# Intelligent Search and Data Entry

Expo 2019 Tutorial

*David Markwell and Anne Randorff Højen*
*SNOMED International*


## Background

- SNOMED CT is the most comprehensive, clinical healthcare terminology in the world
- It includes concepts representing the wide range of types of information that need to be recorded in clinical records
- It is aimed at supporting easy, consistent and accurate data entry and facilitate effective use of clinical data for
  - Data retrieval and analytics
  - Clinical decision support
  - Etc.

The size of SNOMED CT and the underlying logical model demands effective and efficient search and data entry functionalities. !

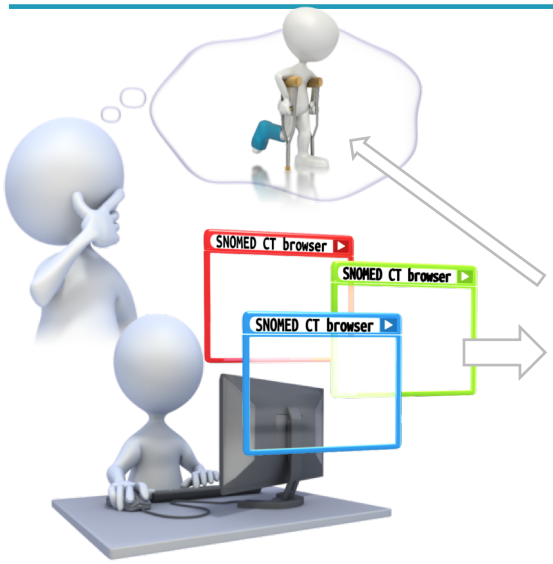
## Overview

- Part 1
  - Search techniques
  - Browser demo
- Part 2
  - Data entry techniques
  - Data entry demo



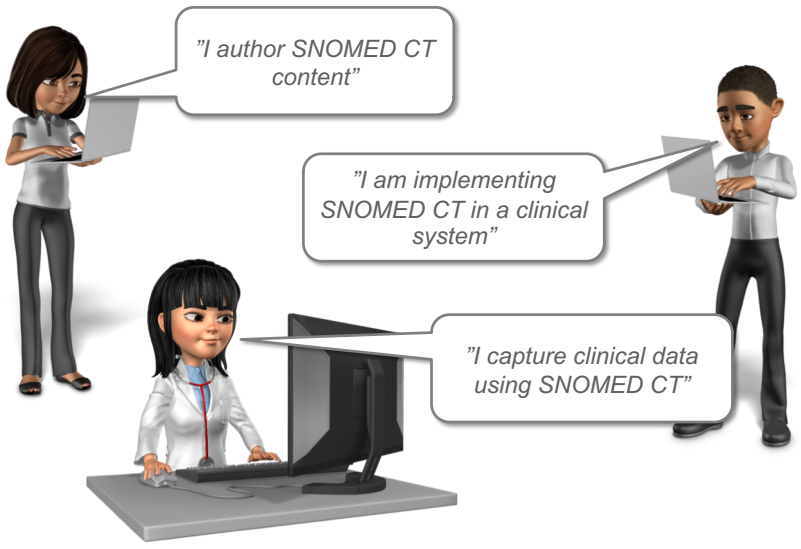
## Searching SNOMED CT

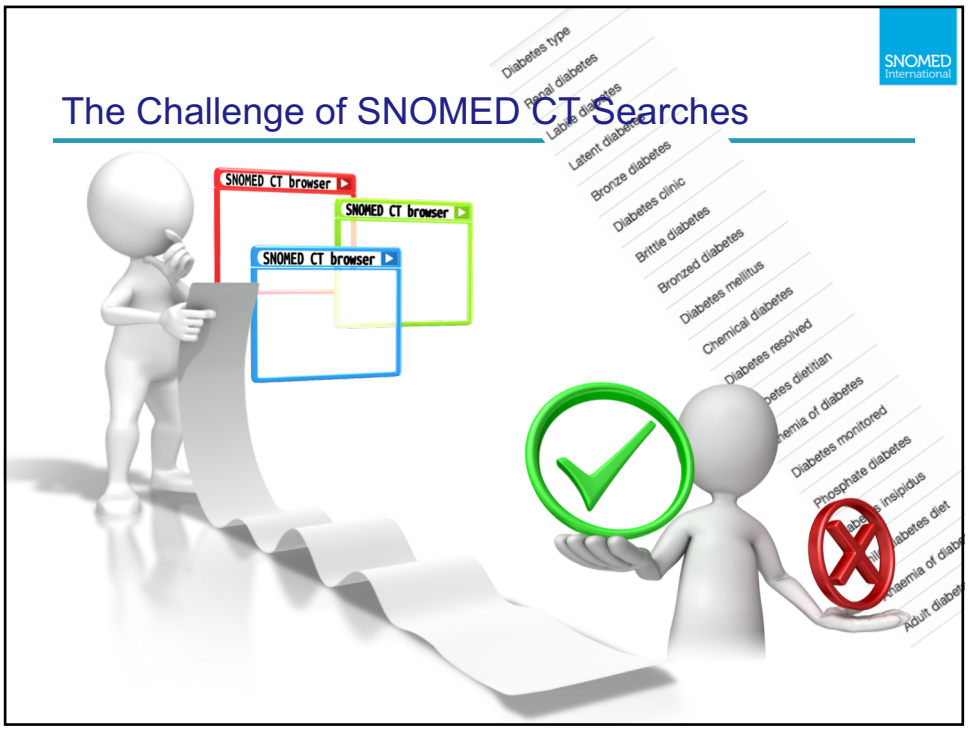
## What is SNOMED CT Search?

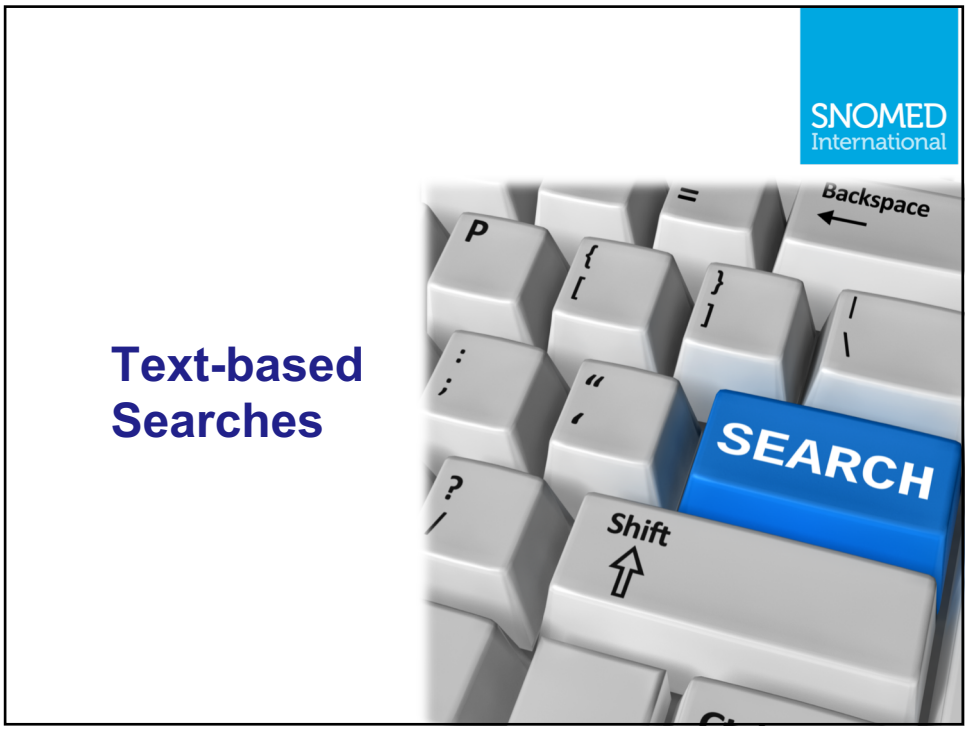



- Fracture of lower limb
- Injury of ankle
- **Fracture of ankle**
- Closed fracture of ankle
- Fracture dislocation of ankle joint
- Fracture of distal end of fibula
- Fracture of distal end of tibia
- Fracture of talus
- Open fracture of ankle

## Who Perform SNOMED CT Searches?




The Challenge of SNOMED CT Searches
SNOMED International
SNOMED CT browser
SNOMED CT browser
SNOMED CT browser
Diabetes type
Latent diabetes
Bronze diabetes
Diabetes clinic
Brittle diabetes
Bronzed diabetes
Diabetes mellitus
Chemical diabetes
Diabetes resolved
Diabetes monitored
Phosphate diabetes
Adult diabet


Text-based Searches
SNOMED International
Backspace
SEARCH
Shift

## Search by Terms

- String searches can be configurable to support searching
- Specific techniques include
  - Words any order
  - Phrase match
  - Group by concept
  - Identifiers

## Words any Order

**Type at least 3 characters** ✔ **Example:** ***shou fra***

myo inf

507 matches found in 0.481 seconds.

| | |
|---|---|
| Infantile myotonia | Infantile myotonia (disorder) |
| Infective myositis | Infective myositis (disorder) |
| Myocardial infarct | Myocardial infarction (disorder) |
| Infectious myositis | Infective myositis (disorder) |
| Infestation by Myobia | Infestation caused by Myobia (disorder) |
| Myocardial infarction | Myocardial infarction (disorder) |
| Infective myocarditis | Myocarditis due to infectious agent (disorder) |

## Phrase Match

**Type at least 3 characters** ✔ **Example:** ***blistered finger***

Myocardial infarct

334 matches found in 1.016 seconds.

| | |
|---|---|
| Myocardial infarct | Myocardial infarction (disorder) |
| Myocardial infarction | Myocardial infarction (disorder) |
| Old myocardial infarction | Old myocardial infarction (disorder) |
| FH: Myocardial infarction | Family history: Myocardial infarction (situation) |
| MI - myocardial infarction | Myocardial infarction (disorder) |
| ECG: myocardial infarction | Electrocardiographic myocardial infarction (finding) |
| EKG: myocardial infarction | Electrocardiographic myocardial infarction (finding) |

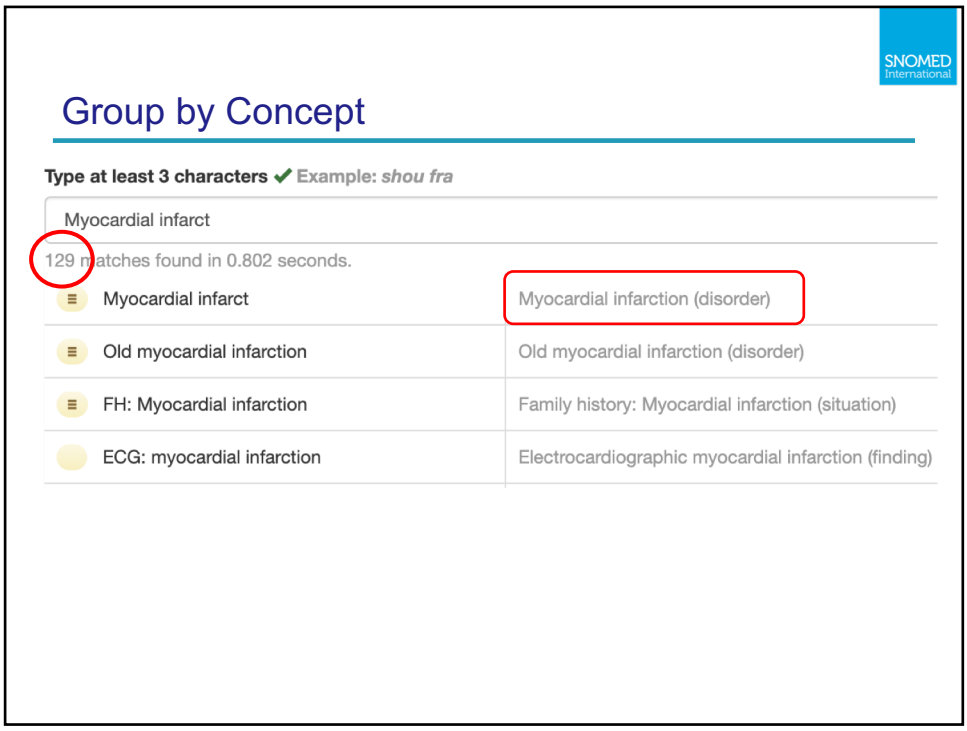
## Group by Concept

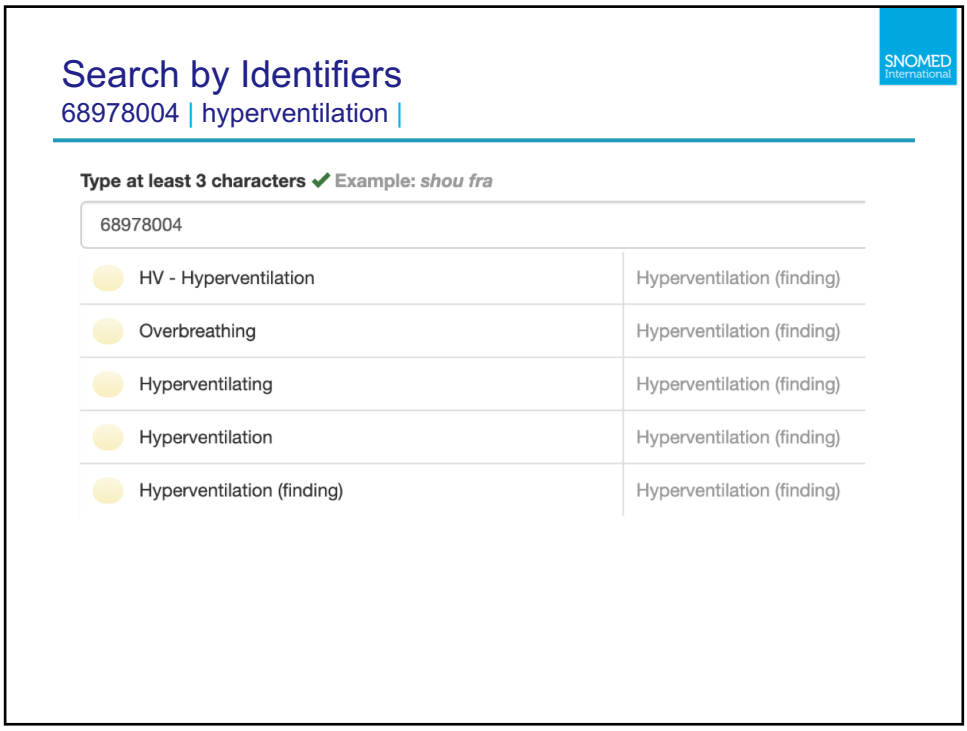
**Type at least 3 characters** ✔ **Example:** ***blistered finger***

Myocardial infarct

334 matches found in 1.016 seconds.

| | |
|---|---|
| Myocardial infarct ? | Myocardial infarction (disorder) |
| Myocardial infarction ? | Myocardial infarction (disorder) |
| Old myocardial infarction | Old myocardial infarction (disorder) |
| FH: Myocardial infarction | Family history: Myocardial infarction (situation) |
| MI - myocardial infarction | Myocardial infarction (disorder) |
| ECG: myocardial infarction | Electrocardiographic myocardial infarction (finding) |
| EKG: myocardial infarction | Electrocardiographic myocardial infarction (finding) |



## Search by Identifiers

68978004 | hyperventilation |

**Hyperventilation (finding)**

SCTID: 68978004, Primitive, Active

**English**

| Term | | Acceptability (en) |
|---|---|---|
| F ☆ | Hyperventilation (finding) | Preferred |
| S | HV - Hyperventilation | Acceptable |
| S ✔ | Hyperventilating | Acceptable |
| S ✔ | Overbreathing | Acceptable |

| DescriptionId | Type | Language | Case Significance | Effective Time | ModuleId |
|---|---|---|---|---|---|
| 114571014 | Synonym | en | Case insensitive | 20170731 | 900000000000207008 |

## Search by Identifiers

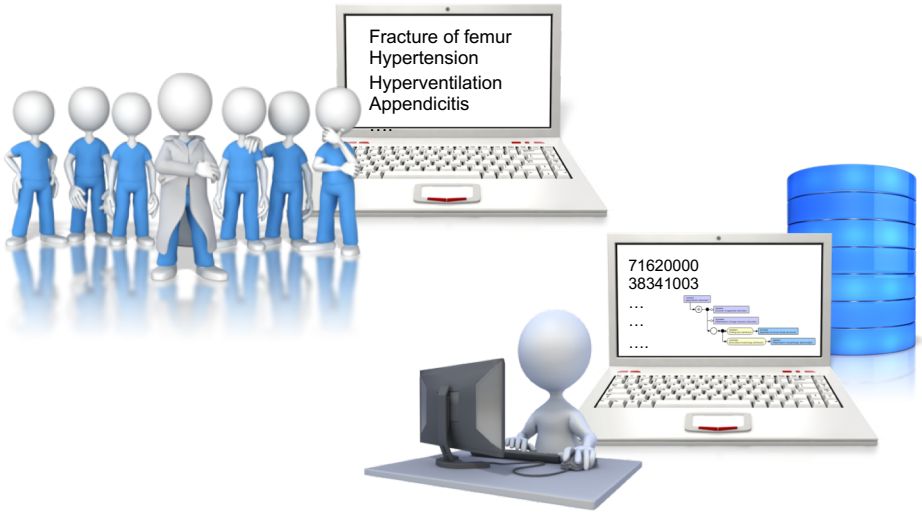
Description Identifier 114571014

**Type at least 3 characters** ✔ **Example:** ***shou fra***

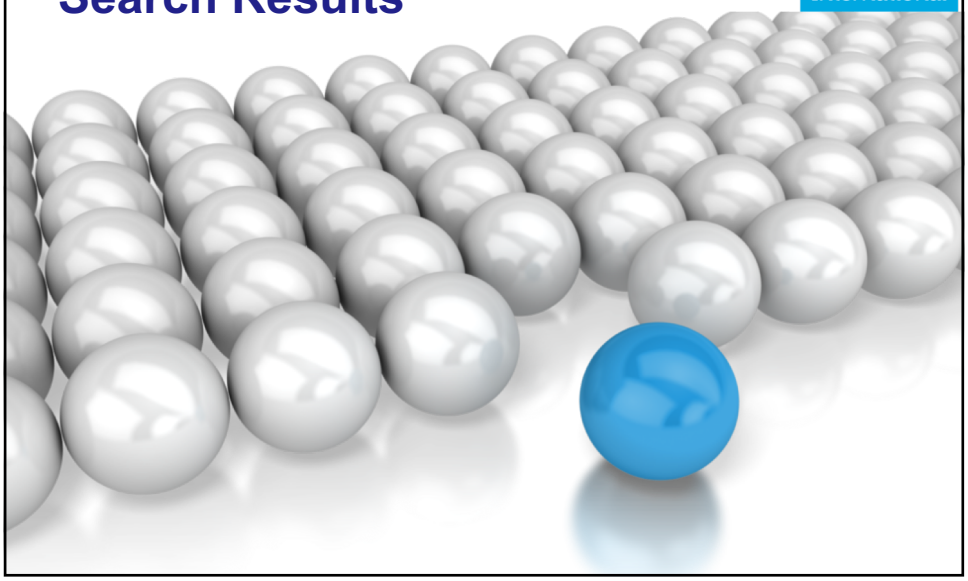
114571014

Hyperventilation

## Search by Identifiers




## Rationalize Search Results



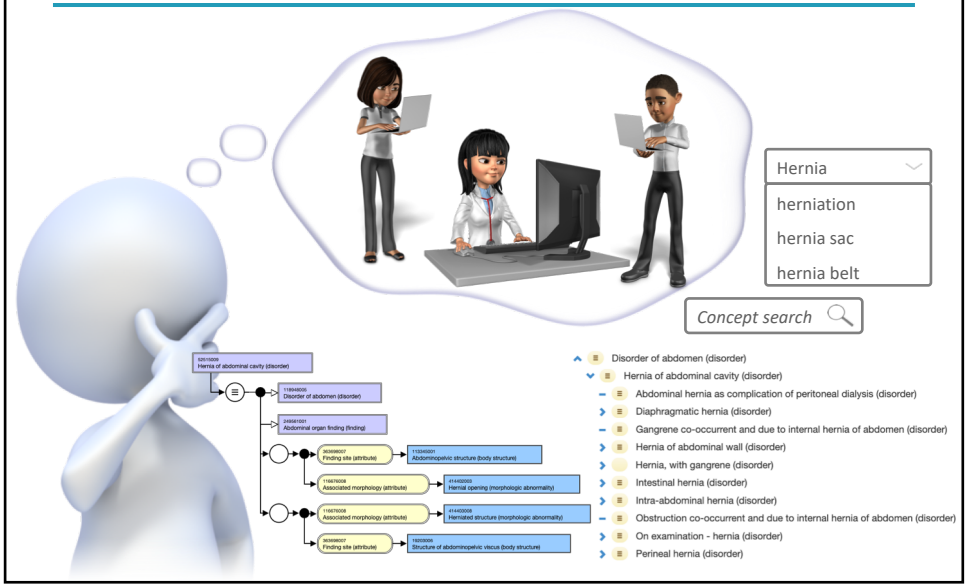
## Rationalize Display of Search Results

*Search string: "Hernia"*

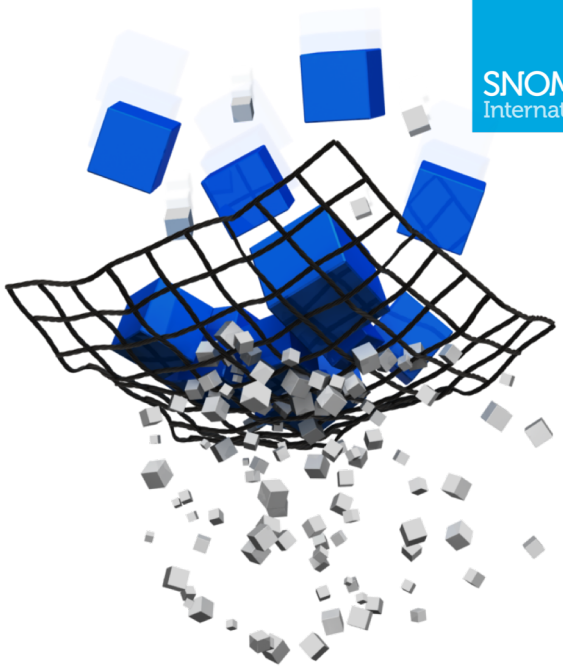
| Position | Alphabetic order of res | Shortest match first |
|---|---|---|
| 1 | abdominal hernia | hernia |
| 2 | abdominal wall hernia procedure | herniation |
| 3 | airway device cuff herniation | hernia sac |
| 4 | anesthesia for hernia repair in lower abdomen | hernia belt |
| 5 | anesthesia for hernia repair in upper abdomen | O/E - hernia |
| 6 | anesthesia for lumbar or ventral incisional hernia of upper abdomen | cecal hernia |
| 7 | anesthesia for transabdominal repair of diaphragmatic hernia | labial hernia |
| 8 | anesthesia for ventral or incisional hernia repair, lower abdomen | hernia repair |
| 9 | anterior perineal hernia | littré hernia |
| .... | | |
| 131 | hernia | |

Recommended for most use cases

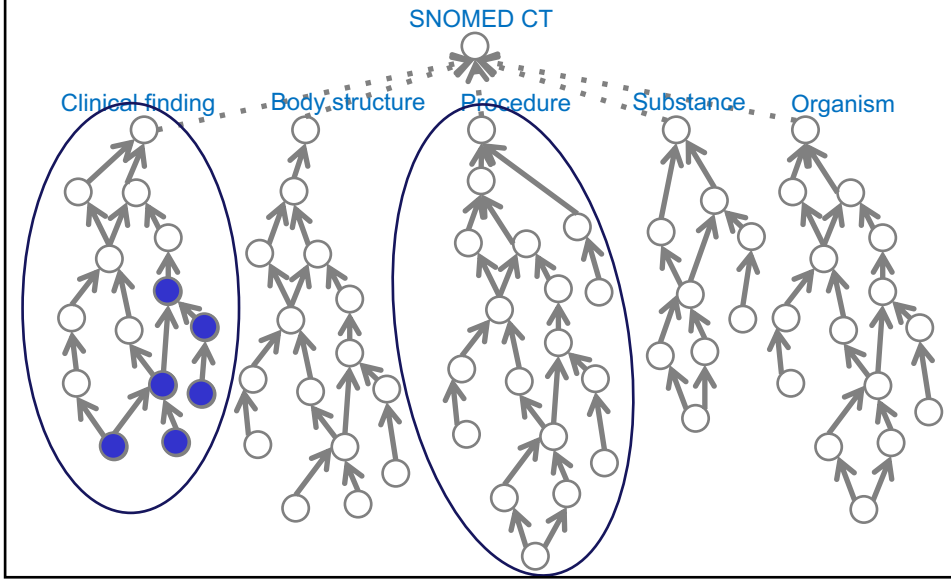
## Display of Search Results



## Constrain Searches



## Constrain Search by Subhierarchy



## Constrain Search by Hierarchy

**Type at least 3 characters** ✔ Example: *shou fra*

blood pressure

458 matches found in 0.367 seconds.

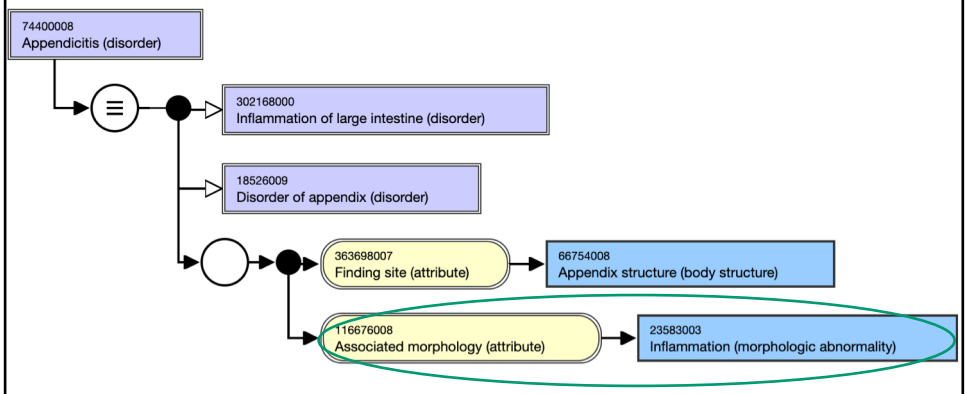
| | |
|---|---|
| Blood pressure | Blood pressure (ob |
| Low blood pressure | Low blood pressur |
| Cuff blood pressure | Non-invasive arteri |
| Mean blood pressure | Mean blood pressu |
| BP - Blood pressure | Blood pressure (ob |
| Blood pressure cuff | Blood pressure cuf |

**Filter results by Semantic Tag**

| | |
|---|---|
| regime/therapy | 9 |
| disorder | 12 |
| physical object | 31 |
| assessment scale | 2 |
| observable entity | 75 |
| procedure | 30 |
| finding | 44 |
| situation | 7 |
| record artifact | 1 |
| qualifier value | 2 |

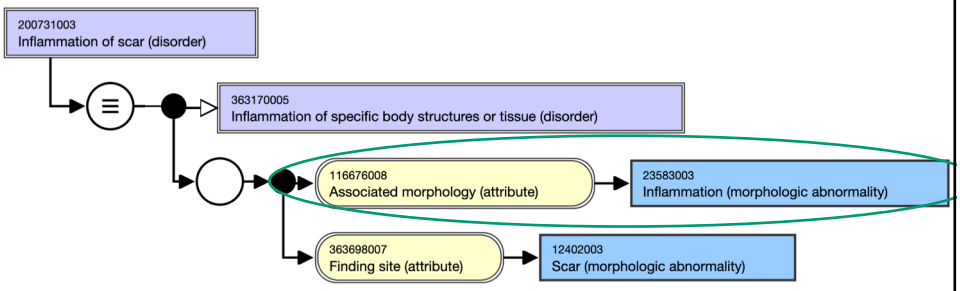
## Constrain by Attribute

- Constrain based on specific attributes of the concept
  - For example, only concepts with the attribute and value
    | associated morphology | = | inflammation |



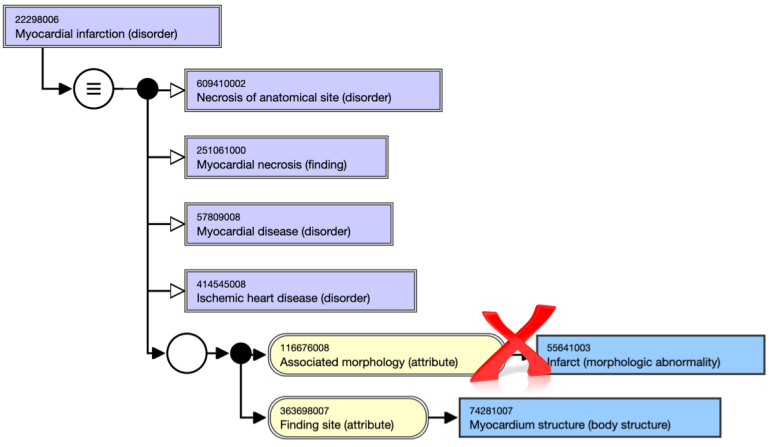
## Constrain by Attribute

- Constrain based on specific attributes of the concept
  - For example, only concepts with the attribute and value
    | associated morphology | = | inflammation |




## Constrain by Attribute

- Constrain based on specific attributes of the concept
  - For example, only concepts with the attribute and value
    | associated morphology | = | inflammation |



## Constrain Searches using ECL

- An expression constraint is a computable rule that can be used to define a bounded set of clinical meanings
- The Expression Constraint Language (ECL) enables queries over SNOMED CT content for a range of purposes, e.g.
  - Authoring and quality assurance of new SNOMED CT content
  - Design and display of SNOMED CT subsets in clinical user interfaces
  - Search or extract concepts with common characteristics

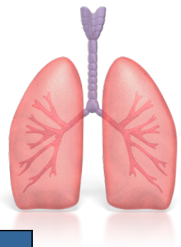
## ECL Example

- Example *Disorder of lung with edema*

  < 19829001 |Disorder of lung|:

  116676008 |Associated morphology|

  = << 79654002 |Edema|



- Valid Concepts

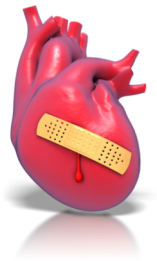
| Concept Id | Term |
|---|---|
| 233709006 | Toxic pulmonary edema |
| 11468004 | Postoperative pulmonary edema |
| 19242006 | Pulmonary edema |
| 61233003 | Silo-fillers' disease |
| 40541001 | Acute pulmonary edema |
| 89687005 | Postimmersion-submersion syndrome |
| 67782005 | Adult respiratory distress syndrome |

## Attribute Groups

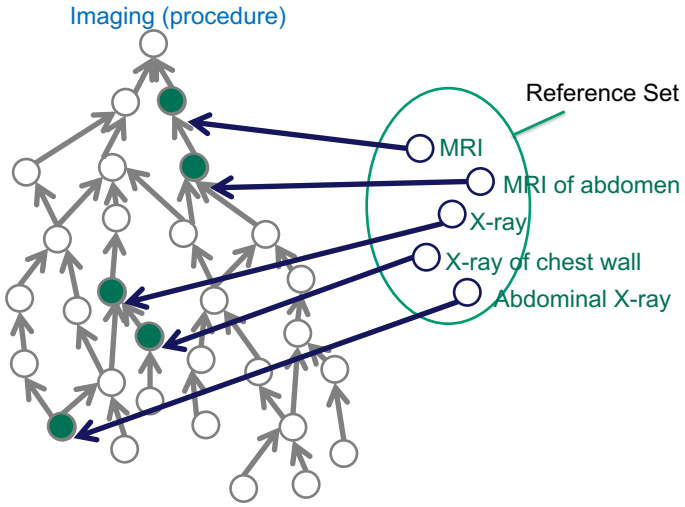
Example *Findings with a matching attribute group*

< 404684003 |Clinical finding|:
{363698007 |Finding site| = << 39057004 |Pulmonary valve structure|,
116676008 |Associated morphology| = << 415582006 |Stenosis|}

| Concept Id | Term |
|---|---|
| 204351007 | Fallot's trilogy |
| 204306007 | Pentalogy of Fallot |
| 703291007 | Prosthetic pulmonary valve stenosis |
| 703192005 | Postprocedural pulmonary valve stenosis |
| 67278007 | Congenital stenosis of pulmonary valve |
| 56786000 | Pulmonic valve stenosis |
| 472845002 | Stenosis of fetal pulmonary valve |



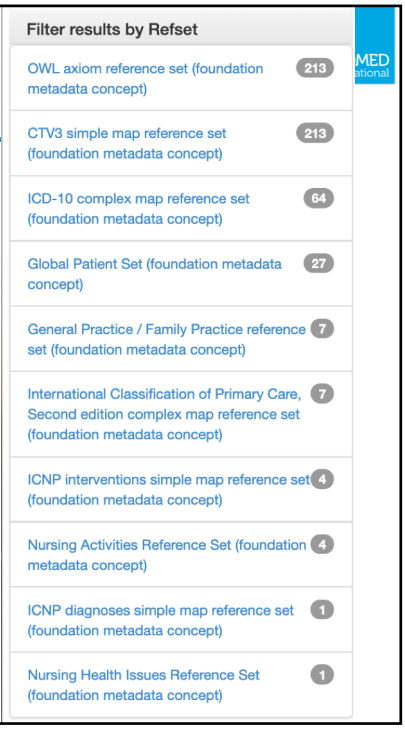
## Constrain Search by Reference Sets



## Constrain Search by Reference Sets

- Searches can be constrained to show concepts referenced in specific reference sets

Search string ”blood pressure”

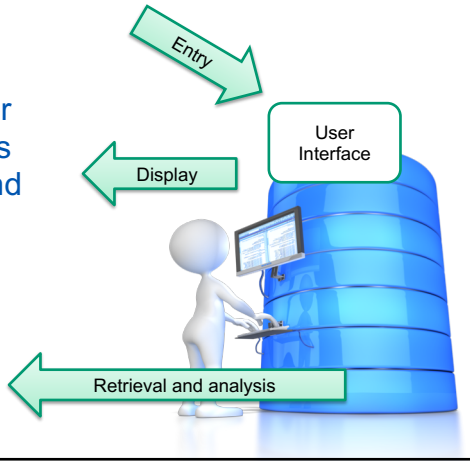



## Demonstration

# Data Entry Requirements

## Data Entry Requirements

- User interfaces that make it easy to accurately enter data that includes SNOMED CT
- User interfaces that render SNOMED CT data in ways that are easy to understand as part of a clinical record
- Effective ways to retrieve data to facilitate analysis and decision support



## Choosing Appropriate Data Entry Methods

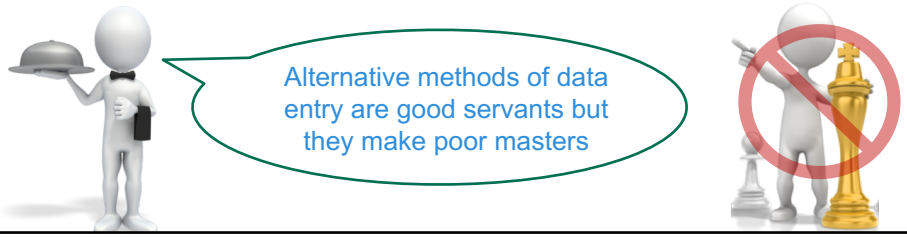
- Data entry methods should be tailored to the way different groups of clinicians think and work

*However …*

- Consistent representation of similar data is essential for effective communication, retrieval and analysis

*Therefore …*

- Data entry methods should **not** dictate the way that data is stored and accessed for reuse




## Problems with Data Entry Dependent Storage

If information is stored in ways determined by how was originally recorded it can be difficult to answer simple questions.

*Does the patient have a family history of diabetes mellitus?*

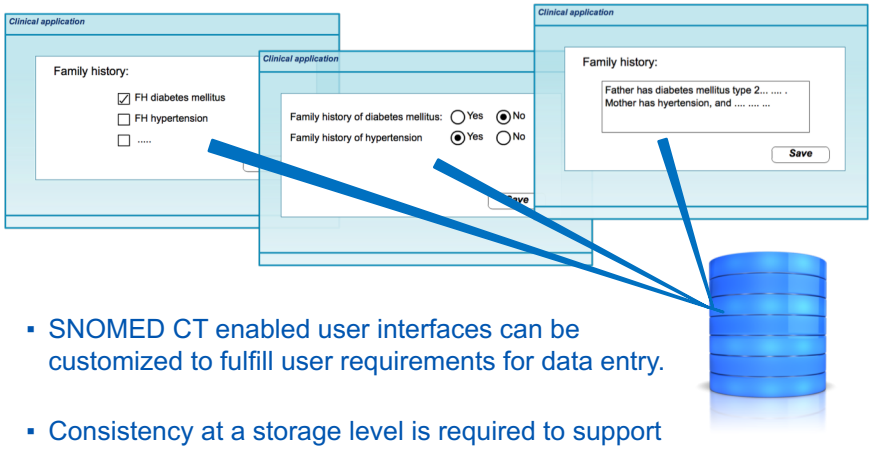
This might require several different searches in the patient record

1. Is the code for *family history of diabetes mellitus* present?
2. Is *diabetes mellitus* ticked in a family history form?
3. Is there a note that a specific relative has *diabetes mellitus*?

… and there are many other possible representations to consider

36

## Flexible Data Entry – Consistent Data Storage




- SNOMED CT enabled user interfaces can be customized to fulfill user requirements for data entry.
- Consistency at a storage level is required to support semantic coherency across user interfaces.

## Data Entry Methods

## Data Entry Using Searches

- SNOMED searches provide an effective way to enter some types of clinical data
- Searches should be constrained so that only concepts appropriate to the data entry context can be selected
  - For example
    - Restricting entry into a diagnosis slot to subtypes of disease
- Permitted concepts can be specified as:
  - Members of an identified subset designed for a data entry field
  - Subtypes of specified concepts
  - Concepts that conform to a specified expression constraint

## Importance of Constrained Searches

How should a new or current diagnosis of malignant melanoma be recorded?

Unconstrained searches of SNOMED CT for "**malignant melanoma**" return many concepts that are not appropriate for recording a new or current diagnosis

372156000 |Malignant melanoma - category (morphologic abnormality)|

The morphological abnormality refers to the cellular anomaly not the clinical diagnosis

161432005 |History of malignant melanoma (situation)|

This concept is used to record a past history not a current diagnosis

427858005 |Family history of malignant melanoma (situation)|

This is a family history concept

372244006 |Malignant melanoma (disorder)|

This concept or one of its subtypes should be used to record the diagnosis

## Practical Results of Unconstrained Searches

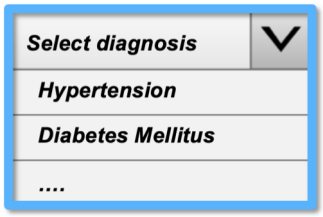
| Search Term | Concepts Incorrectly Selected as ER Diagnoses | Count |
|---|---|---|
| Temperature | 246508008 \|Temperature (attribute)\| | 1097 |
| High temperature | 285717004 \|High temperature (physical force)\| | 145 |
| Drug used | 246488008 \|Drug used (attribute)\| | 17 |
| Alcohol (substance) | 53041004 \|Alcohol (substance)\| *(and similar errors)* | 747 |
| Lymph node | 59441001 \|Structure of lymph node (body structure)\| | 33 |
| Stabbing | 410706007 \|Stabbing sensation quality (qualifier value)\| | 230 |
| RTA | 1776003 \|Renal tubular acidosis (disorder)\| | 535 |

"Overall, 11% of all 408,000 coded data items were very obviously coded to clinically impossible or improbable categories (e.g. to a substance, not a diagnosis)"

*Dr Jeremy Rogers – 2014 presentation SNOMED Expo*

## Alternative Approaches to Data Entry

- SNOMED coded data can also be entered using structured data entry controls such as
  - Check boxes
  - Radio buttons
  - Selection lists
  - Graphical selection
- SNOMED CT expressions can be bound to items in these controls
- When an item is selected the associated expression is then stored in the record

## Using Check Boxes for Data Entry

*Symptoms:*

- Headache ◄ 25064002 | Headache |
- Fever ◄ 386661006 | Fever |
- Cough ◄ 49727002 | Cough |

Although a tick in the checkbox means "Yes" this should **NOT** be recorded in SNOMED CT as

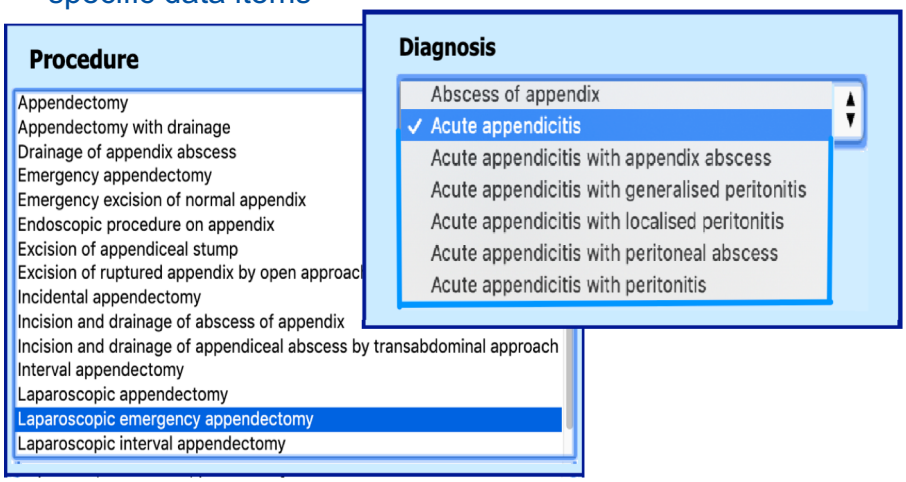
~~373066001~~ | Yes (qualifier value) |

## Using Radio Buttons for Data Entry

- Fully conscious ◄ 162701007 | On examination - fully conscious |
- Semi conscious ◄ 162705003 | On examination - semiconscious |
- Unconscious ◄ 268913004 | On examination - unconscious/comatose |

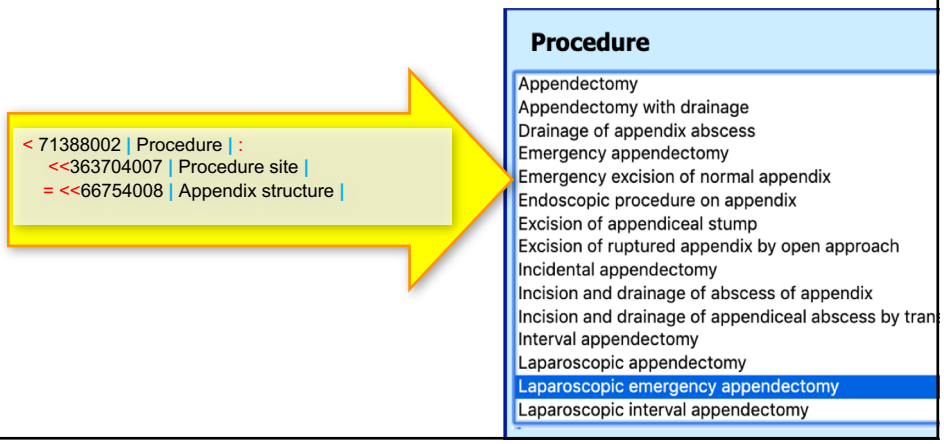
## Using Selection Lists

- Lists or dropdown controls can also be used to enter specific data items



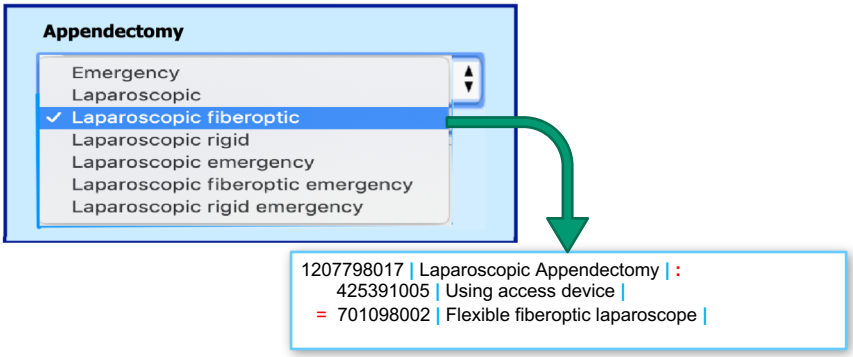

## Defining List Options Using Constraints

- Lists and dropdown options can be using SNOMED CT subsets or expression constraints

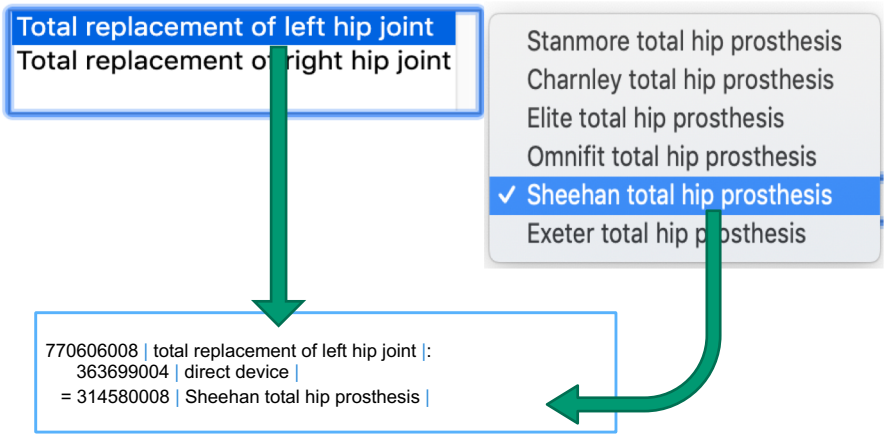


## Defining Customized List Options

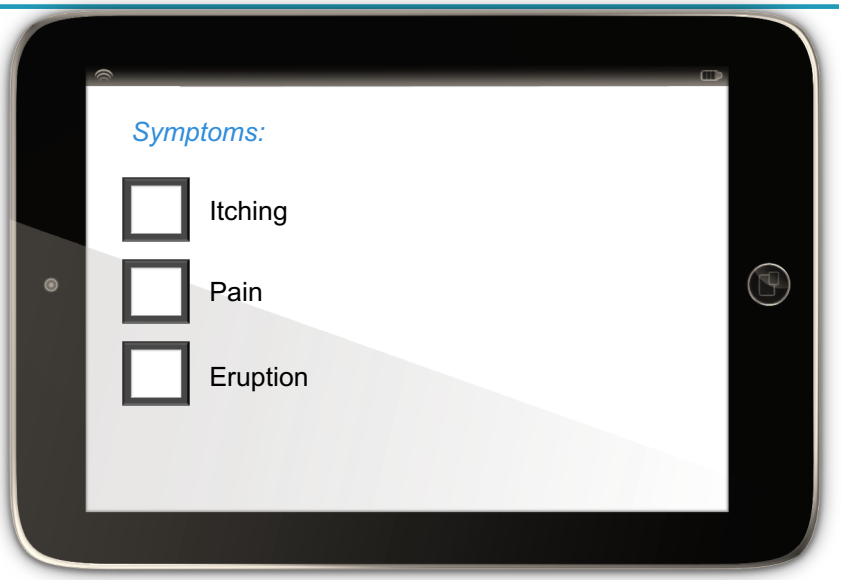
- Lists can also be defined containing custom terms, each bound to a specific SNOMED CT concept or expression
- This approach allows
  - Use of shorter terms qualified by a list title
  - List items linked to postcoordinated expressions



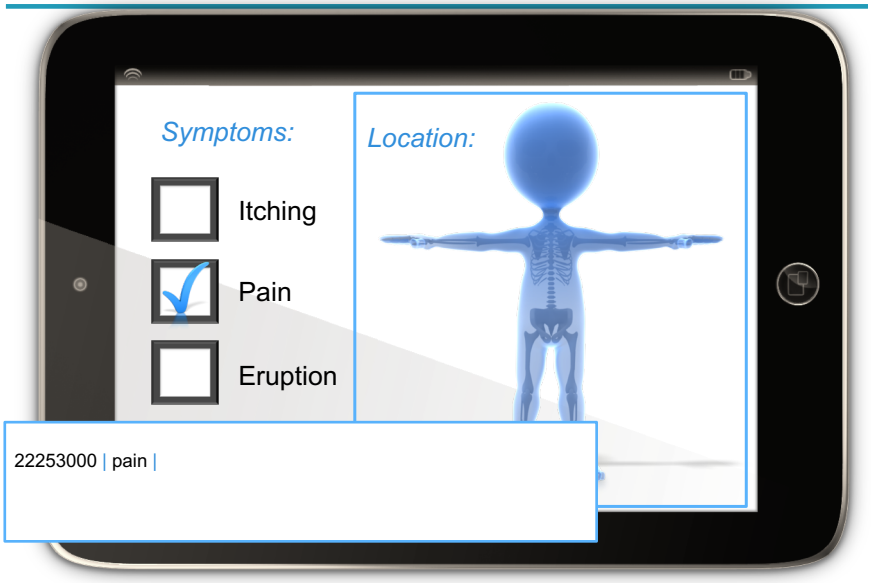

## Capturing Clinical Detail with Postcoordination



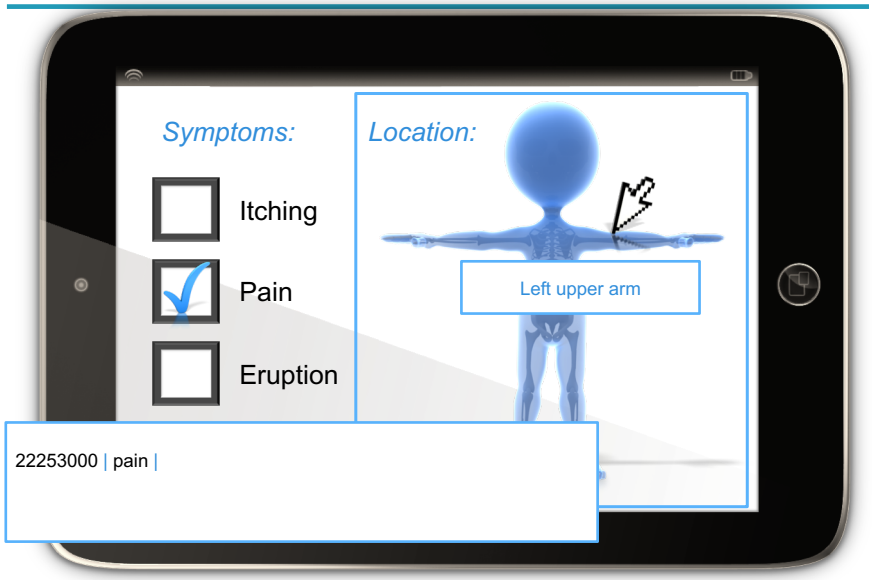
## Graphical Selection for Data Entry



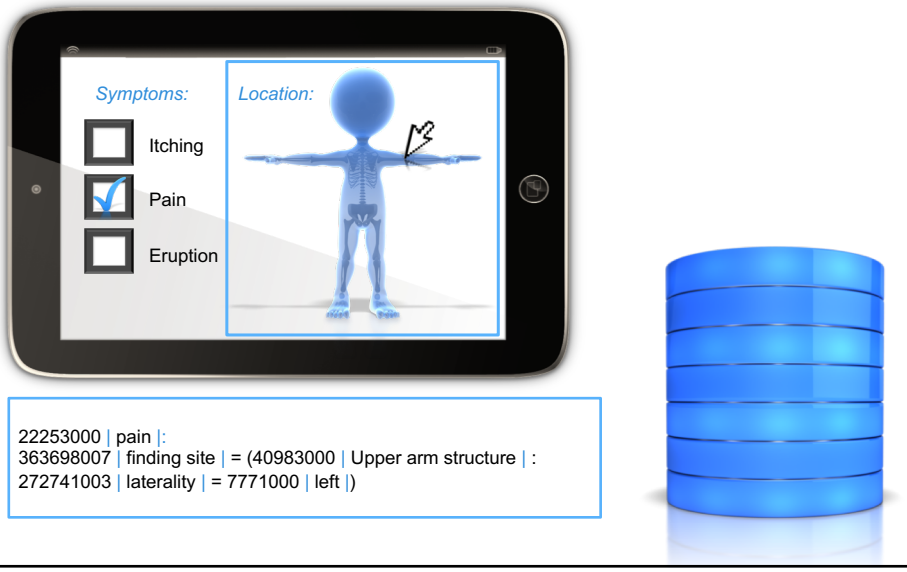

## Graphical Selection for Data Entry

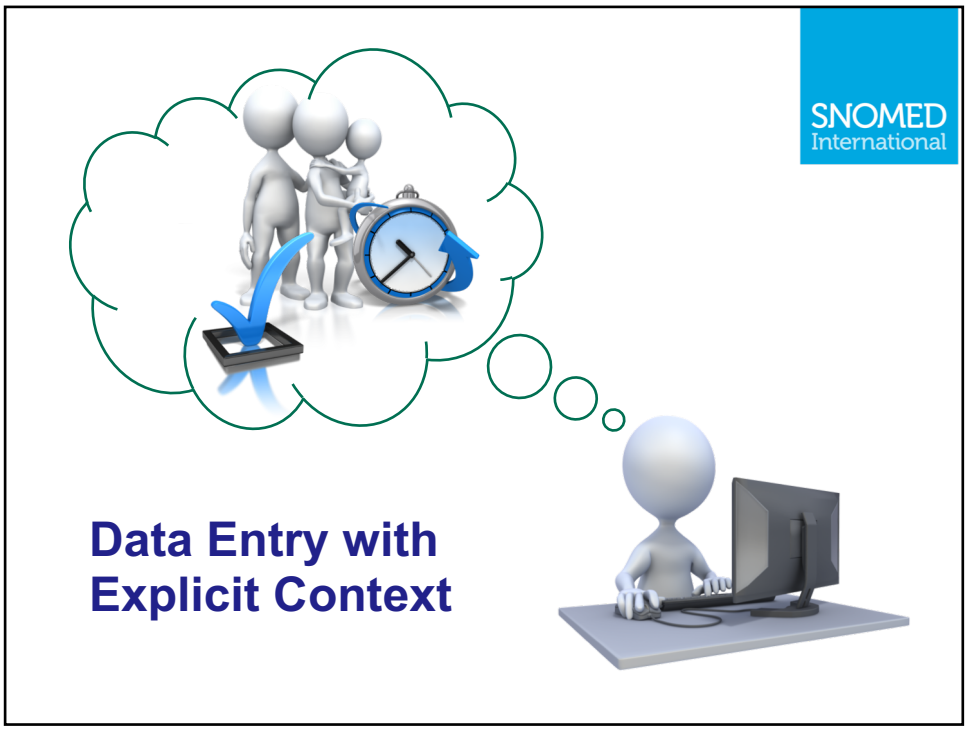


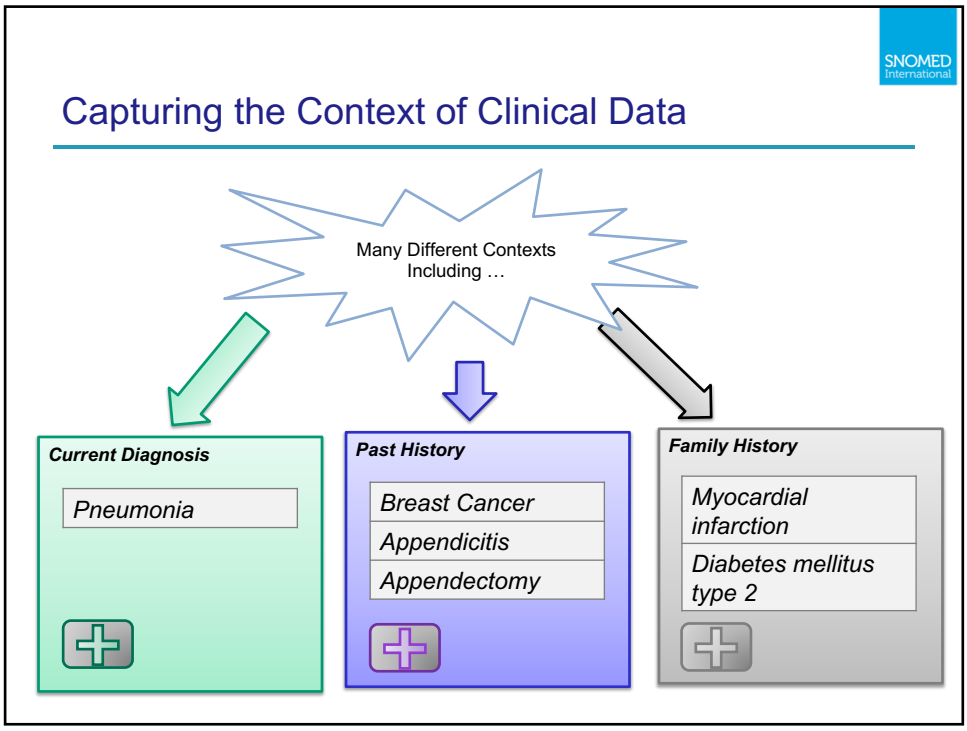
## Graphical Selection for Data Entry




## Graphical Selection for Data Entry




SNOMED International
Data Entry with Explicit Context


SNOMED International
Capturing the Context of Clinical Data
Many Different Contexts Including …
Current Diagnosis
Pneumonia
Past History
Breast Cancer
Appendicitis
Appendectomy
Family History
Myocardial infarction
Diabetes mellitus type 2

## Different Ways to Record Context

- Search for and select a concept that includes context

Family history diabetes mellitus

- Enter disease codes in a context specific sections

**Family History**

Diabetes mellitus ☑

Myocardial infarction ☐

**Past History**

Diabetes mellitus ☐

Myocardial infarction ☑

## Entering Context using Separate Context Fields

**Diagnosis:** Myocardial infarction

*Finding context:* Confirmed

- Suspected
- **Confirmed**
- Excluded

413350009 |finding with explicit context| : {

246090004 |associated finding| = **22298006 | Myocardial infarction |,**

408729009 |finding context| = **410605003 | Confirmed present |,**

408731000 |temporal context| = 15240007 |current| ,
408732007 |subject relationship context| = 410604004 |subject of record| }

# Natural Language Processing

## Natural Language Processing

- NLP enables a computer program to analyze and extract meaning from human language
- That meaning can be represented as SNOMED CT concepts and expressions in a clinical record

**Challenges**

- abbreviations
- spelling errors
- grammatical errors
- unexpected synonyms
- unusual vernacular phrases
- hidden contextual information

## Natural Language Processing with SNOMED CT

Procedure Notes:

Endoscopy revealed an acute gastric ulcer but no evidence of gastric bleeding or perforation of the stomach.

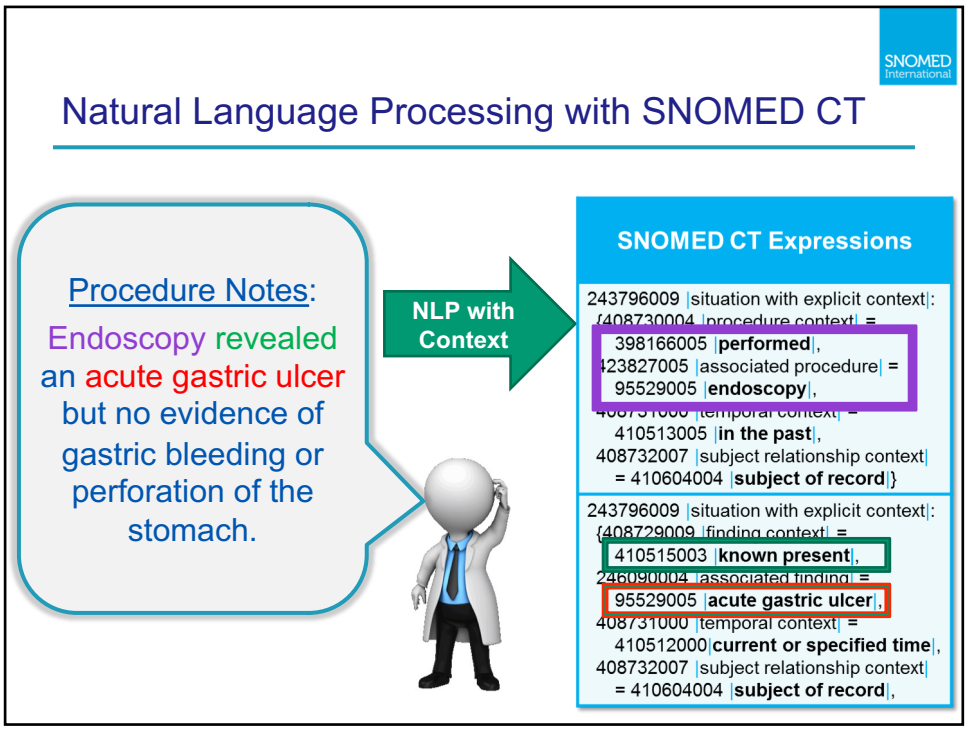
## Natural Language Processing with SNOMED CT

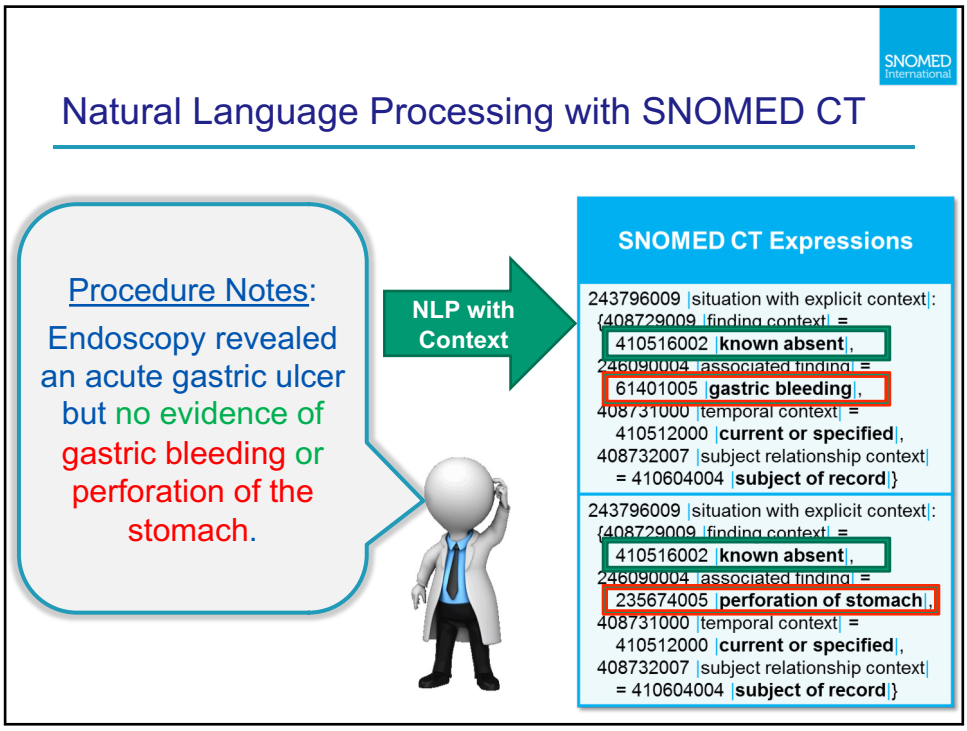
Procedure Notes:

Endoscopy revealed an acute gastric ulcer but no evidence of gastric bleeding or perforation of the stomach.

Simple NLP

| SNOMED CT Concept |
| --- |
| 423827005 \| endoscopy \| |
| 95529005 \| acute gastric ulcer \| |
| 61401005 \| gastric bleeding \| |
| 235674005 \| perforation of stomach \| |



## Data Entry Demonstration

Data Entry demo
Data Entry demo script

## Links to Further Information

- Search and Data Entry Guide
  - Search
    - http://snomed.org/search
  - Data Entry
    - http://snomed.org/dataentry
- Data Entry Demo
  - https://ihtsdo.github.io/snomed-ui-examples/

SNOMED International

## Questions?