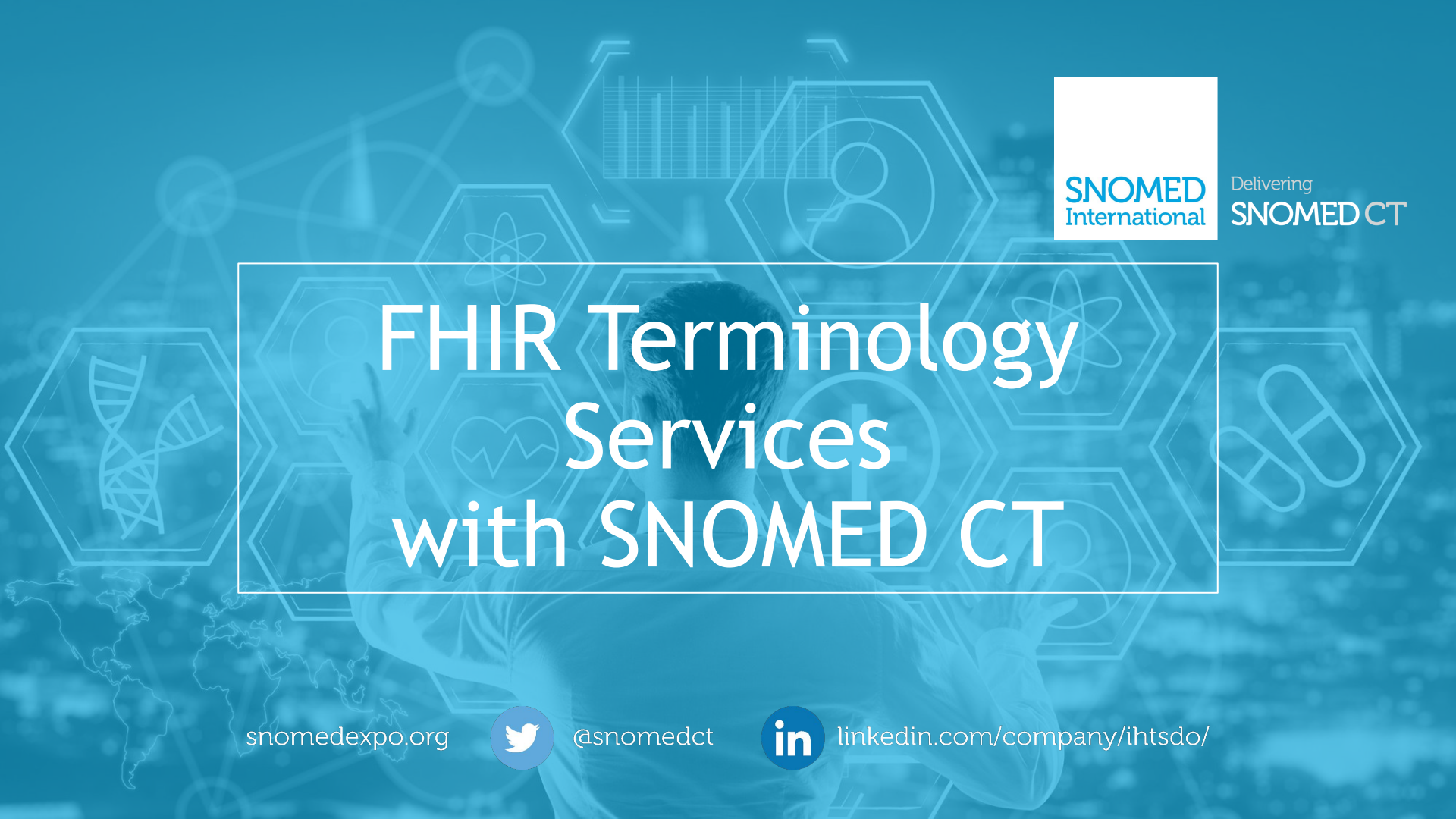
SNOMED International
Delivering SNOMED CT
FHIR Terminology Services with SNOMED CT
snomedexpo.org
@snomedct
linkedin.com/company/ihtsdo/

Objective

The objective of this workshop is to:

- Gain a basic understanding of SNOMED CT enabled terminology services and Snowstorm
- Learn how to deploy Snowstorm Lite in your local environments
- Understand how to use FHIR terminology services

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Outline

9-11	**Set up Snowstorm Lite and Import SNOMED CT** Welcome and introductions *Local introduction* Introduction to SNOMED CT enabled terminology services Snowstorm Lite setup and Import of SNOMED
10h45	***Break***
11-13	**Use Snowstorm Lite to access and query SNOMED CT** Use cases for FHIR Terminology services Practice using terminology services Wrap-up and questions

snomed.org/dev-training

3

SNOMED International

Introduction

SNOMED CT

The global language of healthcare

The world's most comprehensive multilingual clinical terminology

A Brief History

2002

First release of SNOMED CT
(merge of SNOMED and Read Codes)

2007

Acquired by IHTSDO
for the public good in 2007

2017

IHTSDO adopted the trading
name **SNOMED International**

Who is involved now?

49
SNOMED
International
MEMBER

Americas

Argentina
Canada
Chile
El Salvador
Jamaica
United States
Uruguay

Europ frica

Andorra
Austria
Belgium
Croatia
Cyprus
Czech Republic
Denmark
Estonia
Finland
France
Hungary
Iceland
Ireland
Israel
Jordan
Lithuania
Luxembourg
Malta
Netherlands
Poland
Portugal
Republic of Slovenia
Saudi Arabia
Slovak Republic
Spain
Sweden
Switzerland
United Arab Emirates
United Kingdom

Asia Pacific

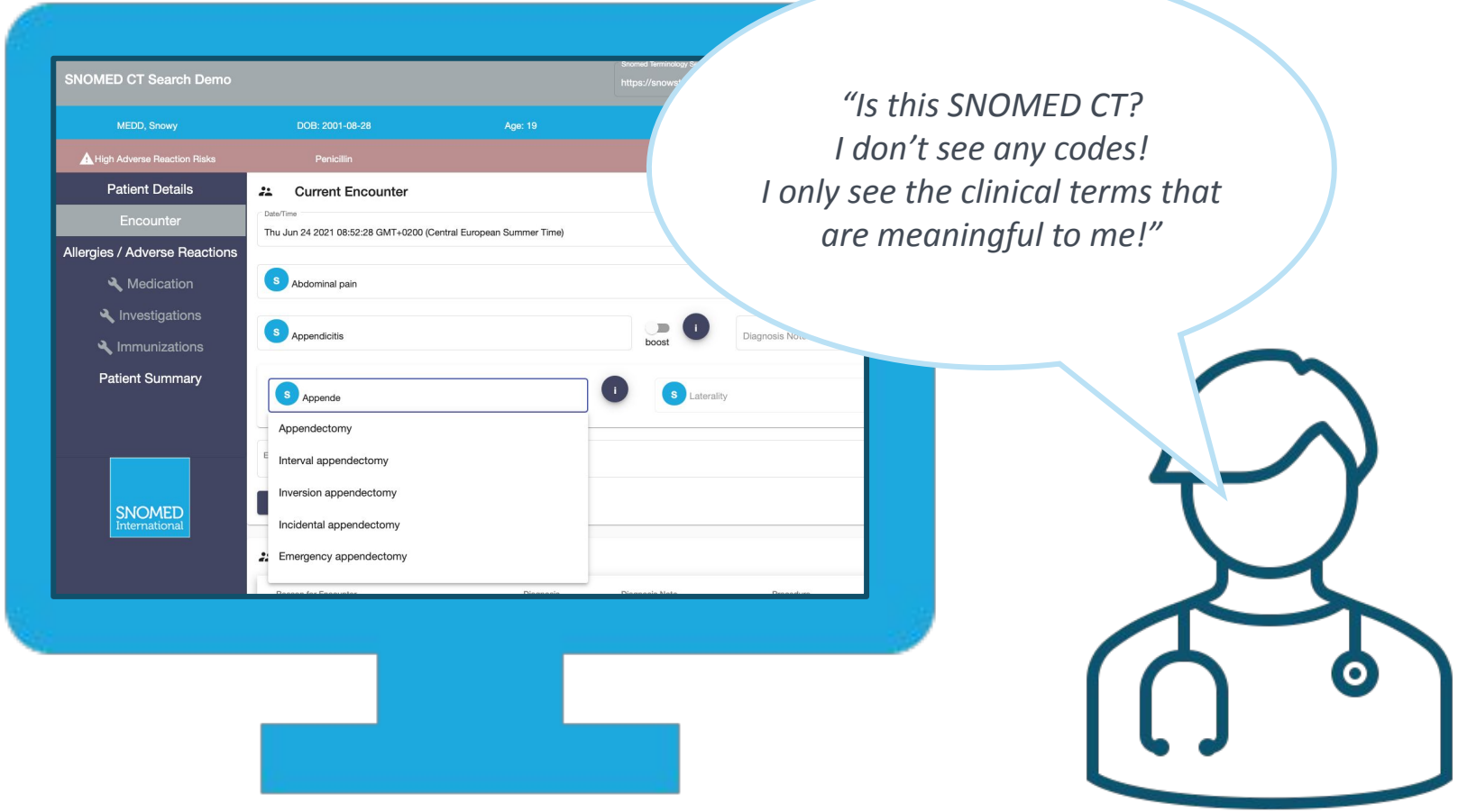
Australia
Brunei
Hong Kong, China
India
Indonesia
Kazakhstan
Malaysia
New Zealand
Republic of Korea
Singapore
Thailand

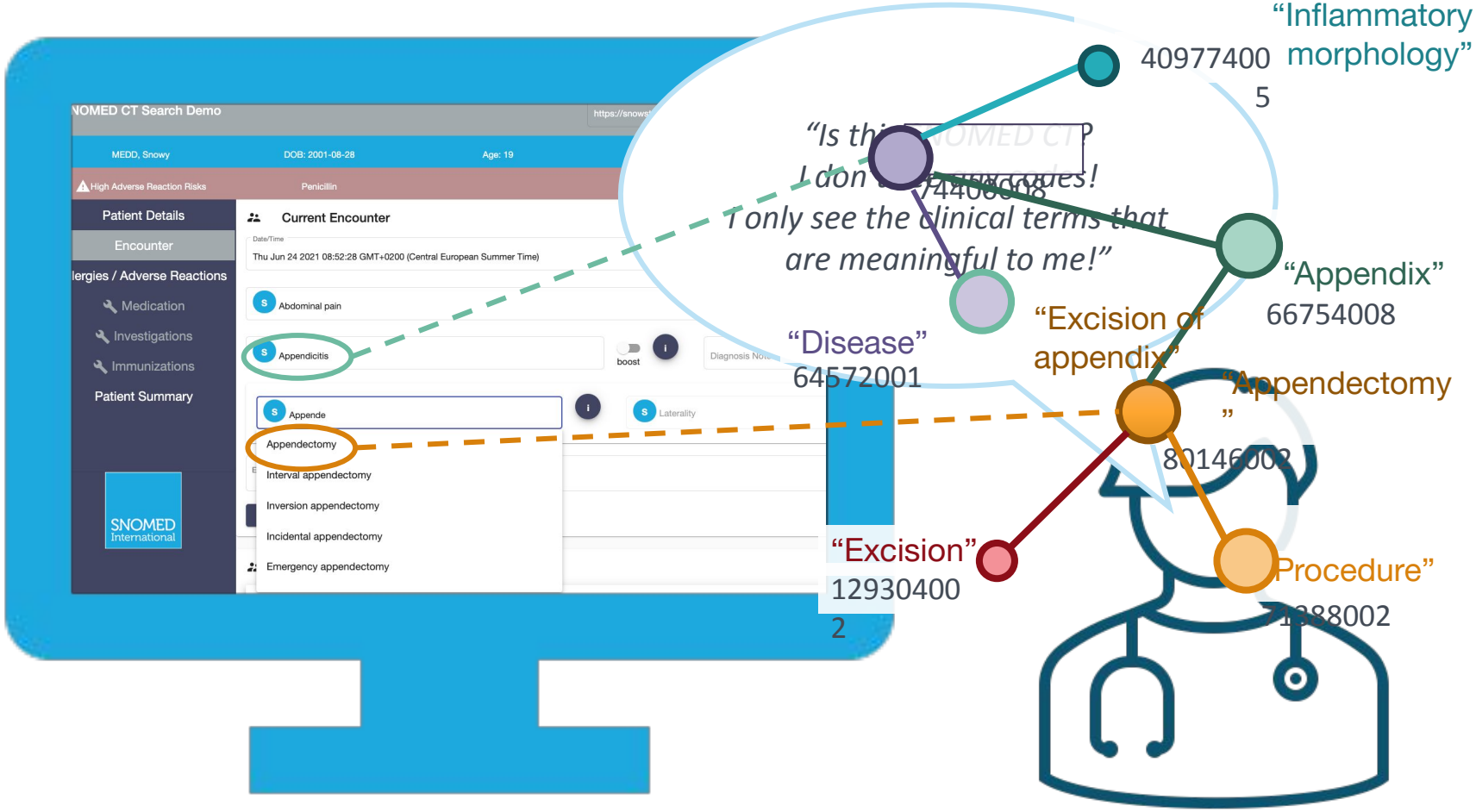
What is SNOMED CT?

It represents clinical meanings uniquely and has a built-in semantic network

Definitions

More than 360.000 active concepts


SNOMED CT Search Demo
MEDD, Snowy
DOB: 2001-08-28
Age: 19
High Adverse Reaction Risks
Penicillin
Patient Details
Encounter
Allergies / Adverse Reactions
Medication
Investigations
Immunizations
Patient Summary
SNOMED International
Current Encounter
Date/Time
Thu Jun 24 2021 08:52:28 GMT+0200 (Central European Summer Time)
Abdominal pain
Appendicitis
boost
Appende
Laterality
Appendectomy
Interval appendectomy
Inversion appendectomy
Incidental appendectomy
Emergency appendectomy
"Is this SNOMED CT?
I don't see any codes!
I only see the clinical terms that
are meaningful to me!"


NOMED CT Search Demo
MEDD, Snowy
DOB: 2001-08-28
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lergies / Adverse Reactions
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Abdominal pain
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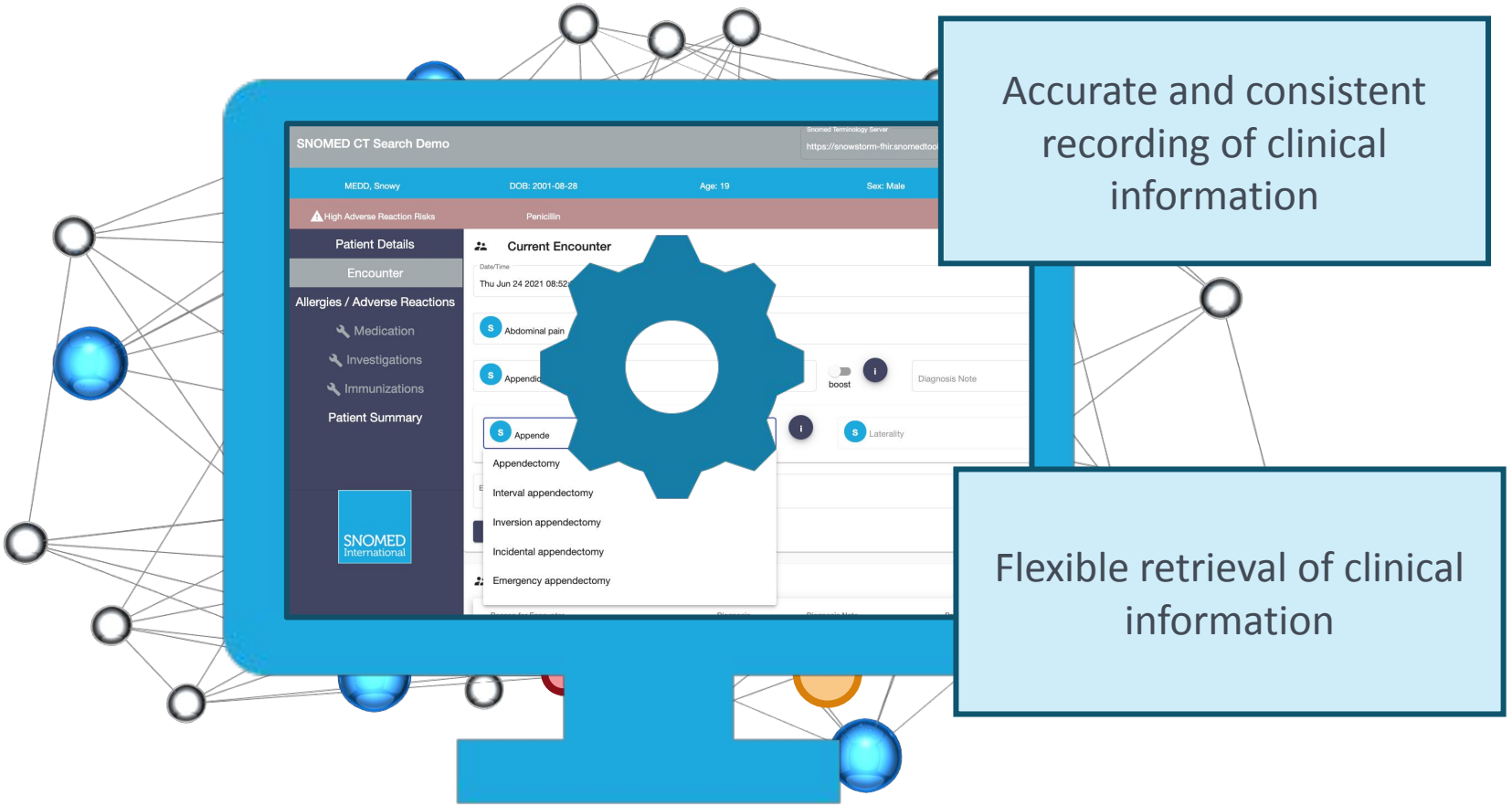
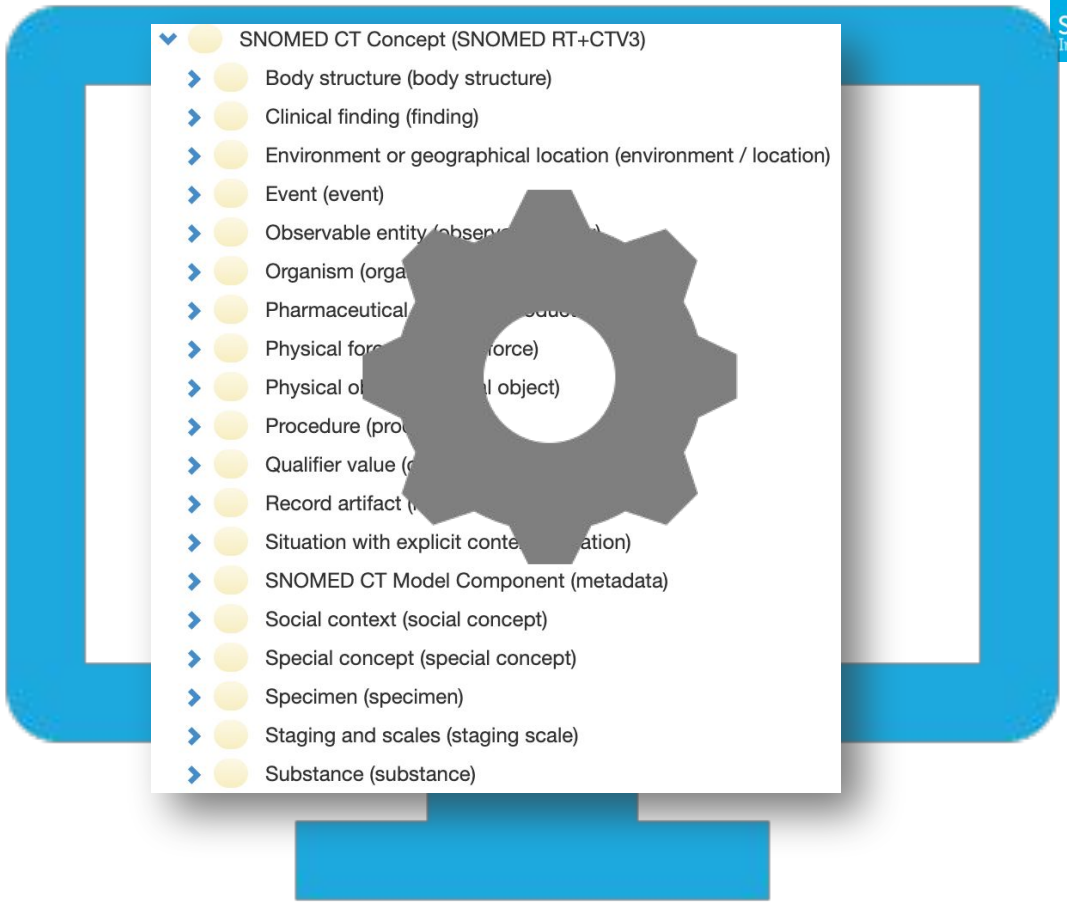
Appendectomy
Interval appendectomy
Inversion appendectomy
Incidental appendectomy
Emergency appendectomy
"Is this SNOMED CT?
I don't speak codes!
I only see the clinical terms that are meaningful to me!"
"Disease"
64572001
"Excision of appendix"
"Appendectomy"
80146002
"Excision"
129304002
"Inflammatory morphology"
409774005
"Appendix"
66754008
"Procedure"
71388002



Accurate and consistent recording of clinical information

Flexible retrieval of clinical information

Enabling the benefits of SNOMED CT requires it to be part of a well-designed system



SNOMED CT Enabled Health Record

A digital record of health information related to individual patients

Examples of SNOMED CT encoded data

- Signs and symptoms
- Diagnosis
- Procedures
- Tests and test results

SNOMED CT Enabled Terminology Server

Content

- Codes (Concepts)
- Terms (Descriptions)
- Knowledge Graph (Relationships)
- Subsets and Maps

Examples of SNOMED CT enabled services

- Search for concepts
  - using all active terms
  - within logical constraints
- Validate that concepts are within a subset
- Translate codes using maps
- Support frequent low cost terminology updates

Services can be reused in multiple systems

Health Record

Easy updating and maintenance

API

Terminology Server

API

API

Health Record

Health Record

Search and data entry

Knowledge linkage and decision support

Health Record

API

Terminology Server

Data retrieval and analytics

Data storage

Communication and exchange

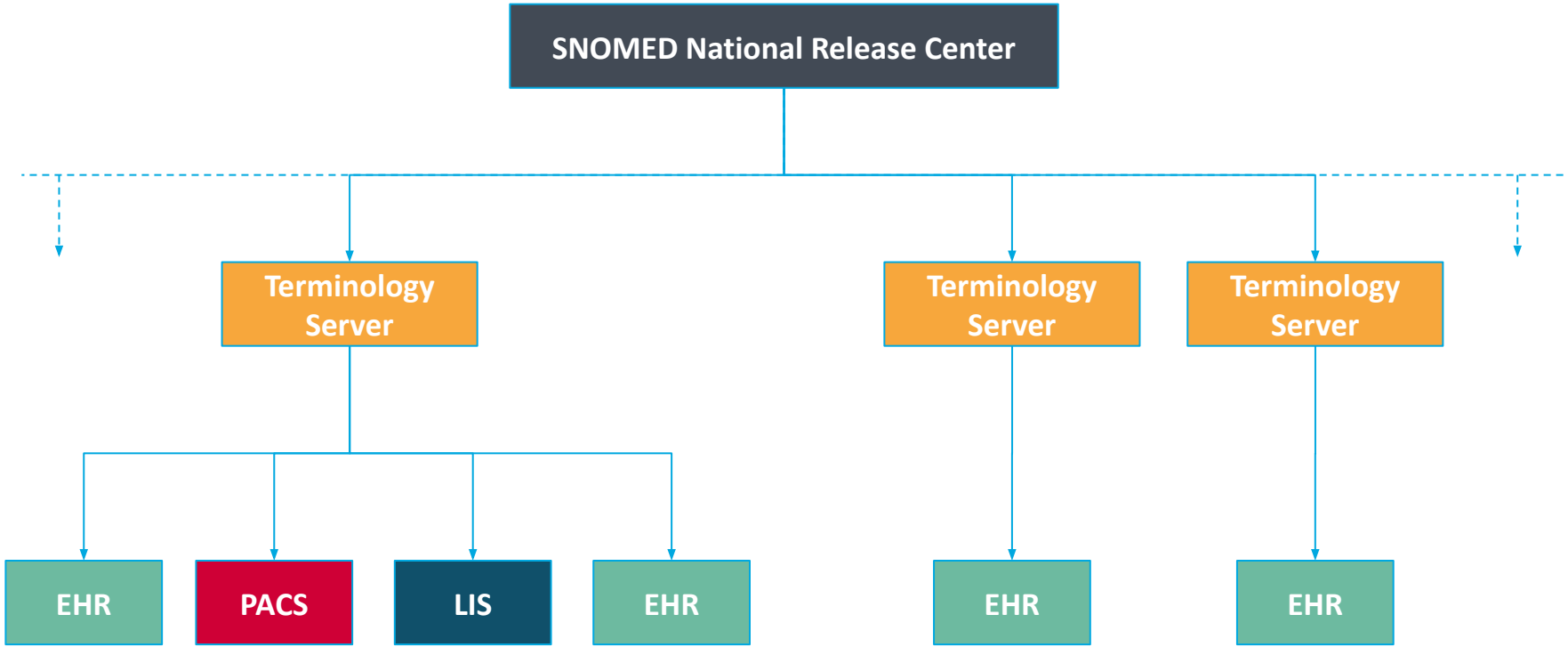
Terminology Services

Why use Terminology Services?

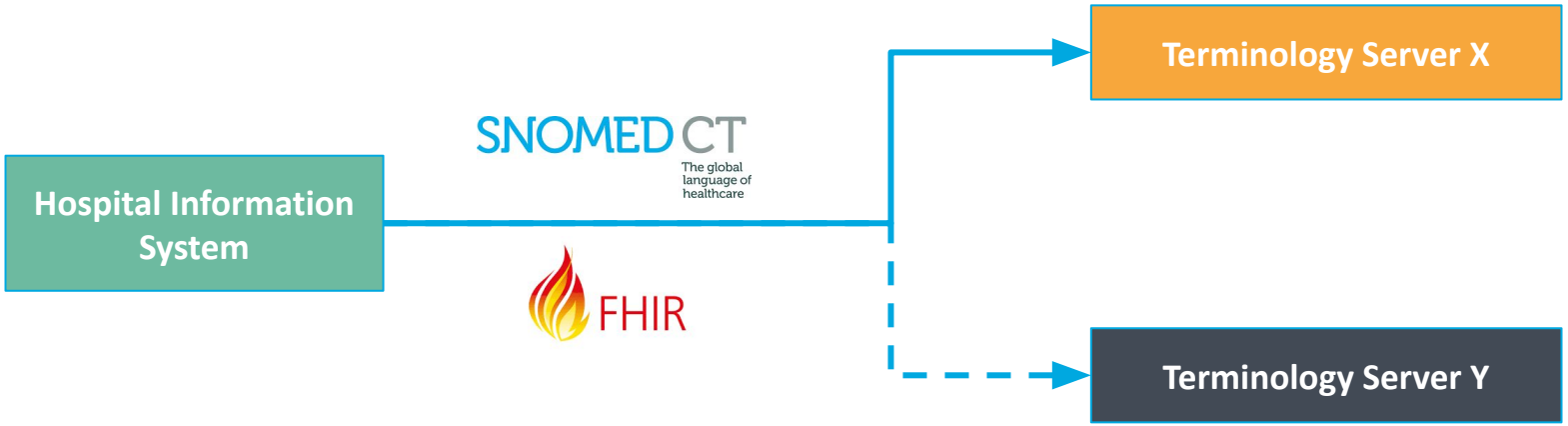
- Search algorithms are the key for effective data entry
- Terminology navigation and retrieval requires optimization
- Queries are constructed using standard languages
- Terminologies are updated frequently

… it's a good separation of concerns

Terminology Services Architecture



Standards in Terminology Services



Standards provide flexibility, simplify software integration, and prevent lock-in

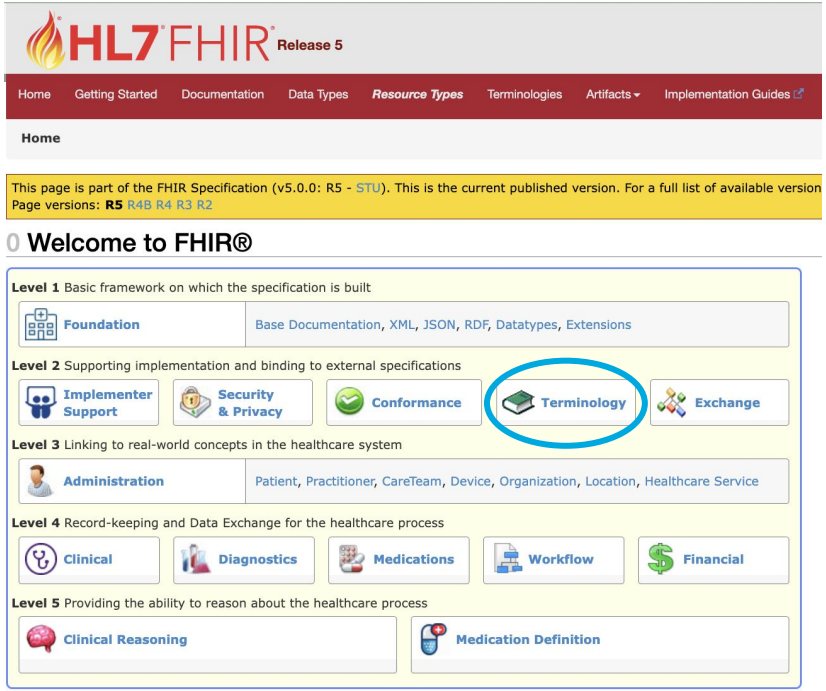
SNOMED CT and HL7 FHIR

Introduction to HL7 FHIR
Terminology Module

The **Terminology Module,** part of FHIR API spec.

Standard way to interact with terminologies and classifications from many publishers:
HL7, *WHO*, *Regenstrief*,
SNOMED International and Members,
many others.

Some of the key fields within the **Clinical**, **Diagnostics** and **Medications** resources may use codes from SNOMED CT
… *"Terminology Binding"*



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Introduction to HL7 FHIR
Terminology Module

The main Terminology **Resources** are:

- **CodeSystem**
  - examples: “SNOMED CT International Edition - Jan 2024”, “LOINC v2.76” or “ICD-10 Version:2019”
- **ValueSet**
  - examples: “Nursing Activities Subset” or “Clinical Procedures”
- **ConceptMap**
  - e.g. “SNOMED CT to ICD-10 Map” or “SNOMED CT to MedDRA Map”

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Introduction to HL7 FHIR
Terminology Operations

A brief summary of the main **Operations** that can be performed on the **Resources**:

- CodeSystem
  - **$lookup** - view the details of a single code / concept
  - **$validate-code** - check that a code (and term) is within a specific CodeSystem
  - **$subsumes** - test if there is an ancestor / descendant relationship between a pair of codes
- ValueSet
  - **$expand** - list all, or search within, the codes in a ValueSet
  - **$validate-code** - check that a code (and term) is within a specific ValueSet
- ConceptMap
  - **$translate** - translate a code from one CodeSystem to a code within another CodeSystem

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Snowstorm and Snowstorm Lite

Snowstorm

Developed to support the **SNOMED CT Browser** and **Authoring Platform**

Capable of hosting many versions of SNOMED CT at once
The FHIR API can also host LOINC ICD-10 and many others

Uses Elasticsearch as a data store

Elasticsearch

Requires a server with at least 8g of memory

Supports the complete ECL query language

SNOWSTORM
by SNOMED International

Snowstorm *Lite*

Developed to as a fast lightweight alternative to Snowstorm
to support the **Bahmni Open Source EHR**

Capable of hosting only one version of SNOMED CT at once
Not able to host LOINC, ICD-10 or anything else

Uses Lucene as a data store

Requires just 1g of memory

Supports the most useful parts
ECL query language

SNOWSTORM
by SNOMED International

Snowstorm Lite Setup

Snowstorm Lite
Setup Options

Step 1: Run the application

Use one of the following options..

Option 1: Docker container
- *Pull image from Docker Hub*

Option 2: Native Java application
- *Download jar from GitHub releases page*

Step 2: Load SNOMED CT

Use one of the following options..

- **Option 1**: Automatic loading with Syndication
  - *Use MLDS login to pull a release down*
- **Option 2**: Manual loading via API
  - *Download SNOMED release and post to Snowstorm Lite API*

Full details at: github.com/ihtsdo/snowstorm-lite

SNOWSTORM by SNOMED International

SNOWSTORM
by SNOMED International

Snowstorm Lite

Docker & Syndication Setup

Start Docker Desktop, then on the command line..

Pull the Docker image

```
docker pull snomedinternational/snowstorm-lite:latest
```

Start Snowstorm Lite, loading SNOMED CT Austrian Edition using Syndication

```
docker run -i -t -p 8080:8080 snomedinternational/snowstorm-lite \
  --admin.password=somePassword \
  --syndicate --version-uri=http://snomed.info/sct/11000234105
```

Full details at: github.com/ihtsdo/snowstorm-lite

SNOMED International

Delivering SNOMED CT

snomed.org @snomedct linkedin.com/company/ihtsdo/

Outline

9-11	**Set up Snowstorm Lite and Import SNOMED CT** Welcome and introductions *Local introduction* Introduction to SNOMED CT enabled terminology services Snowstorm Lite setup and Import of SNOMED
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Use Cases for Terminology Services

Search and data entry

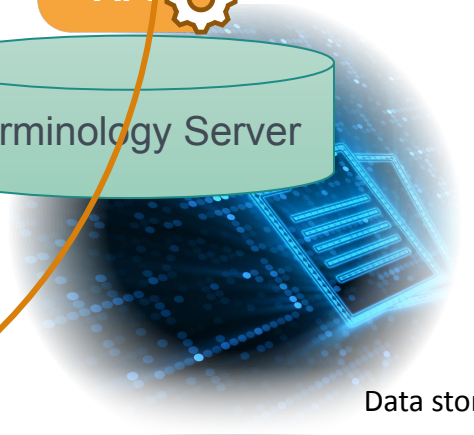
Knowledge linkage and decision support

Health Record

API

Terminology Server

Data retrieval and analytics



Data storage

Communication and exchange

UI Demonstration

snomed.org/ui

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Search and data entry

Health Record

API

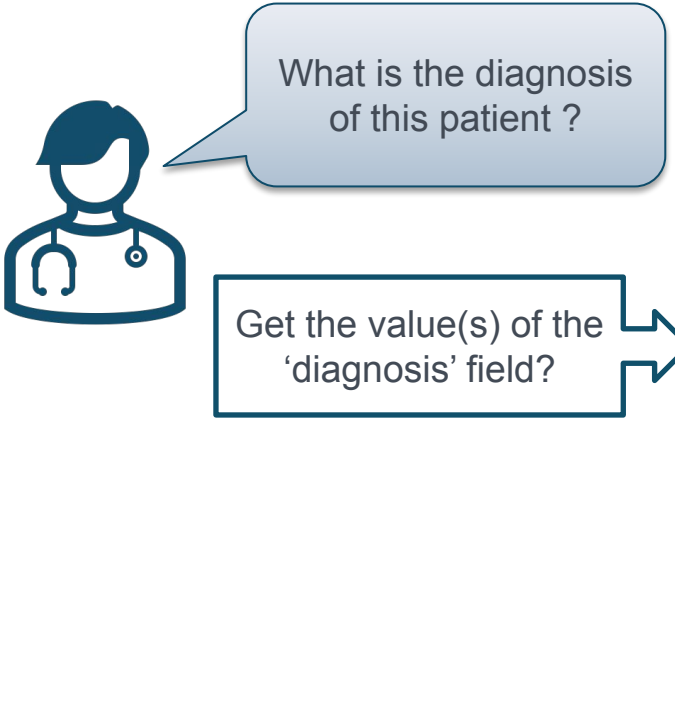
Terminology Server

Knowledge linkage and decision support

Data retrieval and analytics

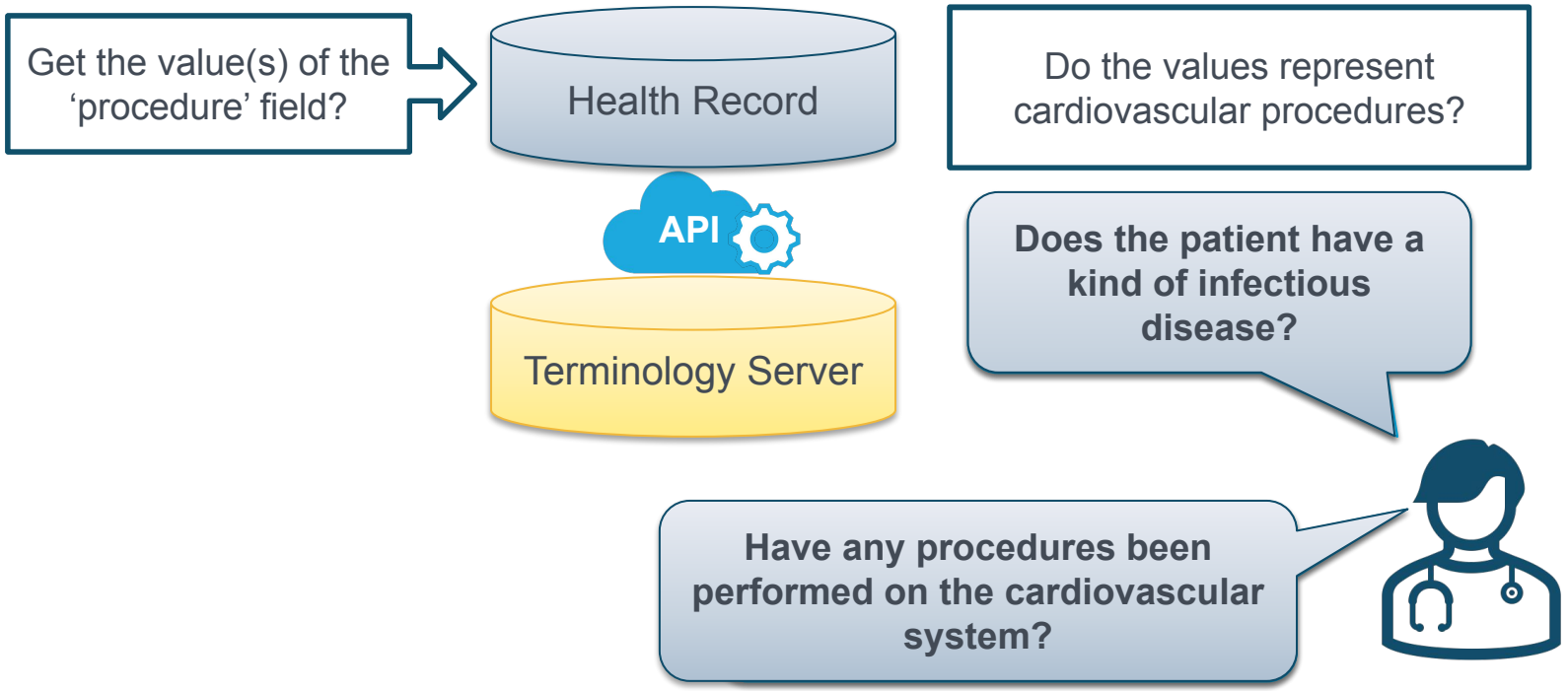
Data storage

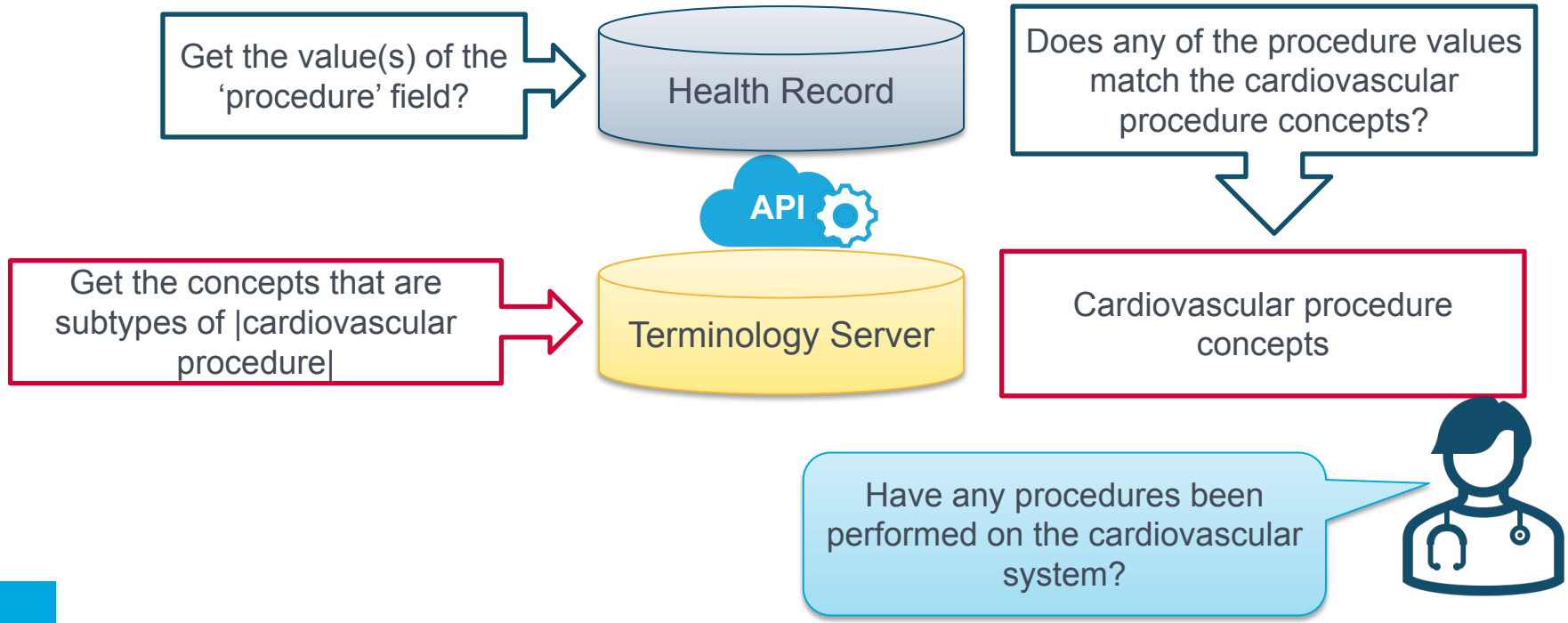
Communication and exchange

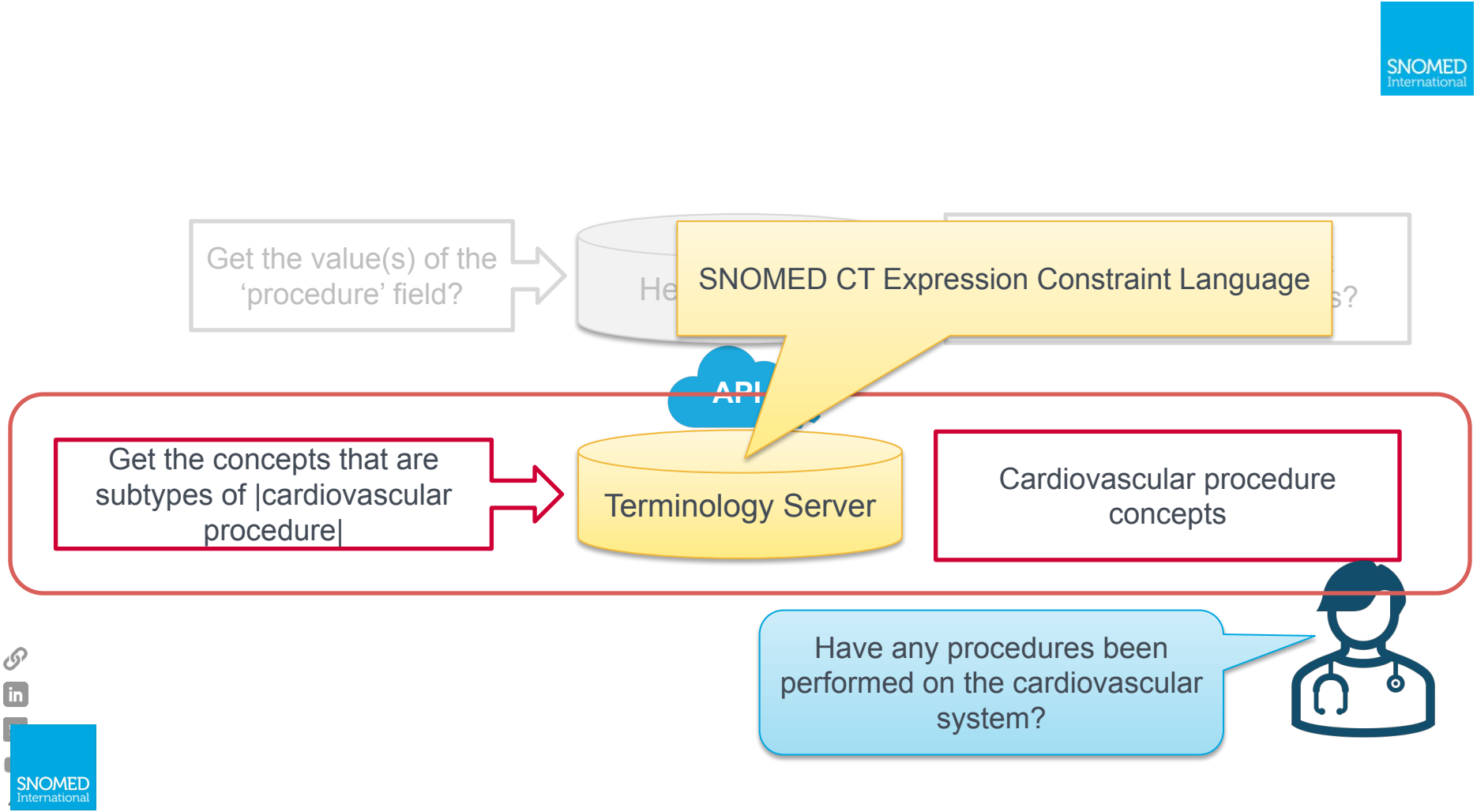


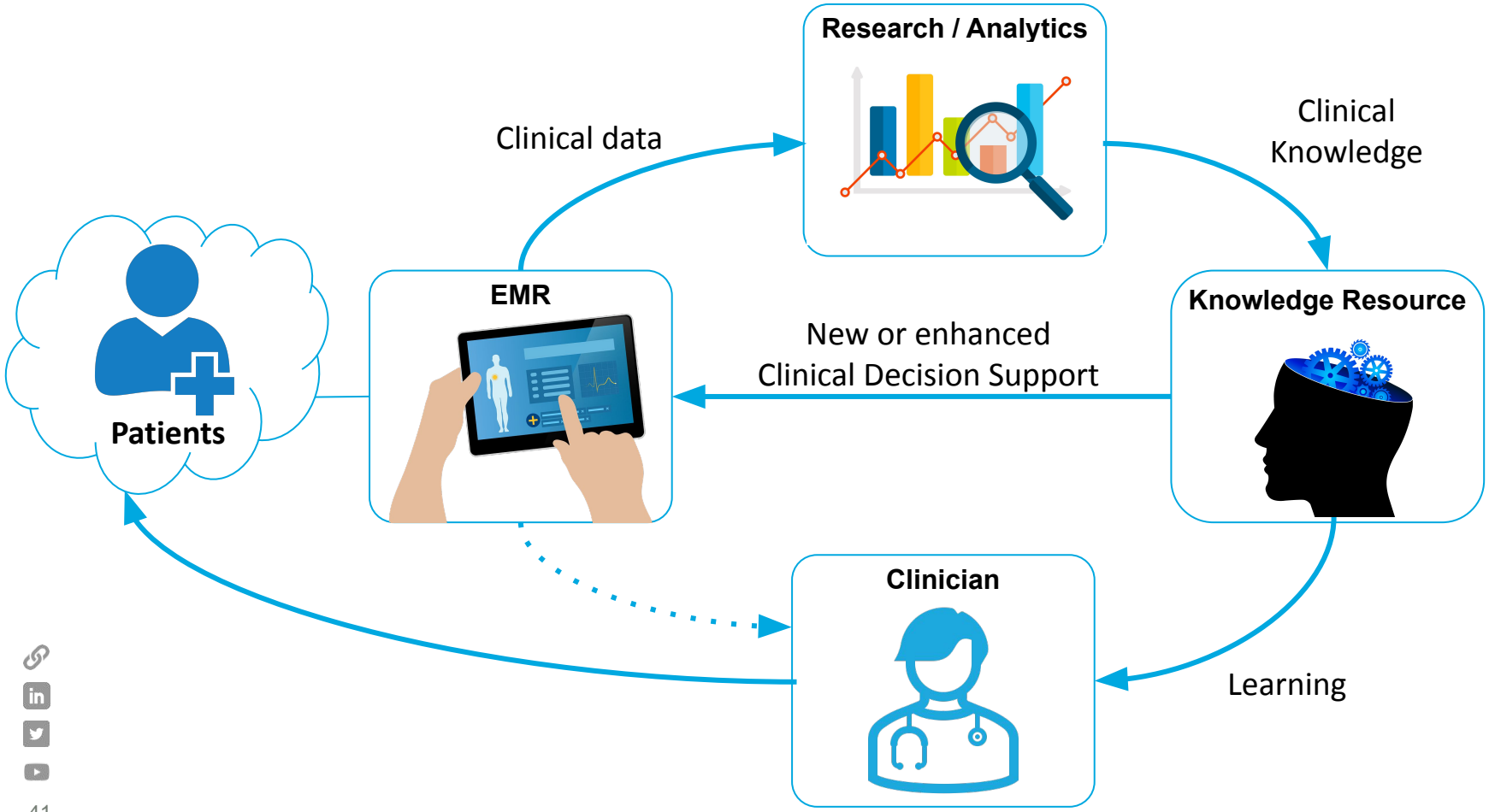
May be answered using the information structure

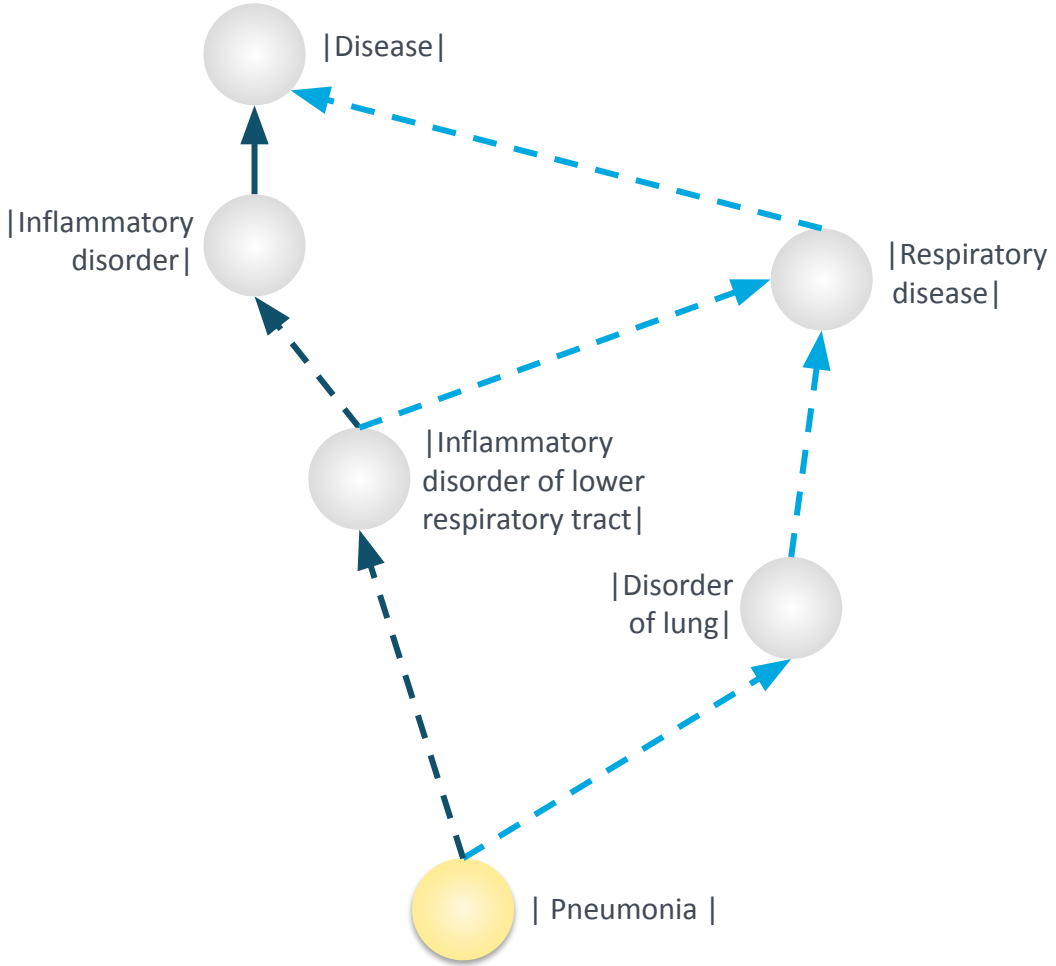
However, this approach requires that you know what data elements to query

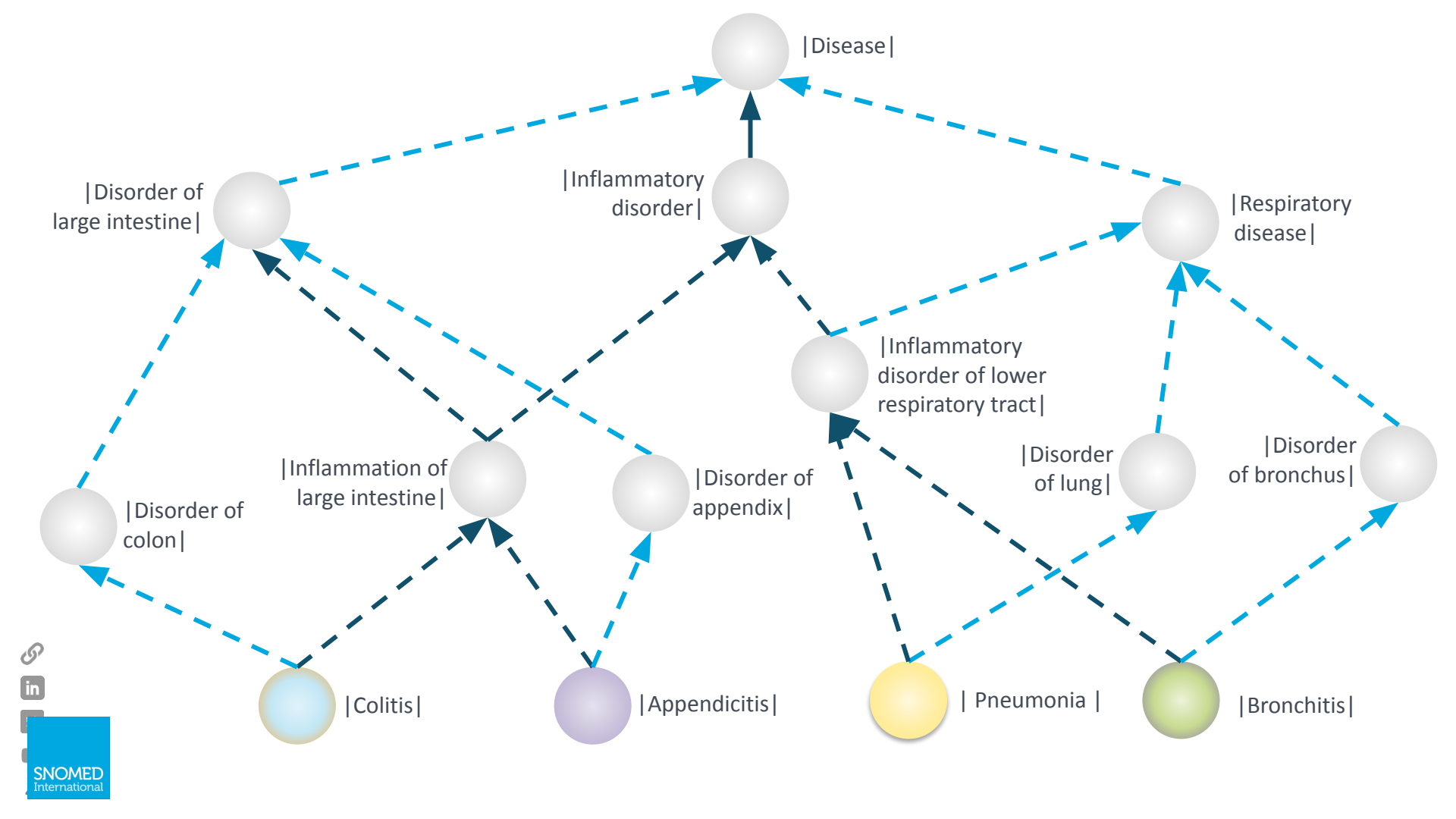

Get the value(s) of the ‘procedure’ field?
Health Record
API
Terminology Server
Do the values represent cardiovascular procedures?
Does the patient have a kind of infectious disease?
Have any procedures been performed on the cardiovascular system?

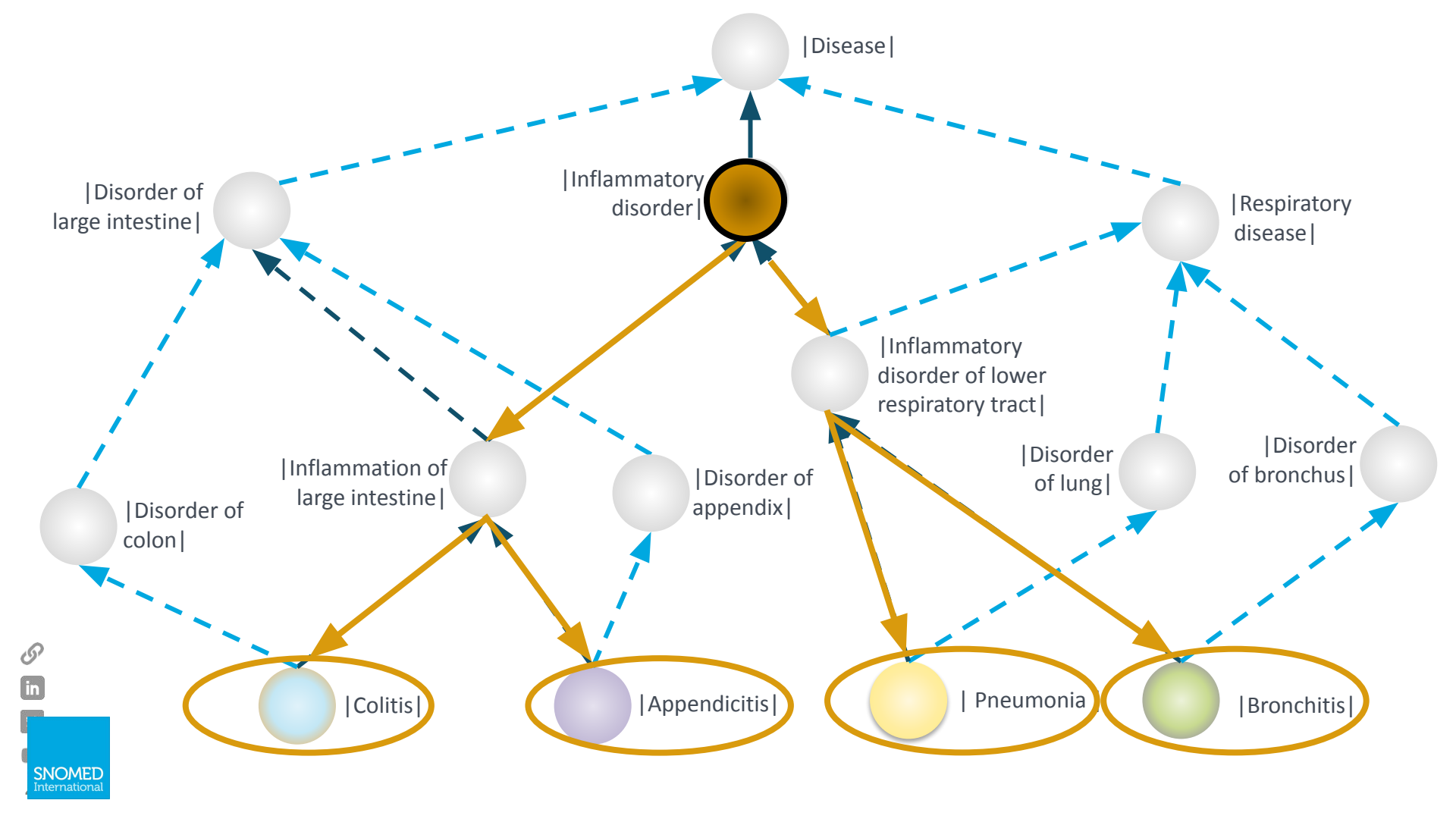

Get the value(s) of the 'procedure' field?
Health Record
Does any of the procedure values match the cardiovascular procedure concepts?
API
Get the concepts that are subtypes of |cardiovascular procedure|
Terminology Server
Cardiovascular procedure concepts
Have any procedures been performed on the cardiovascular system?

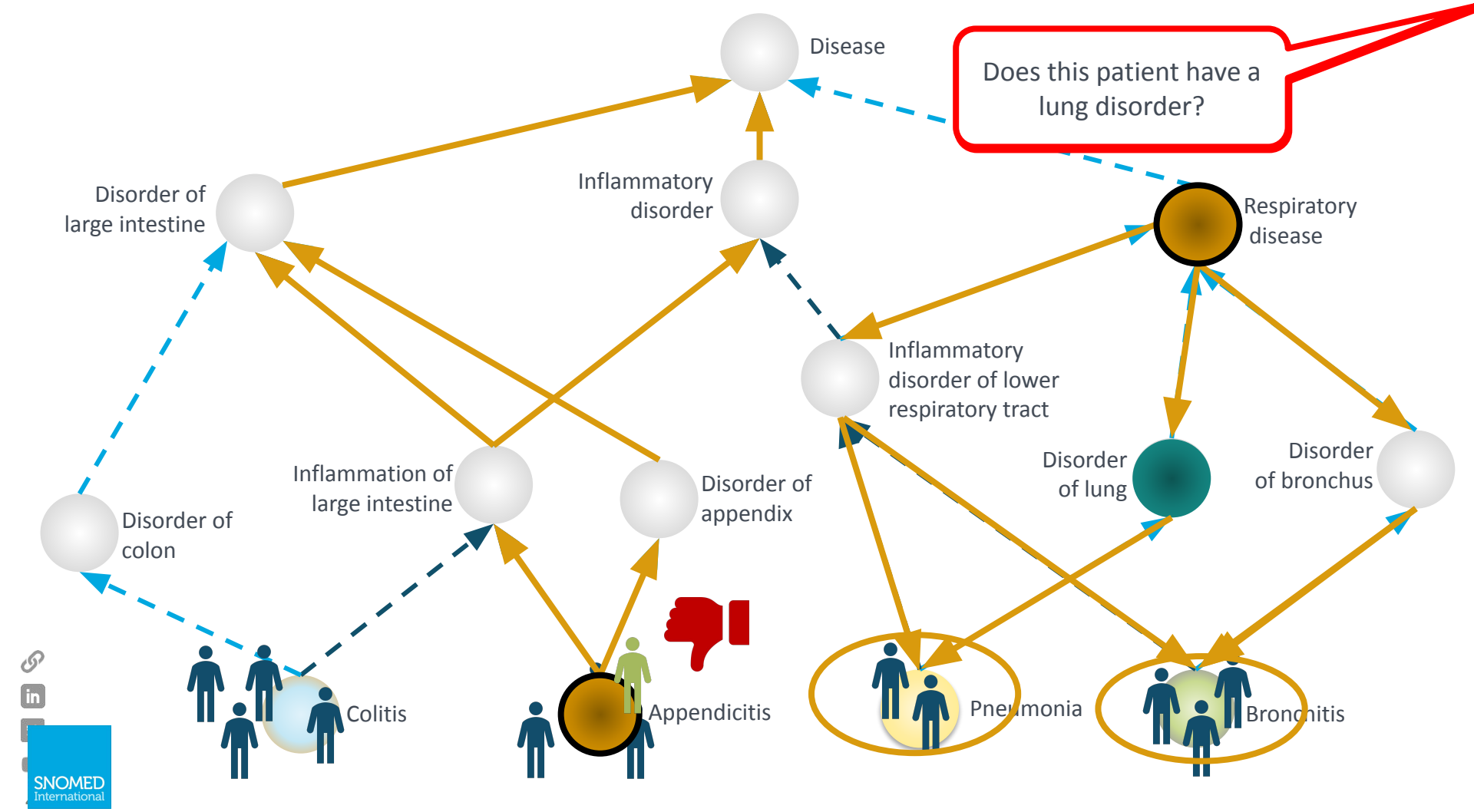

Get the value(s) of the 'procedure' field?
SNOMED CT Expression Constraint Language
Get the concepts that are subtypes of |cardiovascular procedure|
Terminology Server
Cardiovascular procedure concepts
Have any procedures been performed on the cardiovascular system?

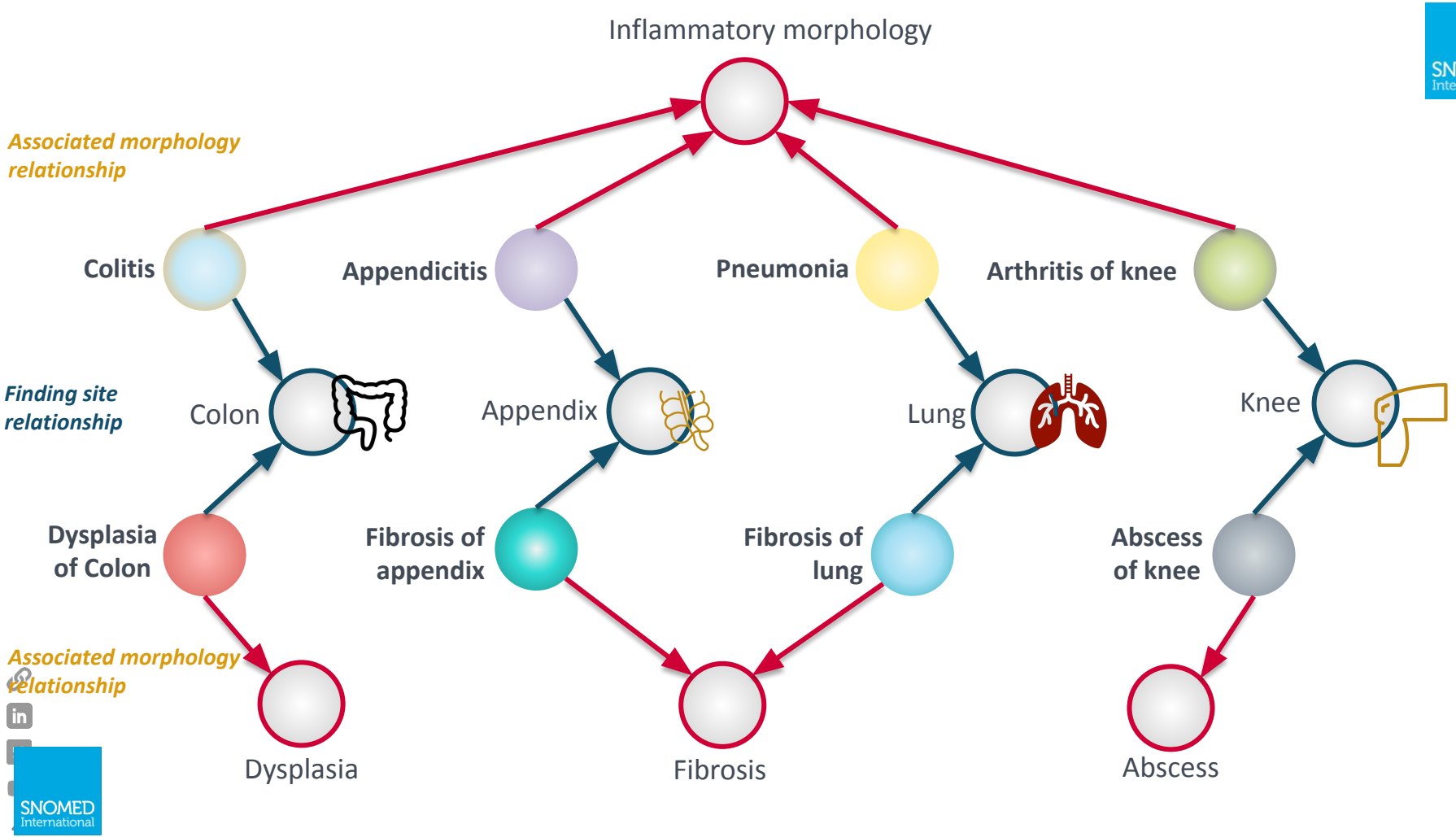

Research / Analytics
Clinical data
Clinical
Knowledge
Patients
EMR
Knowledge Resource
New or enhanced
Clinical Decision Support
Clinician
Learning

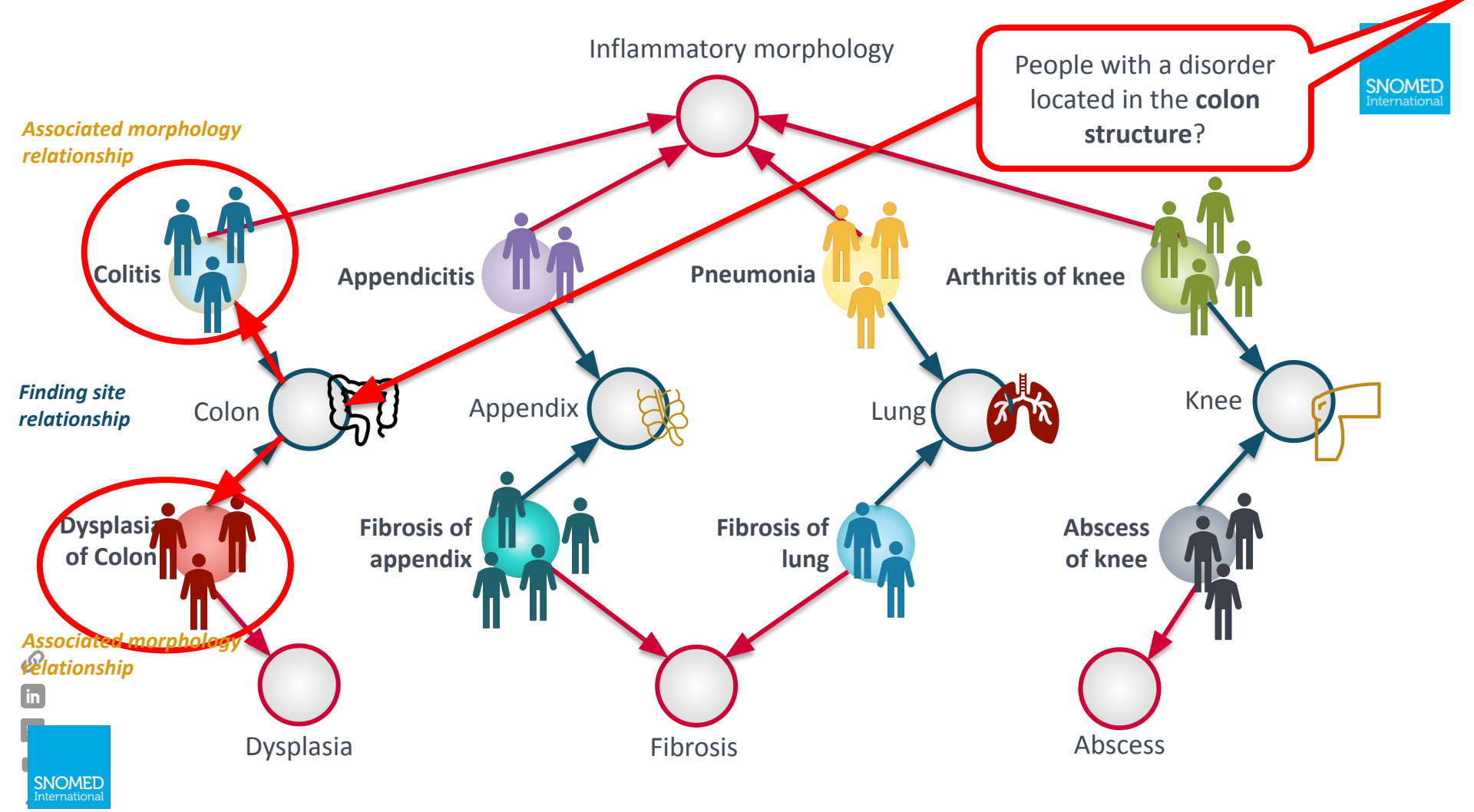

|Disease|
|Inflammatory disorder|
|Respiratory disease|
|Inflammatory disorder of lower respiratory tract|
|Disorder of lung|
| Pneumonia |

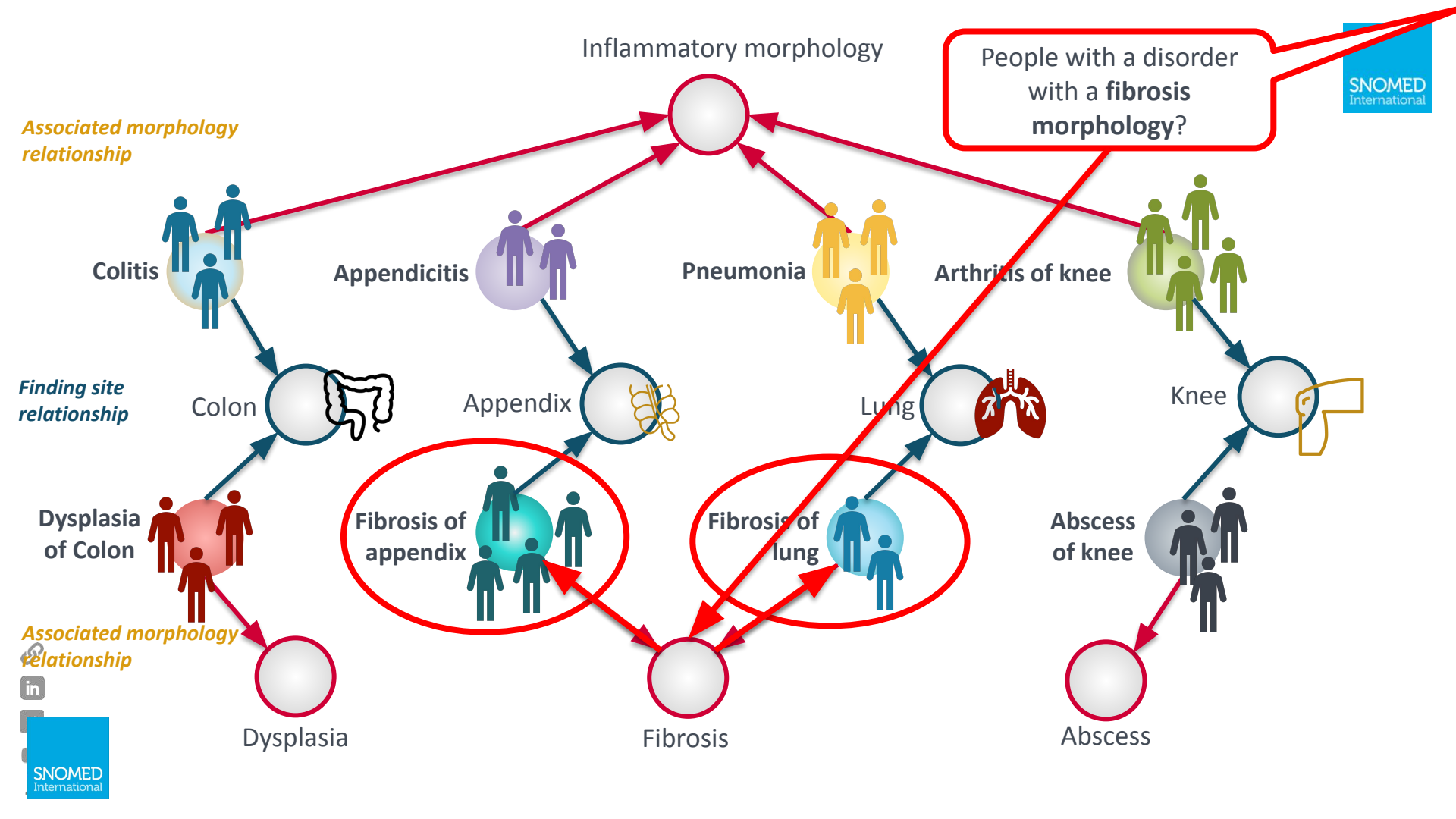

|Disease|
|Disorder of large intestine|
|Inflammatory disorder|
|Respiratory disease|
|Inflammatory disorder of lower respiratory tract|
|Disorder of colon|
|Inflammation of large intestine|
|Disorder of appendix|
|Disorder of lung|
|Disorder of bronchus|
|Colitis|
|Appendicitis|
| Pneumonia |
|Bronchitis|

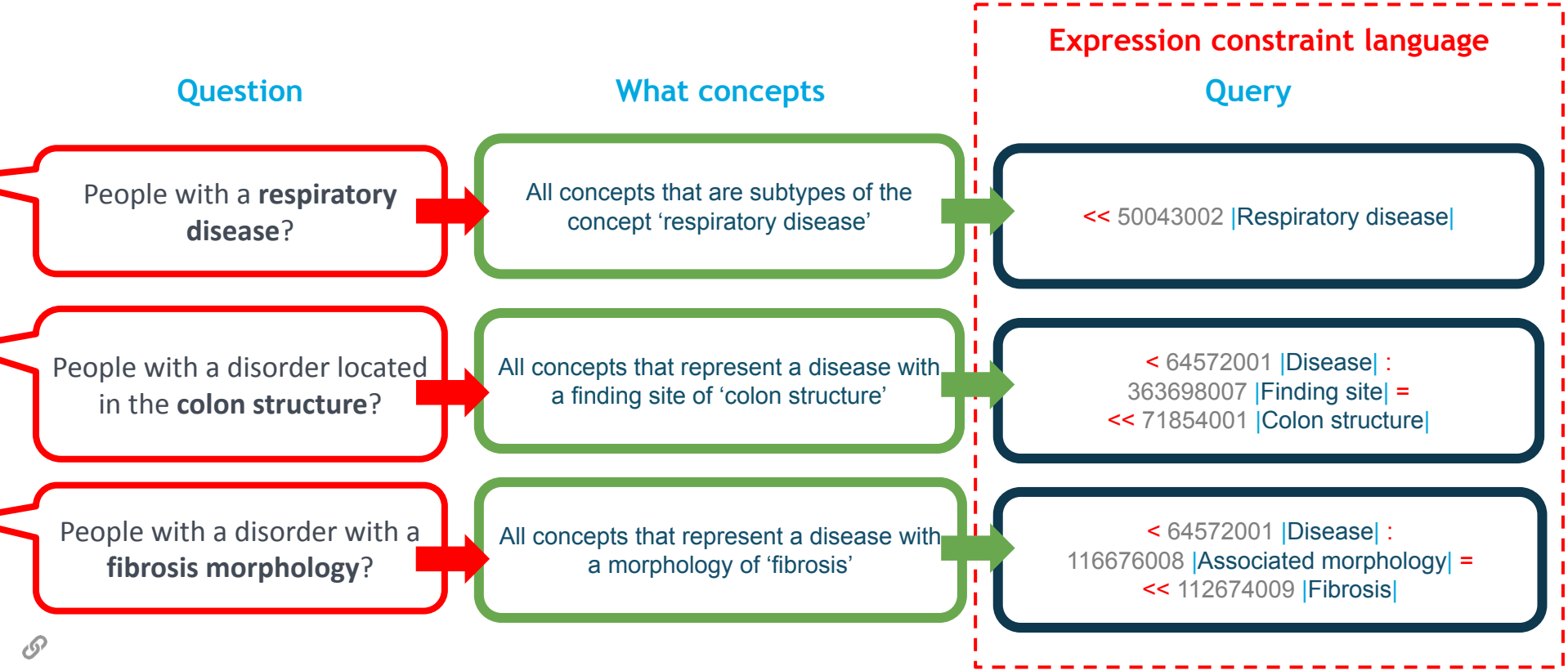

|Disease|
|Disorder of large intestine|
|Inflammatory disorder|
|Respiratory disease|
|Inflammatory disorder of lower respiratory tract|
|Disorder of lung|
|Disorder of bronchus|
|Inflammation of large intestine|
|Disorder of appendix|
|Disorder of colon|
|Colitis|
|Appendicitis|
| Pneumonia
|Bronchitis|


Disease
Does this patient have a lung disorder?
Disorder of large intestine
Inflammatory disorder
Respiratory disease
Inflammatory disorder of lower respiratory tract
Disorder of lung
Disorder of bronchus
Inflammation of large intestine
Disorder of appendix
Disorder of colon
Colitis
Appendicitis
Pneumonia
Bronchitis


Inflammatory morphology
Associated morphology relationship
Colitis
Appendicitis
Pneumonia
Arthritis of knee
Finding site relationship
Colon
Appendix
Lung
Knee
Dysplasia of Colon
Fibrosis of appendix
Fibrosis of lung
Abscess of knee
Associated morphology relationship
Dysplasia
Fibrosis
Abscess


Inflammatory morphology
People with a disorder located in the colon structure?
Associated morphology relationship
Colitis
Appendicitis
Pneumonia
Arthritis of knee
Finding site relationship
Colon
Appendix
Lung
Knee
Dysplasia of Colon
Fibrosis of appendix
Fibrosis of lung
Abscess of knee
Associated morphology relationship
Dysplasia
Fibrosis
Abscess
SNOMED International
SNOMED International


Inflammatory morphology
People with a disorder with a **fibrosis morphology**?
Associated morphology relationship
Colitis
Appendicitis
Pneumonia
Arthritis of knee
Finding site relationship
Colon
Appendix
Lung
Knee
Dysplasia of Colon
Fibrosis of appendix
Fibrosis of lung
Abscess of knee
Associated morphology relationship
Dysplasia
Fibrosis
Abscess


Expression constraint language
Question
What concepts
Query
People with a **respiratory disease**?
All concepts that are subtypes of the concept ‘respiratory disease’
<< 50043002 |Respiratory disease|
People with a disorder located in the **colon structure**?
All concepts that represent a disease with a finding site of ‘colon structure’
< 64572001 |Disease| :
363698007 |Finding site| =
<< 71854001 |Colon structure|
People with a disorder with a **fibrosis morphology**?
All concepts that represent a disease with a morphology of ‘fibrosis’
< 64572001 |Disease| :
116676008 |Associated morphology| =
<< 112674009 |Fibrosis|

Symbol	Name
<	Descendant of
<<	Descendant or self of
>	Ancestor of
>>	Ancestor or self of
<!	Child of
^	Member of
^ [x,y]	Member of with field selection
*	Any
:	Refinement
AND	Conjunction
OR	Disjunction
MINUS	Exclusion
[x..y]	Cardinality
R	Reverse attribute
.	Dotted attribute
{{ D }}	Description filter
{{ C }}	Concept filter
{{ M }}	Member filter
{{ +HISTORY }}	History supplement

Expression constraint language

Query

```
<< 50043002 |Respiratory disease|
```

```
< 64572001 |Disease| :
363698007 |Finding site| =
<< 71854001 |Colon structure|
```

```
< 64572001 |Disease| :
116676008 |Associated morphology| =
<< 112674009 |Fibrosis|
```

To learn more visit:
http://snomed.org/ecl

SNOMED International

Data Analytics with SNOMED CT

Assessing treatments

How effective is each treatment option?

Data Analytics Example

Patient cohort

BRCA1 gene mutation

Increased risk of breast cancer

Treatment

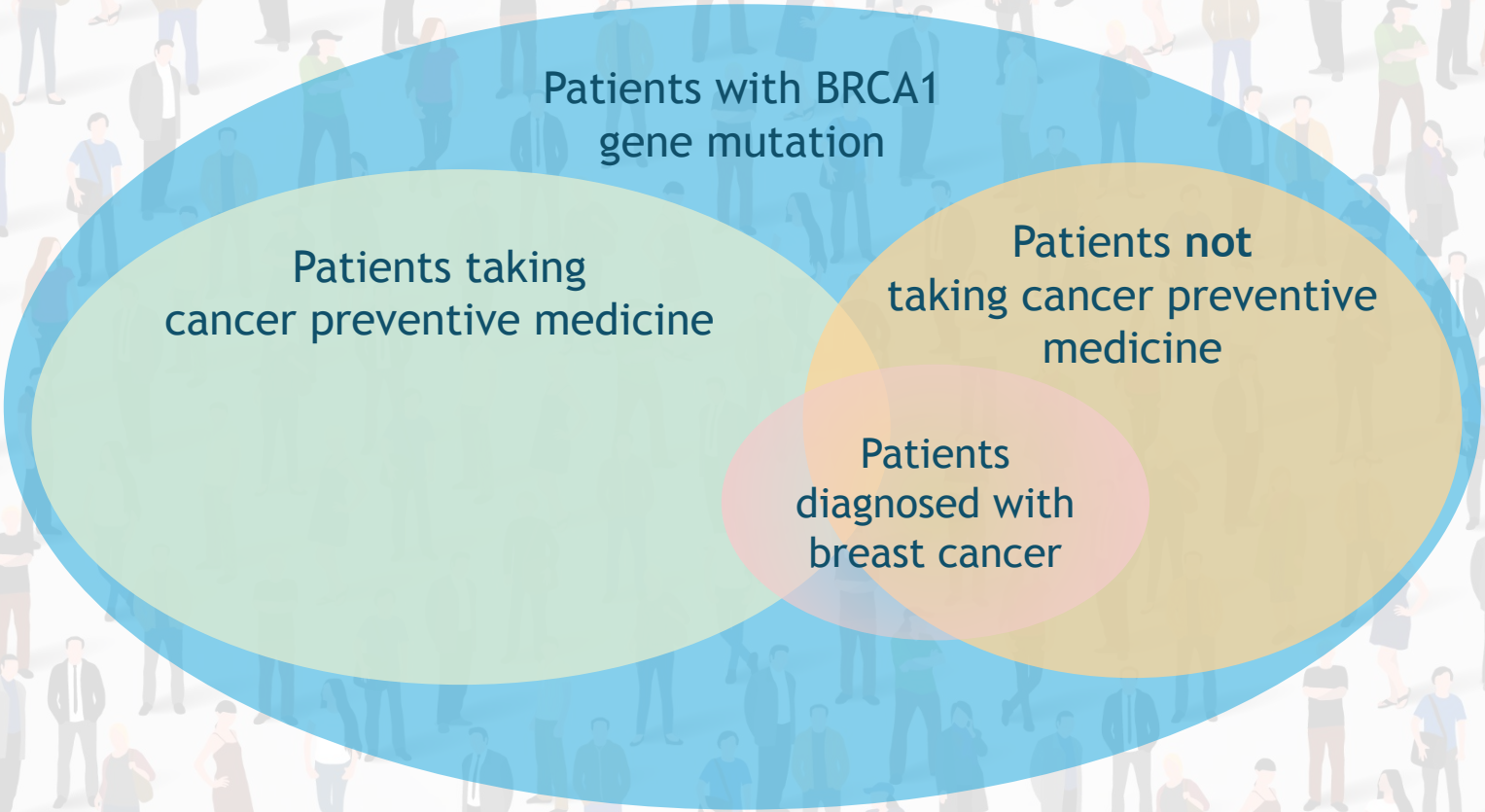
Drug prevention available

Risk of severe side effects

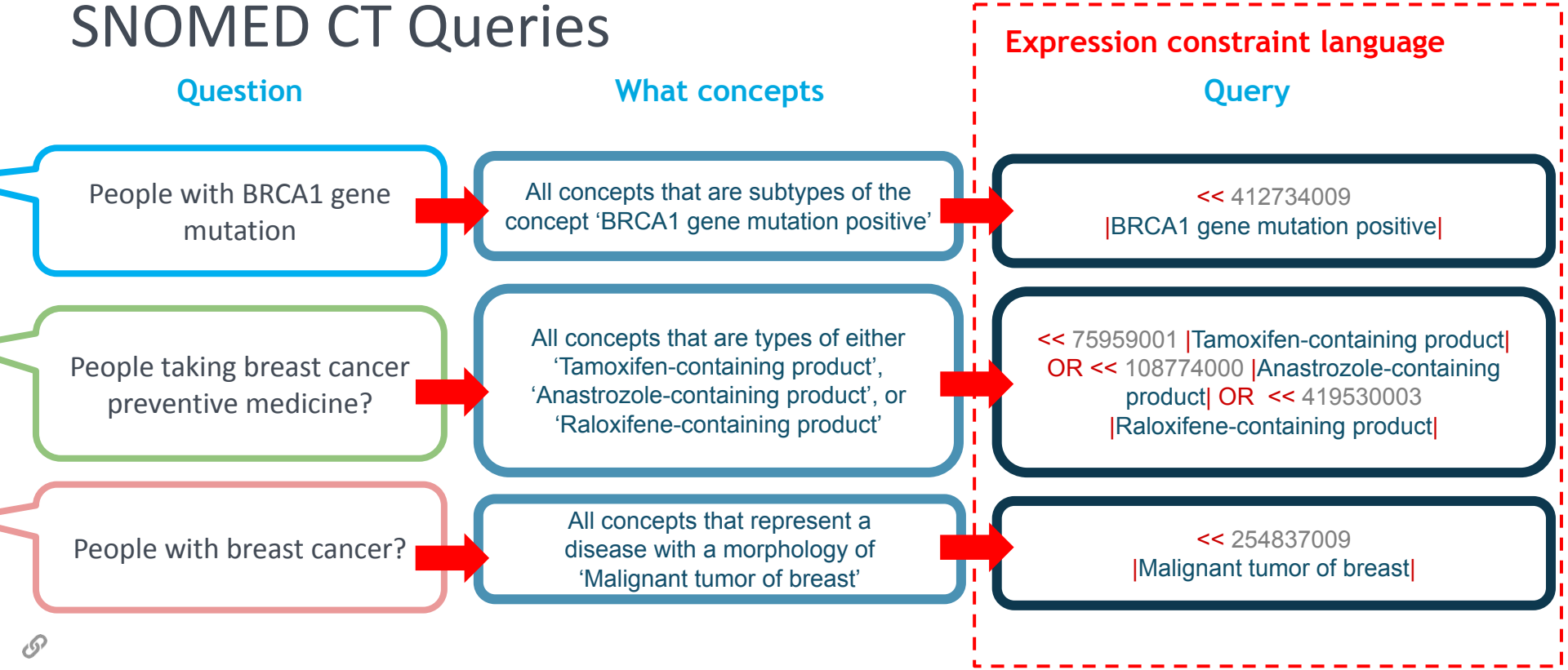
Question

Does the medication significantly reduce the risk of cancer?

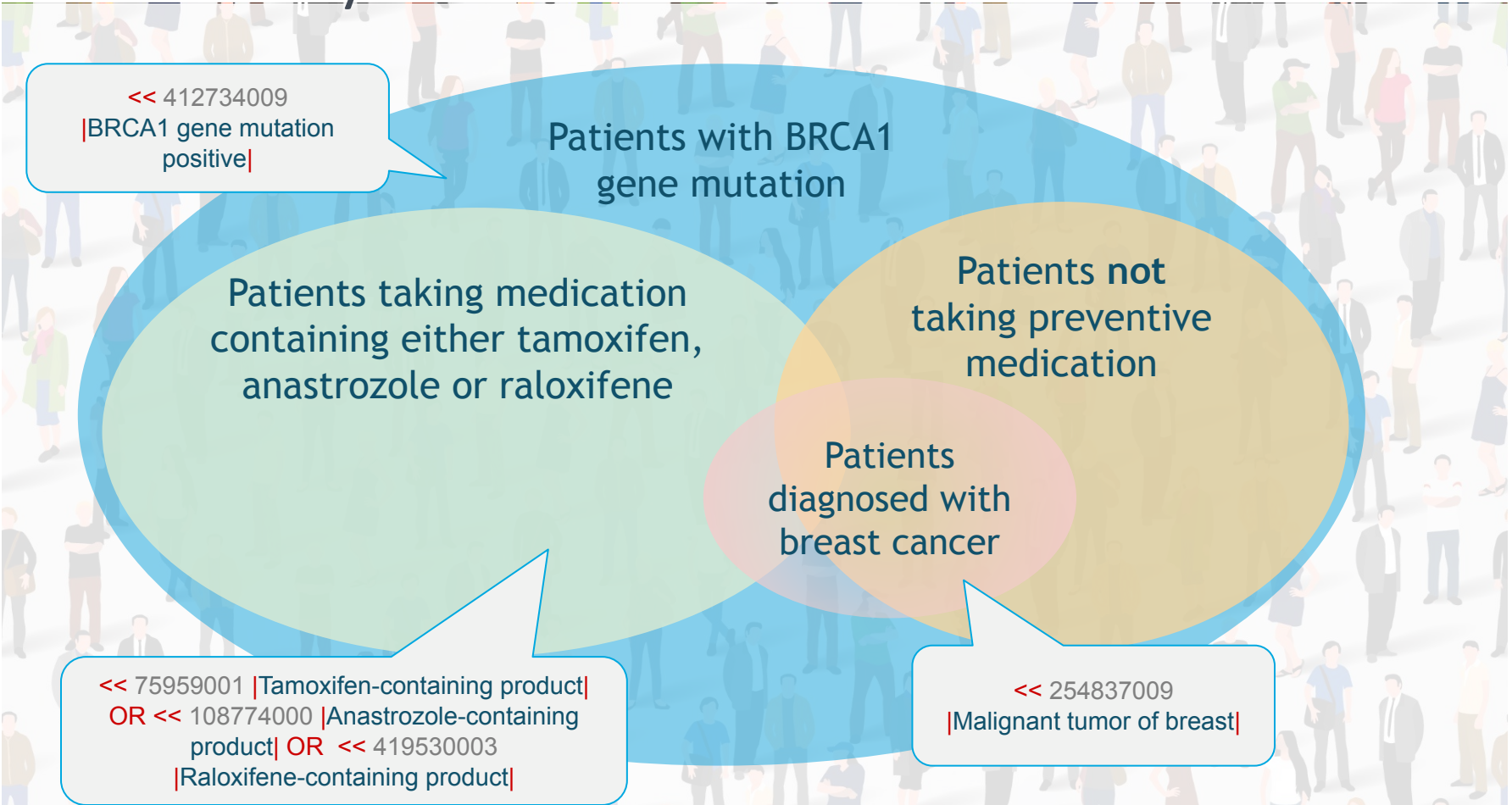
Data Analytics with SNOMED CT



SNOMED CT Queries

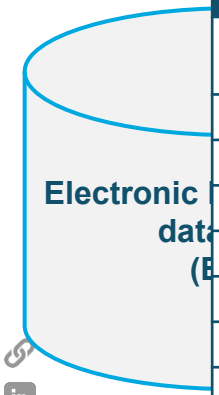


Data Analytics - Scenario 3



Patient Data Analytics

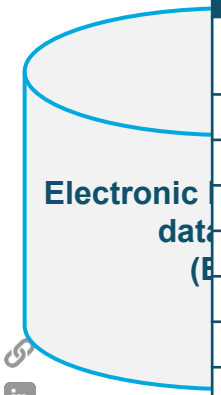
<< 254837009 |Malignant tumor of breast|



Patient_Id	Diagnosis	Diagnosis term
001	145501000119108	Metastatic malignant neoplasm of breast
002	722223000	Cyst of kidney
003	254840009	Inflammatory carcinoma of breast
004	64226004	Colitis
005	1197732001	Colorectal Crohn disease
006	278050001	Sarcoma of breast
007	1197732001	Colorectal Crohn disease
008	254837009	Malignant tumor of breast
009	405944004	Asthmatic bronchitis
010	46635009	Type 1 diabetes mellitus

Patient Data Analytics

```
SELECT Patient_Id FROM EHR WHERE Diagnosis =
(<< 254837009 |Malignant tumor of breast|)
```



Patient_Id	Diagnosis	Diagnosis term
001	145501000119108	Metastatic malignant neoplasm of breast
002	722223000	Cyst of kidney
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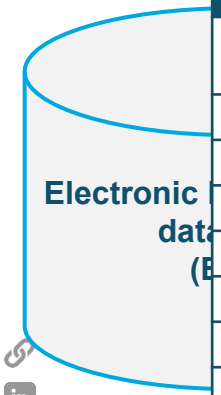
007	1197732001	Colorectal Crohn disease
008	254837009	Malignant tumor of breast
009	405944004	Asthmatic bronchitis
010	46635009	Type 1 diabetes mellitus

ECL Expansion
15950061000119105
353421000119109
145501000119108
354591000119108
448435005
254840009
286896005
278050001
271467005
403458008
373082000
373081007
254837009
254841008
188159008
188159008
…

Patient Data Analytics

```
SELECT Patient_Id FROM EHR WHERE Diagnosis =
(<< 254837009 |Malignant tumor of breast|)
```



Patient_Id	Diagnosis	Diagnosis term
001	145501000119108	Metastatic malignant neoplasm of breast
002	722223000	Cyst of kidney
003	254840009	Inflammatory carcinoma of breast
004	64226004	Colitis
005	1197732001	Colorectal Crohn disease
006	278050001	Sarcoma of breast
007	1197732001	Colorectal Crohn disease
008	254837009	Malignant tumor of breast
009	405944004	Asthmatic bronchitis
010	46635009	Type 1 diabetes mellitus

ECL Expansion
15950061000119105
353421000119109
145501000119108
354591000119108
448435005
254840009
286896005
278050001
271467005
403458008
373082000
373081007
254837009
254841008
188159008
188159008
…

Patient Data Analytics

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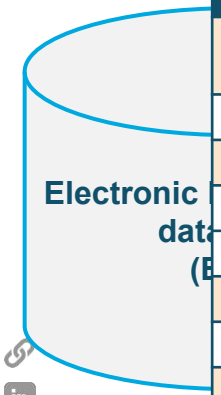
SELECT Patient_Id FROM EHR WHERE Diagnosis =
(<< 254837009 |Malignant tumor of breast|)
```



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ECL Expansion
15950061000119105
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354591000119108
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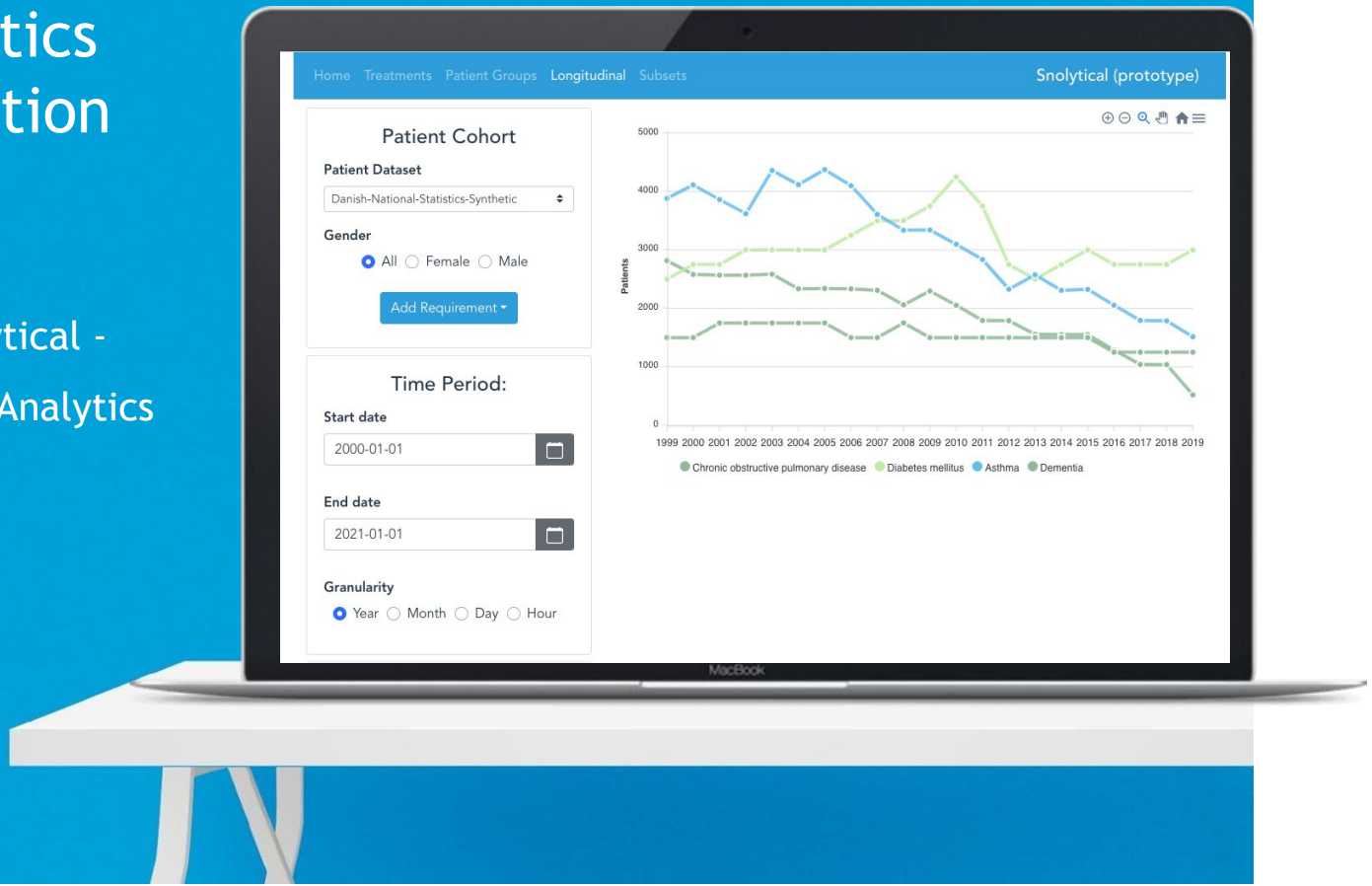
254840009
286896005
278050001
271467005
403458008
373082000
373081007
254837009
254841008
188159008
188159008
…

Data Analytics Demonstration

Showcasing Snolytical - Simplifying Data Analytics with SNOMED CT



Practice using Terminology Services

Finding Terminology Resources

Listing the **CodeSystem** resource:

HTTP GET [base]/CodeSystem

- Lists the CodeSystems loaded
- One for each version of each SNOMED CT Edition, and any other code systems
- The **title** parameter can be used to search

- /ValueSet and /ConceptMap resources can also be listed and searched

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SNOMED Concept Lookup with FHIR

Using **CodeSystem $lookup** operation

https://hl7.org/fhir/R4/codesystem-operation-lookup.html

```
HTTP GET [base]/CodeSystem/$lookup
                ?system=http://snomed.info/sct
                &code=389145006
```

- Here the ***system*** parameter uses the generic URI for SNOMED CT
- The ***code*** parameter is a SNOMED CT concept id
- When no ***version*** parameter is set a terminology server may use its default Edition

Caution: *Snowstorm goes beyond the FHIR specification for this operation and will automatically select the edition that contains the requested code.*

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SNOMED Concept Lookup with FHIR

Using **CodeSystem $lookup** with a specific Edition

HTTP GET [base]/CodeSystem/$lookup
?system=http://snomed.info/sct
&version=http://snomed.info/sct/11000234105
&code=389145006

- This example adds the ***version*** parameter with URI for **SNOMED CT Austrian Edition**
  - 11000234105 is the Austrian module
- This will use the latest version of the Austrian Edition on the server
- In the response we can see many descriptions from the International and Austrian Editions including the Austrian-German “Allergisches Asthma bronchiale” (see *valueString*)

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SNOMED CT **URI Standard**

There is no single distribution that contains all defined SNOMED CT codes in all contexts of use.

The International Edition contains all concepts shared and agreed to be internationally relevant.

National Release Centres distribute this International Edition plus additional national content.

Unambiguously reference a particular SNOMED CT **edition** and/or **version** using a **URI**:

- Refer to SNOMED in general
  http://snomed.info/sct
- Refer to a particular **Edition** *(e.g. Austrian Edition)*
  http://snomed.info/sct/**11000234105**
- Refer to a particular **Edition Version**
  http://snomed.info/sct/**11000234105**/version/**20240215**

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SNOMED Concept Search with FHIR

Using **ValueSet $expand** operation

HTTP GET [base]/ValueSet/$expand
?url=**http://snomed.info/sct/11000234105?fhir_vs**
&displayLanguage=de
&filter=funk

- This ***url*** parameter is the “implicit value set” of **all SNOMED CT concepts** in the Austrian Edition
- The ***displayLanguage*** parameter switches both the search and display language
- The ***filter*** parameter is the user search term
- ***Never search the whole of SNOMED CT for data entry! Use a subset or ECL constraint (next)***

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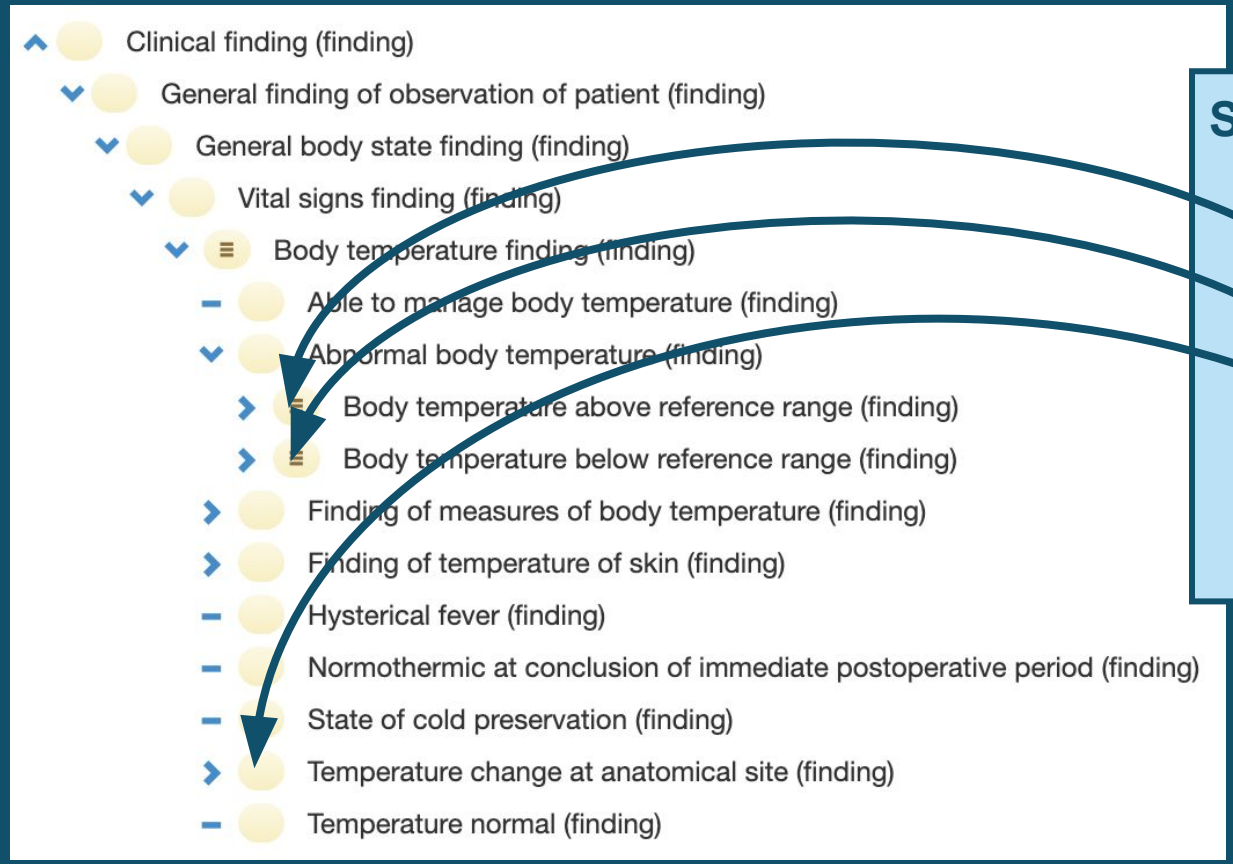
SNOMED
International
SNOMED subsets
with the FHIR API

SNOMED CT (Versioned Edition)

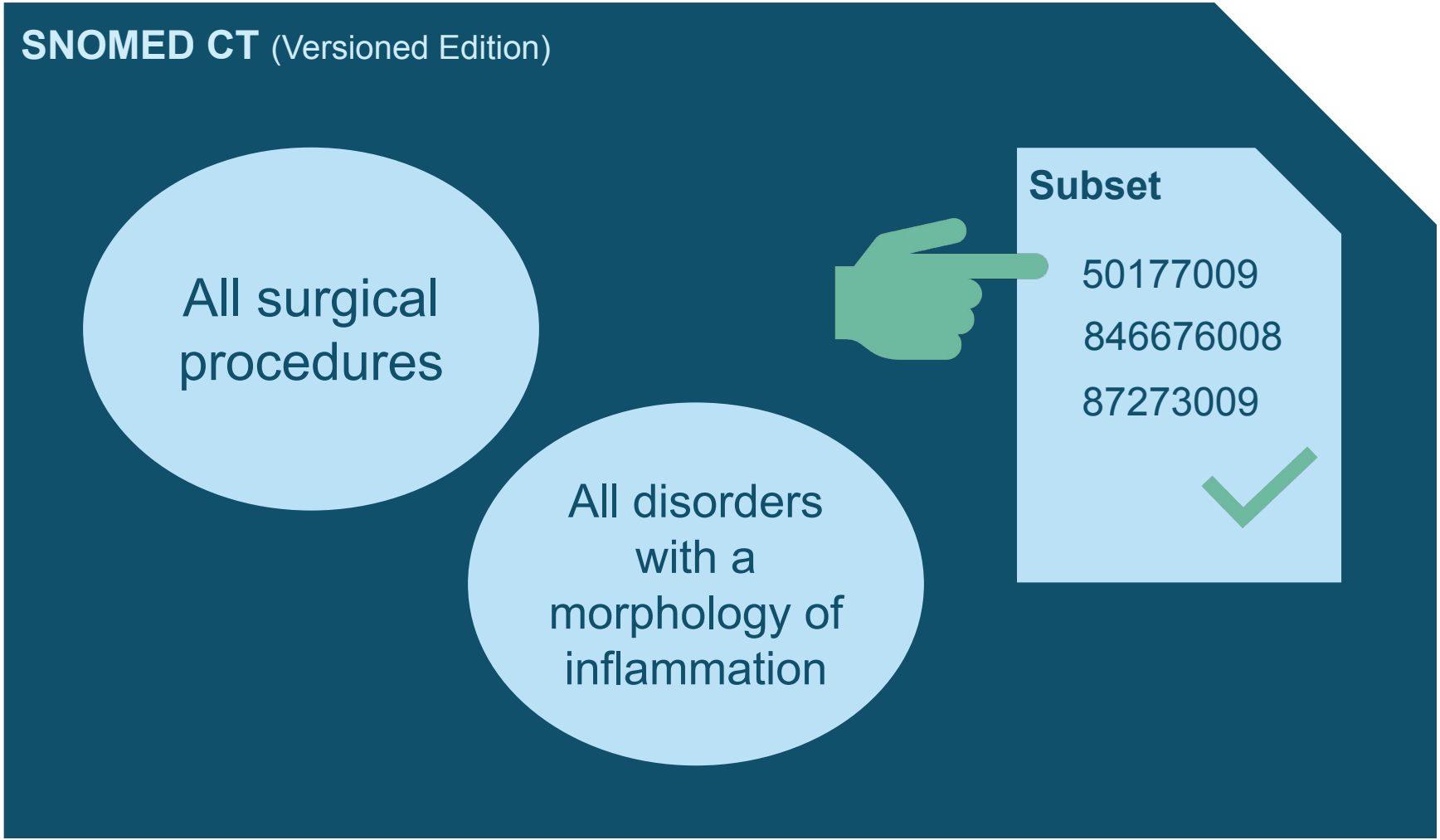


Subset

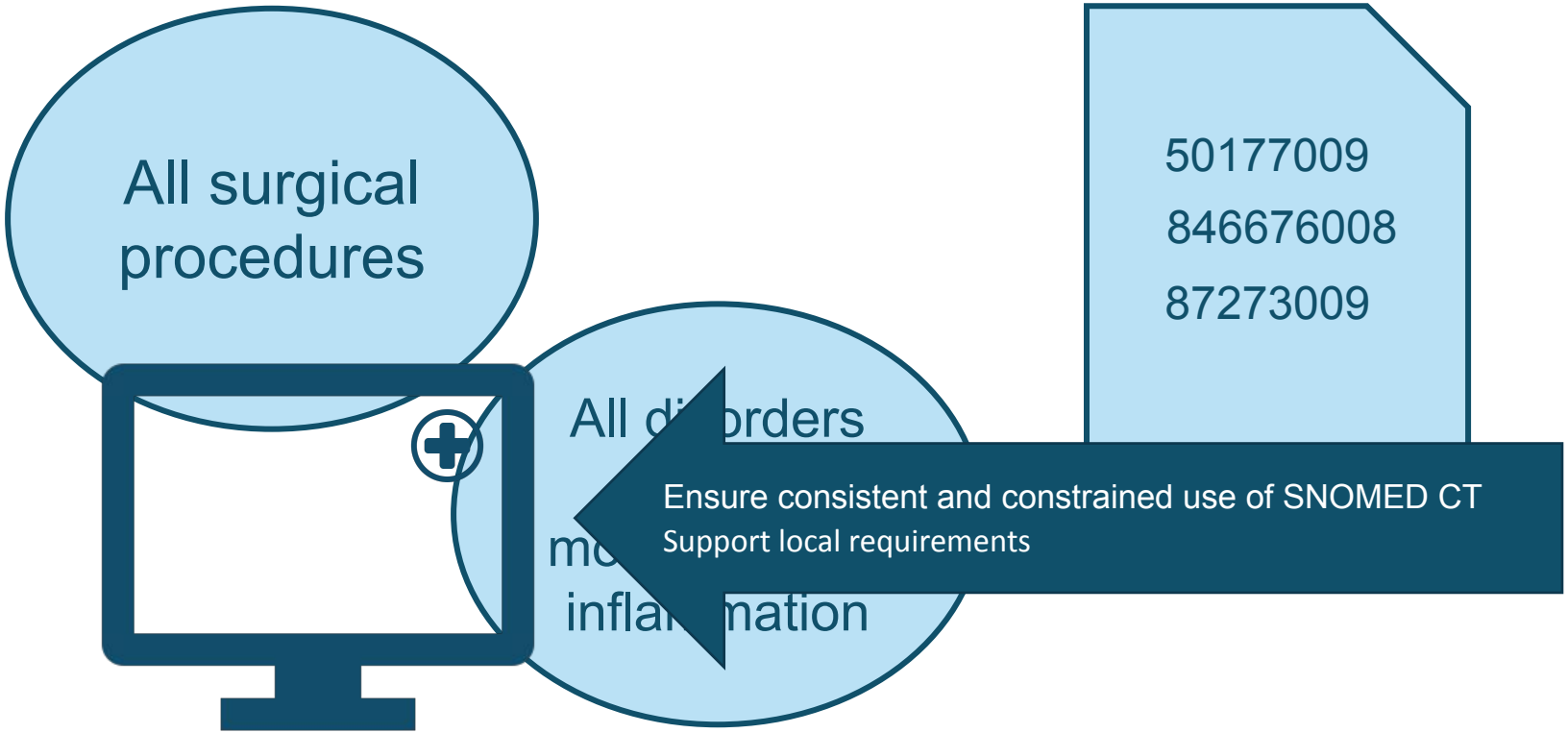
50177009

846676008

87273009

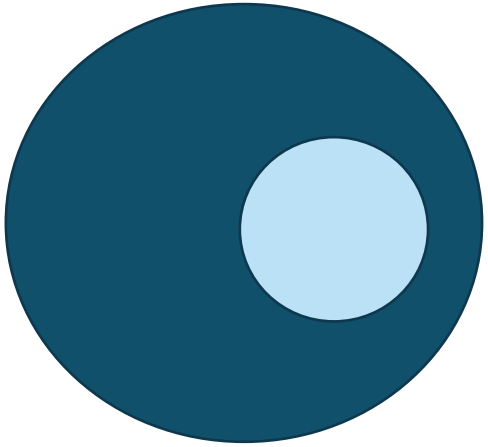

SNOMED CT (Versioned Edition)
All surgical procedures
All disorders with a morphology of inflammation
Subset
50177009
846676008
87273009

SNOMED CT Subsets

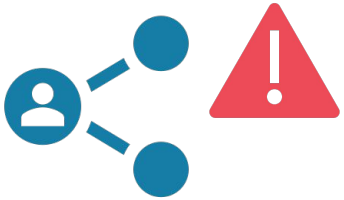


Subset Use Cases

Constrain search and data entry



Specify value sets used for communication, reporting and decision support



Specify groups used for retrieval and analytics

Subsets = FHIR Value Sets

There are many ways to create and access Value Sets with SNOMED CT:

- A native FHIR ValueSet with a simple list of codes:
  - *URI:* "http://example.com/my-list"
- Reference a SNOMED Simple Reference Set:
  - *URI:* "http://snomed.info/sct/11000172109?**fhir_vs=refset**/816080008"
- Use the "isa" filter:
  - *URI:* "http://snomed.info/sct/11000172109?**fhir_vs=isa**/195967001"
- Use ECL (SNOMED Query)
  - *URI:* "http://snomed.info/sct/11000172109?**fhir_vs=ecl**/<<195967001"

https://terminology.hl7.org/SNOMEDCT.html#snomed-ct-implicit-value-sets

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Search within Refsets with FHIR

Using **ValueSet $expand** operation

https://www.hl7.org/fhir/valueset-operation-expand.html

HTTP GET [base]/ValueSet/$expand
?url=http://snomed.info/sct/11000172109?fhir_vs=**refset/816080008**
&displayLanguage=en
&filter=swell

- The ***url*** is an implicit value set containing the “International Patient Summary”
- ***filter*** is a search term

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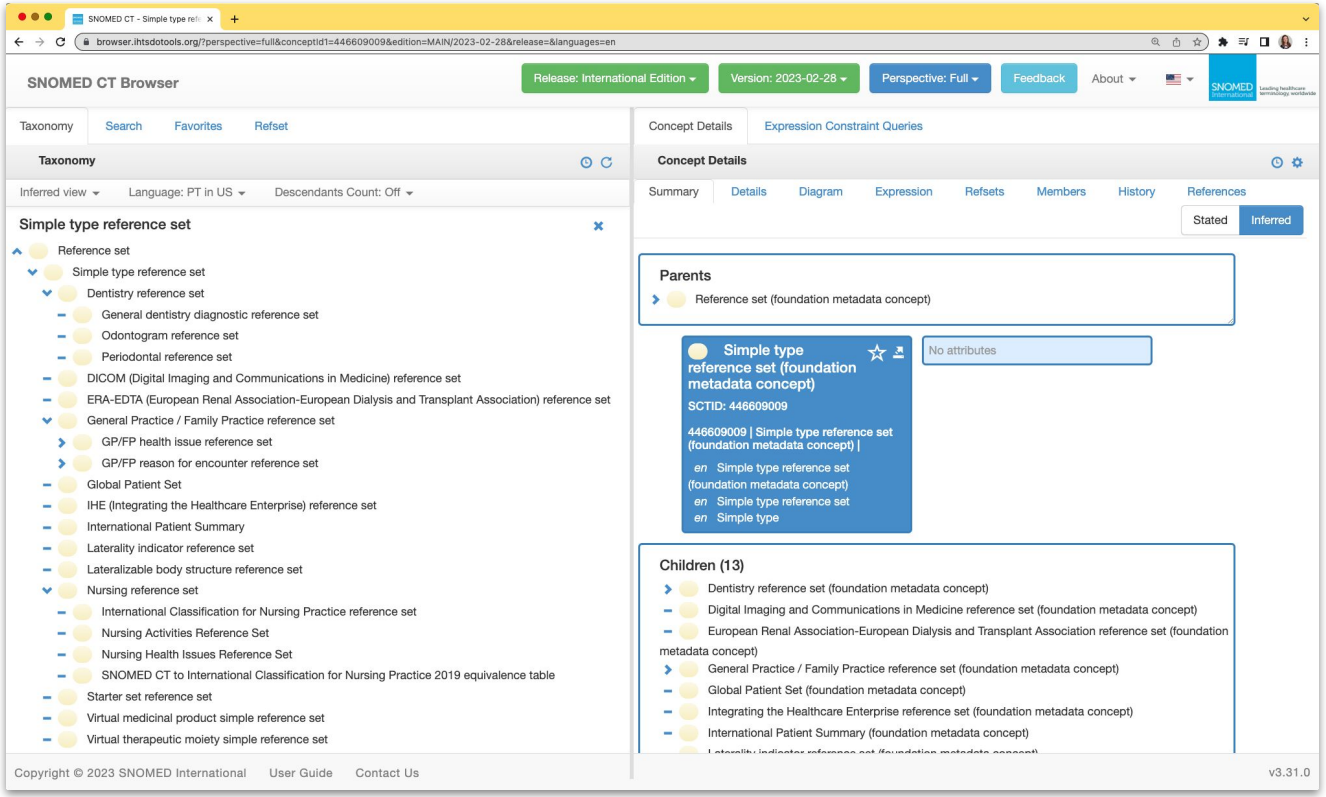
Browser - Simple Reference Sets



https://browser.snomedtools.org/

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SNOMED ECL Query with FHIR

Using **ValueSet $expand** operation

https://www.hl7.org/fhir/valueset-operation-expand.html

HTTP GET [base]/ValueSet/$expand
?url=http://snomed.info/sct/11000234105?fhir_vs=**ecl/<128139000**
|Inflammatory disorder|
&filter=ear

- The ***url*** is an implicit value set containing all descendants of 128139000 |Inflammatory disorder|

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Search within Subsets with FHIR

Using **ValueSet $expand** operation

Best practice search behaviour

- Search terms may use multiple word prefixes, in any order
  - For example to find the concept “**Blood oxygen pressure within reference range**”
    A good search term could be: “**blood ox within**”
  - Users who learn this type less and find faster
  - This is also a great way to avoid spelling mismatch issues

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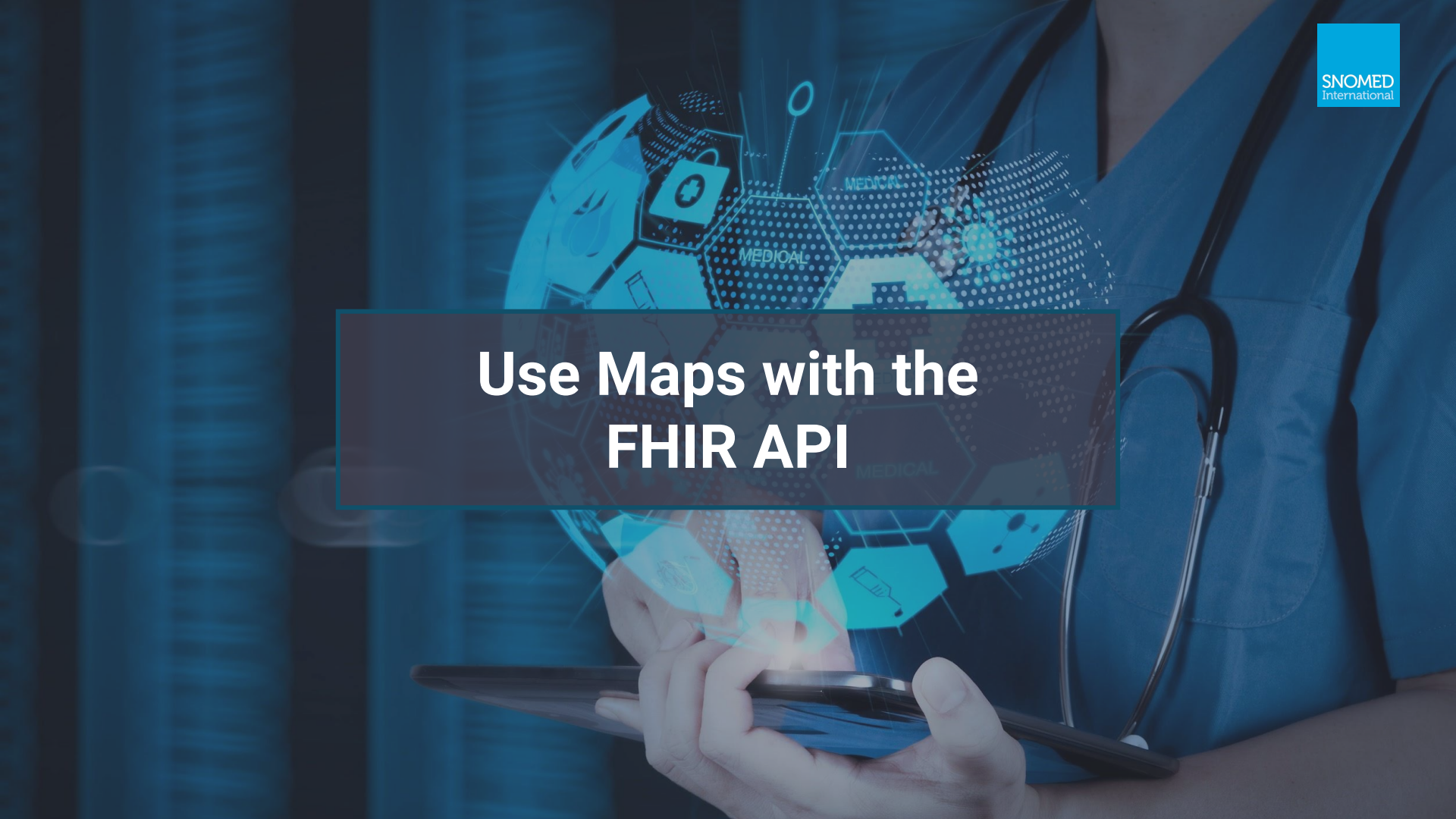

SNOMED
International
Use Maps with the
FHIR API

Background

Link SNOMED CT to other code systems

Integrating local codes and SNOMED CT

- Using a library of clinical phrases as an interface terminology
- Communication of clinical data between organizations
- Migration to SNOMED CT

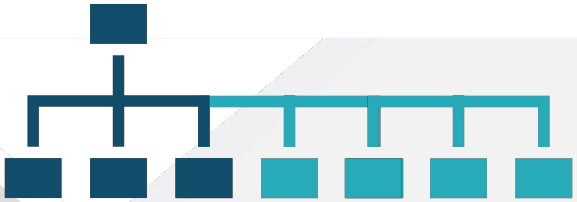
Integrating statistical classification systems and SNOMED CT

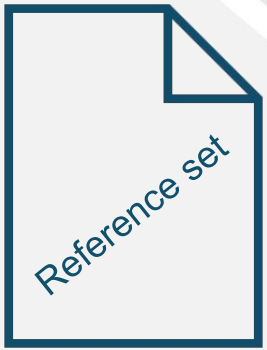
- Statistical analysis of SNOMED CT encoded data
- Meaning-based analysis of statistical data

SNOMED CT to ICD-O simple map reference set

...	refsetId	referencedComponentId	mapTarget
...	446608001	2142002	8721/3
...	446608001	2227007	8370/3
...	446608001	21326004	8045/3
...	446608001	27313007	8857/0
...	446608001	32913002	8510/3
...	446608001	41607009	8312/3

|SNOMED CT to ICD-10 extended map|





SNOMED CT

8619003 |Infertile|

ICD-10

N97.9 Female infertility, unspecified

N46 Male infertility

Map to other CodeSystems with FHIR

Using **ConceptMap $translate** operation

https://hl7.org/fhir/R4/conceptmap-operation-translate.html

HTTP GET [base]/ConceptMap/$translate
?code=254153009
&system=http://snomed.info/sct
&version=http://snomed.info/sct/11000234105/version/20240215
&targetsystem=**http://hl7.org/fhir/sid/icd-10**

- ***code*** is the concept to translate
- ***system*** is the source CodeSystem, in this case SNOMED CT
- ***version*** selects the SNOMED CT Austrian Edition
- **targetsystem** is the uri of the CodeSystem to translate the code to, ICD-10

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Summary

We have covered:

- The basics of Terminology Services
- How to deploy and use Snowstorm Lite
- How to use the HL7 FHIR Terminology module to access and query SNOMED CT

We can't wait to hear about what you build with it!

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Thank you for attending

SNOMED International

Implementation Support Portal
implementation.snomed.org

Learning More

- **Expression constraint language specification**
  snomed.org/ecl
- **Data Analytics with SNOMED CT**
  snomed.org/analytics
- **MRCM browser**
  https://browser.snomedtools.org/mrcm
- **Terminology services guide**
  snomed.org/tsg
- **Snolytical**
  github.com/IHTSDO/health-data-analytics