

# A Fast Healthcare Interoperability Resources (FHIR) layer implemented over i2b2

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## ABSTRACT

**Background:** Standards and technical specifications have been developed to define how the information contained in Electronic Health Records (EHRs) should be structured, semantically described and communicated. Current trends rely on differentiating the representation of data instances from the definition of clinical information models. The dual model approach, which combines a reference model (RM) and a clinical information model (CIM), sets in practice this software design pattern. The most recent initiative, proposed by HL7, is called Fast Health Interoperability Resources (FHIR). The aim of our study was to investigate the feasibility of applying the FHIR standard to modelling and exposing EHR data of the Georges Pompidou European Hospital (HEGP) i2b2 clinical data warehouse (CDW). **Results:** We implemented a FHIR server over i2b2 to expose EHR data in relation with five FHIR resources: DiagnosisReport, MedicationOrder, Patient, Encounter and Medication. The architecture of the server combines a Data Access Object design pattern and FHIR resource providers, implemented using the Java HAPI FHIR API. Two types of queries were tested: query type #1 requests the server to display DiagnosisReport resources, for which the diagnosis code is equal to a given ICD-10 code. A total of 80 DiagnosisReport resources, corresponding to 36 patients, were displayed. Query type #2, requests the server to display MedicationOrder resources, for which the FHIR Medication identification code is equal to a given code expressed in a French coding system. A total of 503 MedicationOrder resources, corresponding to 290 patients, were displayed. Results were validated by manually comparing the results of each request to the results displayed by an ad-hoc SQL query. **Conclusion:** We showed the feasibility of implementing a Java layer over the i2b2 database model to expose data of the CDW as a set of FHIR resources. An important part of this work was the structural and semantic mapping between the i2b2 model and the FHIR RM. To accomplish this, developers must manually browse the specifications of the FHIR standard. Our source code is freely available and can be adapted for use in other i2b2 sites.

## CONTACT

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## INTRODUCTION

The wide adoption of electronic health records (EHRs) has made a large amount of data available to various actors, including executives, physicians, researchers, etc., for various purposes, including administration, management, clinical practice, and research [1]. Many groups have promoted the secondary use of EHR data for clinical research (Fig. 1) [2, 3].

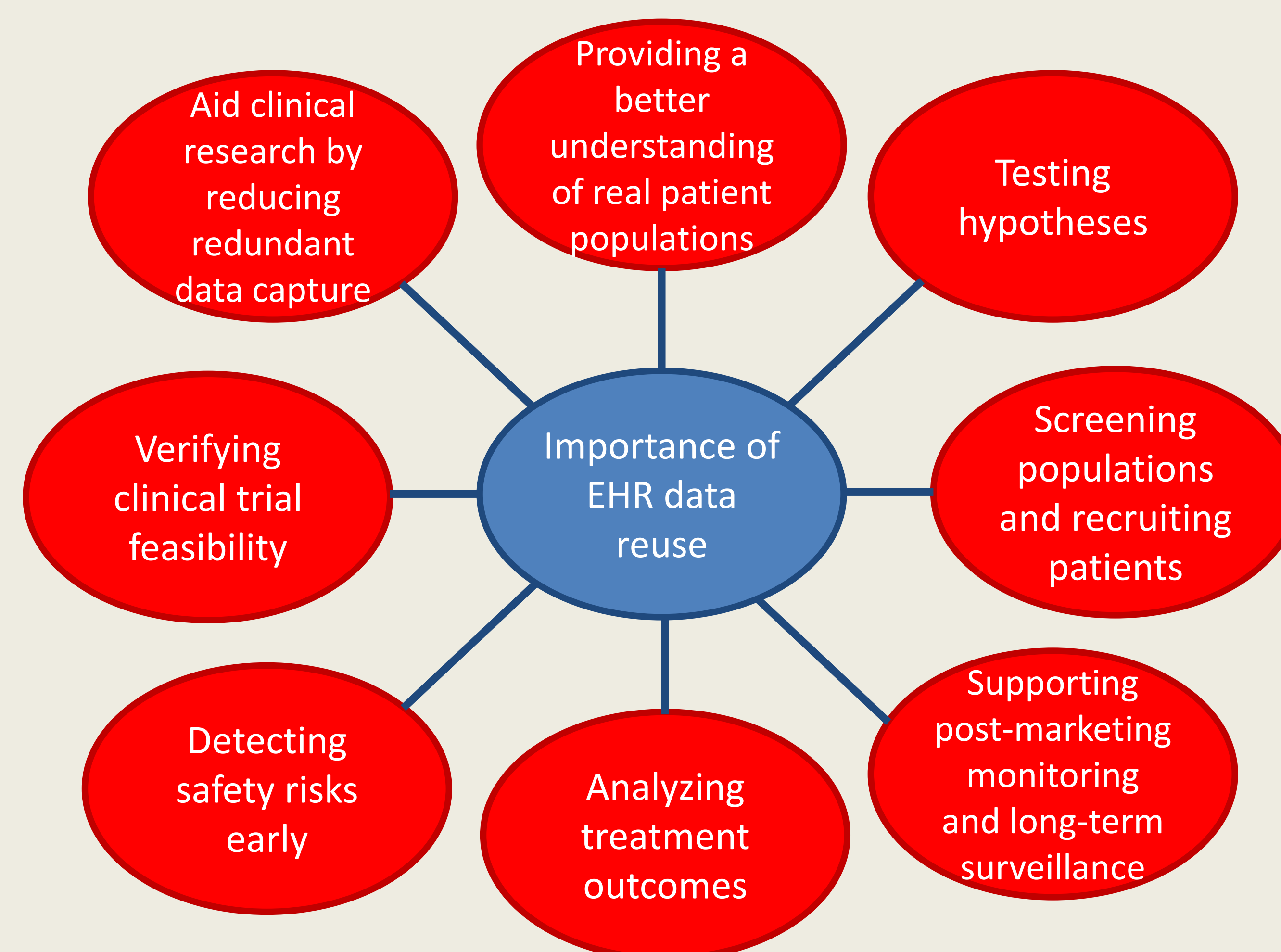


Figure 1. Importance of EHR data reuse [4]

Deriving benefits from the reuse of EHR data through data warehousing appears to be the best strategy [5]. One of the most important barriers to reach the objective of reusing EHR data across different institutions is the non-interoperability of their underlying storage systems [6].

The aim of this study was to investigate the feasibility of applying the HL7 Fast Healthcare Interoperability Resources (FHIR) standard to modeling and exposing EHR data of the Georges Pompidou European Hospital (HEGP) i2b2 clinical data warehouse (CDW) (table 1).

## MATERIAL AND METHODS

Table 1. Content of the HEGP i2b2 clinical data warehouse (as of July 1st, 2016) [7].

	September 2009	December 2013	July 2016
<b>Concepts</b>			
Biology (thousands)	7.29	9.1	11.2
Diagnostic codes (ICD-10) (thousands)	21.39	39.91	40.25
Drugs (thousands)	31.36	33.67	41.6
<b>Data facts</b>			
ICD Diagnosis (millions)	1.87	2.94	7.67
Clinical items (millions)	20.8	61.1	122.2
Laboratory results (millions)	62.8	98.0	124.3
Drug orders (millions)	0.95	3.2	6.4
Text reports (millions)	0.16	2.36	3.7

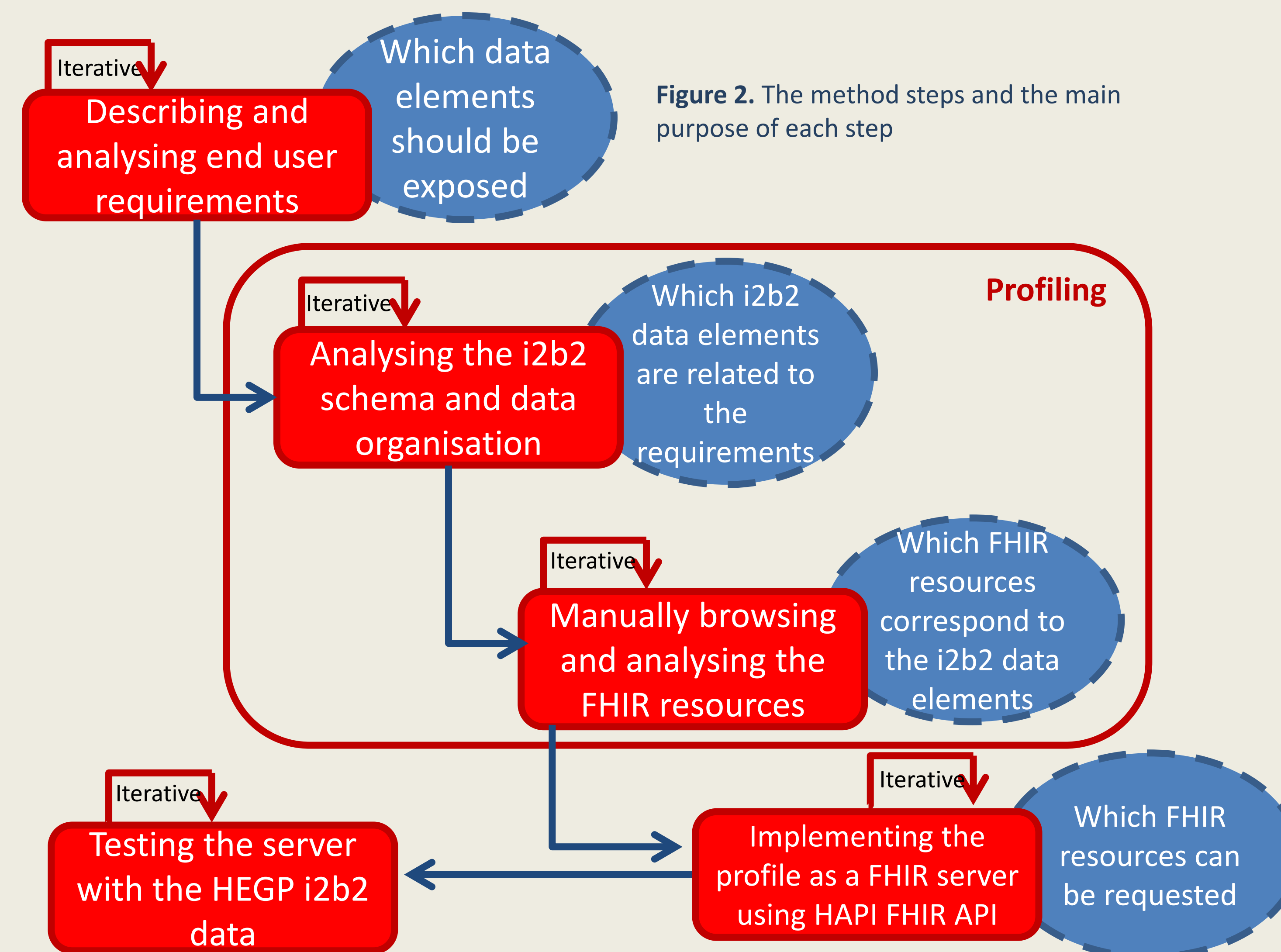


Figure 2. The method steps and the main purpose of each step

## RESULTS

The current architecture of the i2b2 FHIR server is composed of two main packages of Java classes (Fig. 3): the “i2b2 FHIR Resources” handles the client FHIR HTTP requests and the “DAO layer” allows setting up of the mapping between the requested FHIR resources and i2b2.

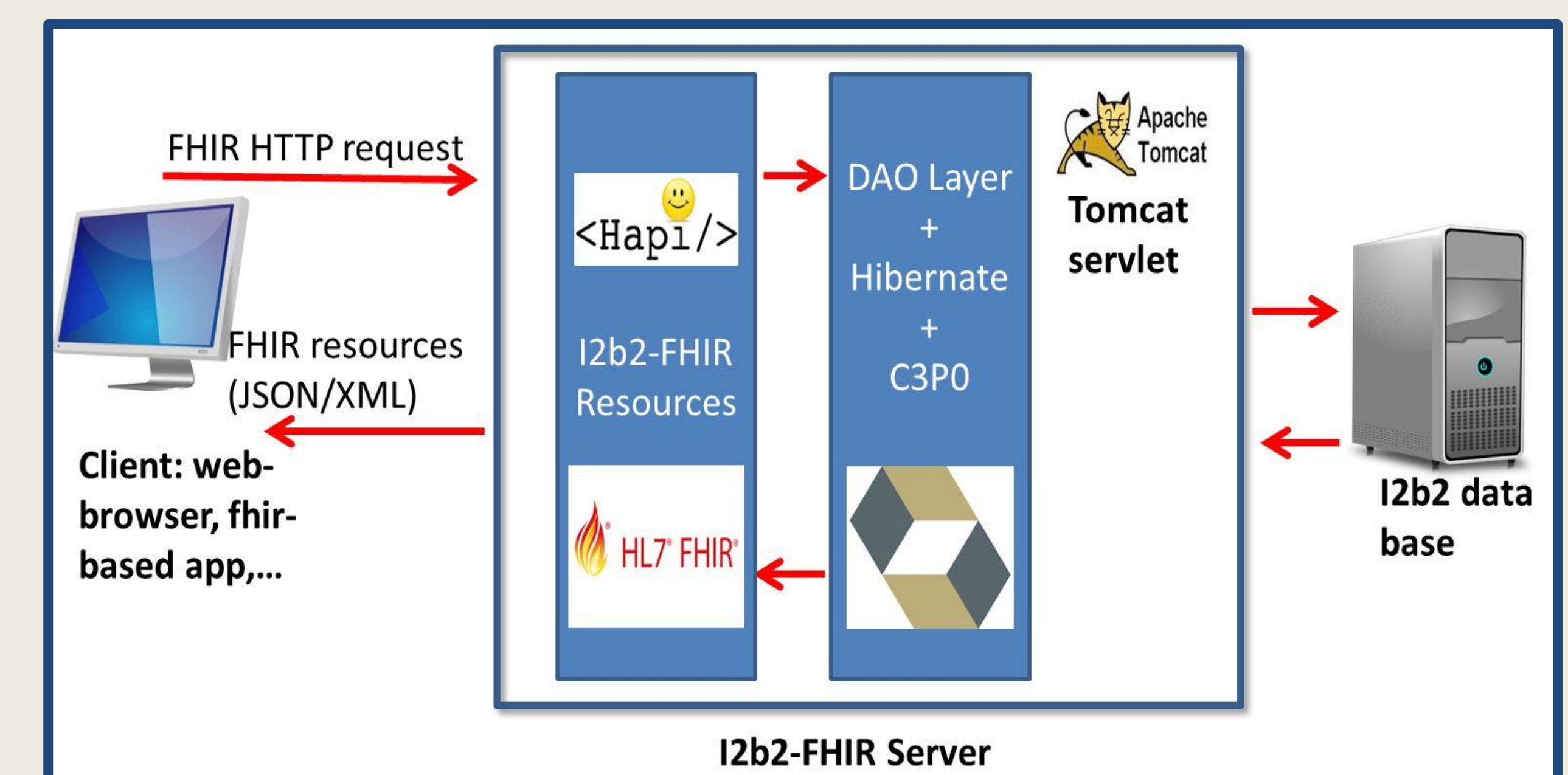


Figure 3. The i2b2 FHIR server architecture

The i2b2 FHIR resources layer contains the FHIR resource provider classes which implement the mapping between the local i2b2 data model and the FHIR resources (Table 2).

Two types of queries have been tested: Query type #1 (Table 3) requests the FHIR server to display FHIR DiagnosticReport resources, in which the diagnosis code is equal to “M321” in the ICD-10 coding system, corresponding to “systemic lupus erythematosus”. Query type #2 requests the FHIR server to display FHIR MedicationOrder resources, in which the FHIR Medication identification code is equal to “3400893219874” in the CIP coding system, corresponding to “BISOPROLOL BGR 1.25MG CPR”.

Table 2. Example of mapping between the i2b2 database fields and the FHIR resources fields

i2b2_Table: I2B2_FIELD:I2B2_FIELD_SPL IT	FHIR_Resource:FHIR_Class:FHIR _Attribute	System / Terminology - Ontology
Observation_fact:START_DATE:N/A	MedicationOrder:MedicationOrder:dateWritten	N/A
Observation_fact:UNIT_CD:QUANTITE	MedicationOrder:DispenseRequest:Quantity:value	N/A
Observation_fact:UNIT_CD:UNITEPRESCT	MedicationOrder:MedicationOrder:unit	<a href="http://medicationprescriptionunit.hegp.fr">http://medicationprescriptionunit.hegp.fr</a>
Observation_fact:UNIT_CD:FRZJOUR	MedicationOrder:DosageInstruction:Timing:text	N/A

Table 3. Example of FHIR queries that can be executed using the i2b2 FHIR server

	FHIR query	Number of returned FHIR resources	Number of patients
#1	<a href="http://10.XXX.XXX.XX:8080/FhirServerV12/i2b2Layer/DiagnosticReport?code=M321&amp; include=DiagnosticReport:subject&amp; include=DiagnosticReport:encounter">http://10.XXX.XXX.XX:8080/FhirServerV12/i2b2Layer/DiagnosticReport?code=M321&amp; include=DiagnosticReport:subject&amp; include=DiagnosticReport:encounter</a>	80 FHIR DiagnosticReport	36
#2	<a href="http://10.XXX.XXX.XX:8080/FhirServerV12/i2b2Layer/MedicationOrder?medication.code=3400893219874&amp; include=MedicationOrder:patient&amp; include=MedicationOrder:encounter&amp; include=MedicationOrder:medication">http://10.XXX.XXX.XX:8080/FhirServerV12/i2b2Layer/MedicationOrder?medication.code=3400893219874&amp; include=MedicationOrder:patient&amp; include=MedicationOrder:encounter&amp; include=MedicationOrder:medication</a>	503 FHIR MedicationOrder	290

## CONCLUSION

We have been able to show the feasibility of implementing a FHIR layer over the i2b2 database model to expose data of the HEGP CDW as a set of FHIR resources using the HAPI FHIR API. An important part of this work was the structural and semantic mapping between the i2b2 model and the FHIR reference model (Figure 2, steps 2 and 3). The code source is freely available online as open source: <https://github.com/3abdel3ali/HAPI-FHIR-based-I2B2-Layer>

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