

## 4. Tutorials: Using the i2b2 CDM

This chapter contains a series of tutorials that describe how to model different types of data using the i2b2 CDM. The tutorials start with simpler, more common use cases, and progress to more advanced concepts.

### 4.1 Diagnoses and Demographics (Basic Facts)

Below are examples of basic facts in the i2b2 CDM.

A diagnosis, such as acute pharyngitis, has an associated code, such as "ICD10:J02.9". The customizable i2b2 ontology defines the concept and codes. Different sites might use their own codes for the acute pharyngitis. The observation of this diagnosis is stored as a record in the OBSERVATION\_FACT table. A patient\_num (1000001), encounter\_num (730868), and start\_date (2017-10-22) are required. A provider\_id, modifier\_cd, and instance\_num are also required, but these can be set to their default values, "@", "@", and 1.

The patient\_num and encounter\_num corresponding to these diagnoses must be listed in the PATIENT\_DIMENSION and VISIT\_DIMENSION tables. In this example, the patient is female (sex\_cd=F) and white (race\_cd=W). The encounter is an outpatient visit (inout\_cd=O), with start\_date and end\_date both October 22, 2017.

Note that the date of the observation in the OBSERVATION\_FACT table can be different from the dates in the VISIT\_DIMENSION. This is illustrated in a second diagnosis of asthma (ICD10:J45.909), which was recorded the day after the patient was discharged from an inpatient visit (encounter\_num=798502). This diagnosis also has a provider (the observer). The PROVIDER\_DIMENSION lists the provider (provider\_id=X1824); it indicates her name is Jane Smith; and, the path can be used to group providers, for example, by department or specialty. In this example, the asthma diagnosis is duplicated. When this occurs, the instance\_num must be incremented to ensure that the primary keys of each record are unique.

The i2b2 ontology enables concepts to be modeled in different ways. For example, the ontology can specify that the race\_cd field of the PATIENT\_DIMENSION be used to store the patient's race. Having all demographics in the PATIENT\_DIMENSION table can simplify certain analyses. Alternatively, race can be an observation stored in the OBSERVATION\_FACT table (e.g., concept\_cd="DEM|Race:W"). This can be useful if demographics are separately recorded for each admission, or if there is a need to store multiple races for a patient.

The CONCEPT\_DIMENSION table has vocabulary terms that map to the codes used in the concept\_cd field of the OBSERVATION\_FACT table. Terms may be grouped into hierarchies. The hierarchical representation used in the concept table is similar to that of a hierarchical file system. The parent term is positioned in the "folder" position of the path, and the child term in the "file" position. In the examples here, acute pharyngitis and asthma both have paths that are children of the term "Diseases of the Respiratory System". In the i2b2 and transSMART software, a query for the parent term will match the concept\_cd codes corresponding to any of the child nodes.

#### OBSERVATION\_FACT

patient_num	encounter_num	concept_cd	provider_id	start_date	modifier_cd	instance_num
1000001	730868	ICD10:J02.9	@	2017-10-22	@	1
1000001	798502	ICD10:J45.909	X1824	2018-02-12	@	1
1000001	798502	ICD10:J45.909	X1824	2018-02-12	@	2
1000001	798502	DEM Race:W	@	2018-02-08	@	1

#### PATIENT\_DIMENSION

patient_num	sex_cd	race_cd
1000001	F	W

#### VISIT\_DIMENSION

encounter_num	patient_num	inout_cd	start_date	end_date
730868	1000001	O	2017-10-22	2017-10-22
798502	1000001	I	2018-02-08	2018-02-11

#### PROVIDER\_DIMENSION

provider_path	provider_id	name_char
Medicine\Pulmonary\X1824\	X1824	Jane Smith, MD

#### CONCEPT\_DIMENSION

concept_path	concept_cd	name_char
Dem\Race\White\	DEM Race:W	White
Diag\ICD10\J00-J99\	ICD10:J	Diseases of the Respiratory System
Diag\ICD10\J00-J99\J02\J02.9\	ICD10:J02.9	Acute pharyngitis, unspecified
Diag\ICD10\J00-J99\J45\J45.909\	ICD10:J45.909	Unspecified asthma, uncomplicated

Figure 2. Example data in the i2b2 CDM.

## 4.2 Laboratory Tests and Vital Signs (Value Constraints)

Laboratory tests, vital signs, and other data types can have an associated value. The OBSERVATION\_FACT table contains six fields to store values: VALTYPE\_CD, TVAL\_CHAR, NVAL\_CHAR, VALUEFLAG\_CD, UNITS\_CD, and OBSERVATION\_BLOB. A description of these fields are at

<https://community.i2b2.org/wiki/display/ServerSideDesign/Value+Columns>

Note that the i2b2 and transSMART ontology must be configured properly so that the software uses these value-related fields. A description of how the ontology works with the value fields is at

<https://community.i2b2.org/wiki/display/ServerSideDesign/Example+of+Value+Constraints+Used+in+Queries>

Additional information about the i2b2 Ontology Management Cell can be found at

<https://community.i2b2.org/wiki/display/ServerSideDesign/Ontology+Management+%28ONT%29+Cell>

## 4.3 Medications, Procedures and Allergies (Modifiers)

A single observation can be represented in the i2b2 CDM as a fact with an unlimited number of modifier codes. A medication, for example, can be modified with dose, route, and frequency. Each of these modifiers is stored as a separate record in the OBSERVATION\_FACT table.

For example, a prescription for Aspirin 325 mg QD PO on 4/4/2010 is stored as four records. All four have "med:aspirin" as the CONCEPT\_CD and "4/4/2010" as the START\_DATE. The "base" record for the observation uses "@" for the MODIFIER\_CD. The three modifier records have MODIFIER\_CD values of "MED:DOSE", "MED:FREQ", and "MED:ROUTE", with their associated values (325 mg, "QD", and "PO") stored in the value fields. In this example, the concept med:aspirin is defined in the CONCEPT\_DIMENSION tables; and, the three modifier codes, MED:DOSE, MED:FREQ, and MED:ROUTE, are defined in the MODIFIER\_DIMENSION table. The i2b2 and transSMART software also require these to be included in the ontology. A more detailed description of this example and an example using procedures are available at

<https://community.i2b2.org/wiki/display/DevForum/Modifiers+in+i2b2+Data+Model>

Modifiers can be used for many other things, such as indicating whether a diagnosis is primary or secondary or adding stage to a cancer diagnosis. Another example using modifiers to indicate patients' allergies is at

<https://community.i2b2.org/wiki/display/DevForum/Representing+Allergies+in+Star+Schema+with+modifiers>

## 4.4 Clinical Notes, Imaging and Genomics Data (Blob Data)

### Clinical Notes

There is a wealth of information within the plain text clinical narrative. Notes can be represented in the i2b2 CDM in a couple ways. First, the entire note can be a single record in the OBSERVATION\_FACT table. The concept\_cd can be, for example, "NOTE:DischargeSummary"; and, the text of the note is stored in the observation\_blob field. This field contains a FULLTEXT index in the Microsoft SQL Server implementation of the i2b2 CDM to enable efficient searches of notes. A description of text search in i2b2 is at

<https://community.i2b2.org/wiki/display/DevForum/Text+search+in+i2b2>

Alternatively, natural language processing (NLP) software can be used to extract concepts from notes. Each concept can be stored as a separate record in the OBSERVATION\_FACT table. An example of this using the NLP CTAKES program is at

<https://community.i2b2.org/wiki/display/NLPCTAKES/NLP+cTakes+Home>

### Imaging Data

The observation\_blob field can also be used to store binary data, such as medical images. An example of this was a project called mi2b2 (Medical Imaging Informatics Bench to Bedside), which linked i2b2 to separate PACS (Picture Archiving and Communication System) systems. Although the original images were stored in the PACS systems, a thumbnail version was placed in the i2b2 observation\_blob field, so that it could be previewed within the i2b2 user interface. A description of mi2b2 is at

<https://community.i2b2.org/wiki/display/mi2b2/mi2b2+User+Documentation>

### Genomics Data

Like notes, genomics data can be modeled in different ways. A tutorial showing how to load genomic VCF (Variant Call Format) files into the observation\_blob field is at

<https://community.i2b2.org/wiki/display/IGD/Demo+Data>

## 4.5 Lab Panels and Specimens (Dummy Records)

The encounter\_num typically represents a visit. However, it can also be used more generally to group related observations. A "dummy" encounter\_num value, for example, can be created that corresponds to a lab panel, such as a complete blood count (CBC). The start\_date for this encounter in the VISIT\_DIMENSION table could be the specimen date. The results of each test within the panel are stored as separate records in the OBSERVATION\_FACT table, using the same encounter\_num.

## 4.6 Clinical Trial Data (Extending the Data Model)

Encounters in clinical trials are often associated with a visit number. The VISIT\_DIMENSION table can be extended with a visit\_num field to store the visit number. The ontology can include a concept for the visit number that points to this field, so that the user can query for observations that occurred as part of a particular visit number.