to provide clinicians and administrative staff rapid access to relevant patient data to support judgment and decision-making.

HIE must be very smart system to provide quick access to relevant data for doctors, administrative staff and other health care support staff to support a decision making.

For HIE the source of data is Electronic Patient Record (EPR) and EPR has multiple sources of data? How to access all these data and manage it?
Summary

- So, the advancement of technologies have the ability to share and exchange data that is generated by one system into another system.

- All **directors** must be educated with **IT system** and understand the importance of **Interoperability** so it will help them to buy appropriate (interoperable) medical system or products.

- Health care delivery system, product, manufactures, suppliers must have agreed standard unique architecture.

- We could deploy the AI, Machine Learning techniques in the various sectors of health care delivery system.

- **Robust** healthcare system should be offered **“Patient-Centre-Service”** which means - service should be available *when people want to use it*, not *when people need it*.

- You can not feel safe even if you are living near a hospital, if hospital doesn’t have the robust interoperable system.
My Current Activities

- **Journal Paper**: submitted at British Medical Journal - under review
  - **Title**: A Fuzzy Medical Diagnosis Framework Based on Temporal Logic.

- **Current research project**:
  - Clinical Decision Support Systems for Management of Arrhythmias; the components are:
    - (a) Management of atrial fibrillation: **Completed**
    - (b) Management of narrow complex tachycardia,
    - (c) Management of broad complex tachycardia

- **Current working papers**:
  - Smart Interface Template and Conceptual Framework for Auto Data Mapping in Healthcare Integration System. (75% complete)
  - A Supervised Machine Learning Approach to Generate the Auto Rule for Clinical Decision Support System (revising)
  - Automatic Extraction Patient Information form XML and Text file to Categorize the Diseases and Generate the various documents
Interoperability

Any Questions?
References


- Wei Ye and John Heidemann USC Information Sciences Institute, ”Enabling Interoperability and Extensibility of Future SCADA Systems” [Accessed 11/12/2018], Available online at https://pdfs.semanticscholar.org/f87e/e1fed6975b12e3d066a97e9e0f02ca85461b.pdf


- Open Clinical, Available at: http://www.openclinical.org/dssSuccessFactors.html


References


Images: from Google: All materials only use for academic /training/presentation purpose

https://informatics.bmj.com/content/26/1/0.3