



## Intelligent Search and Data Entry

Expo 2019 Tutorial

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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. **!**



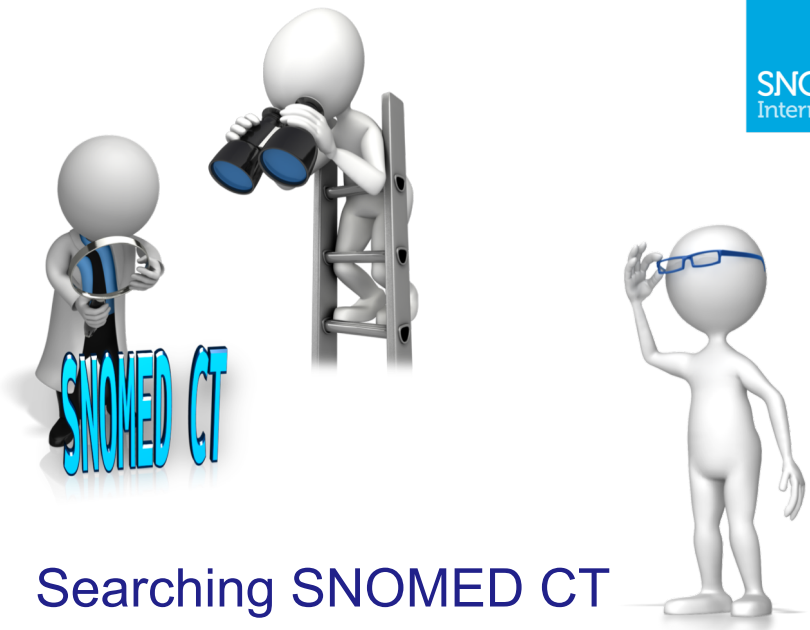
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## Overview


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



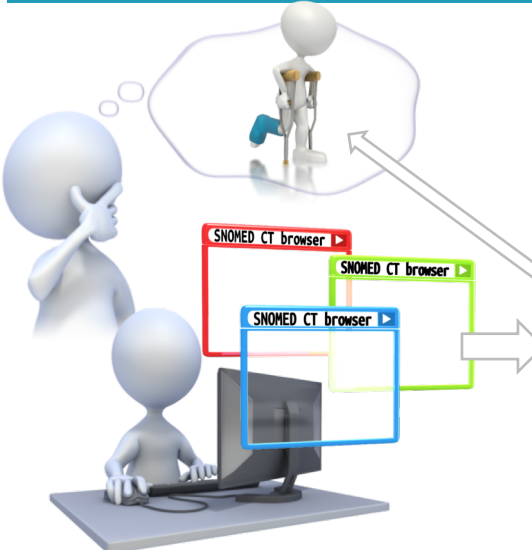
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## Searching SNOMED CT



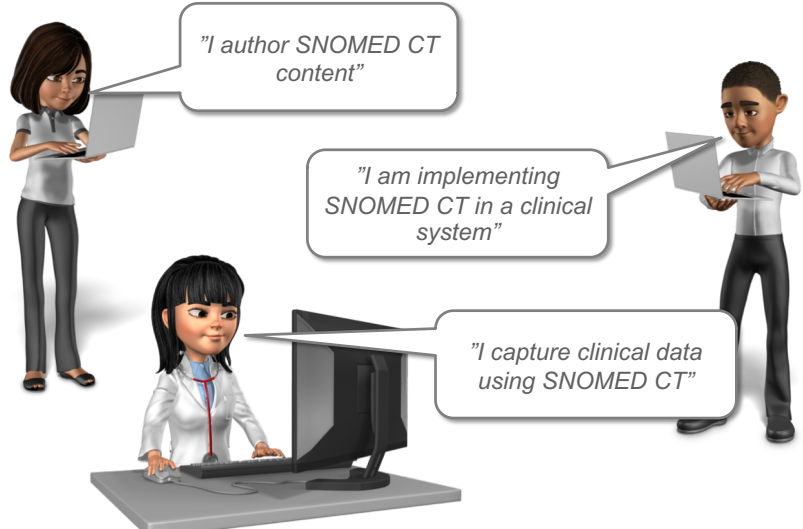
### What is SNOMED CT Search?



- 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



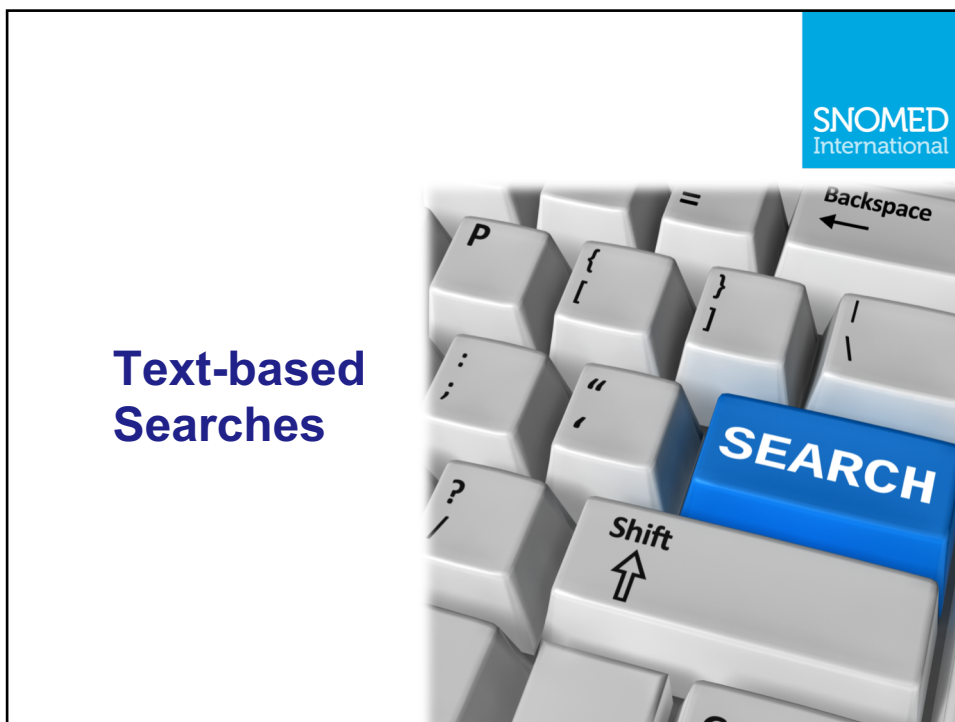
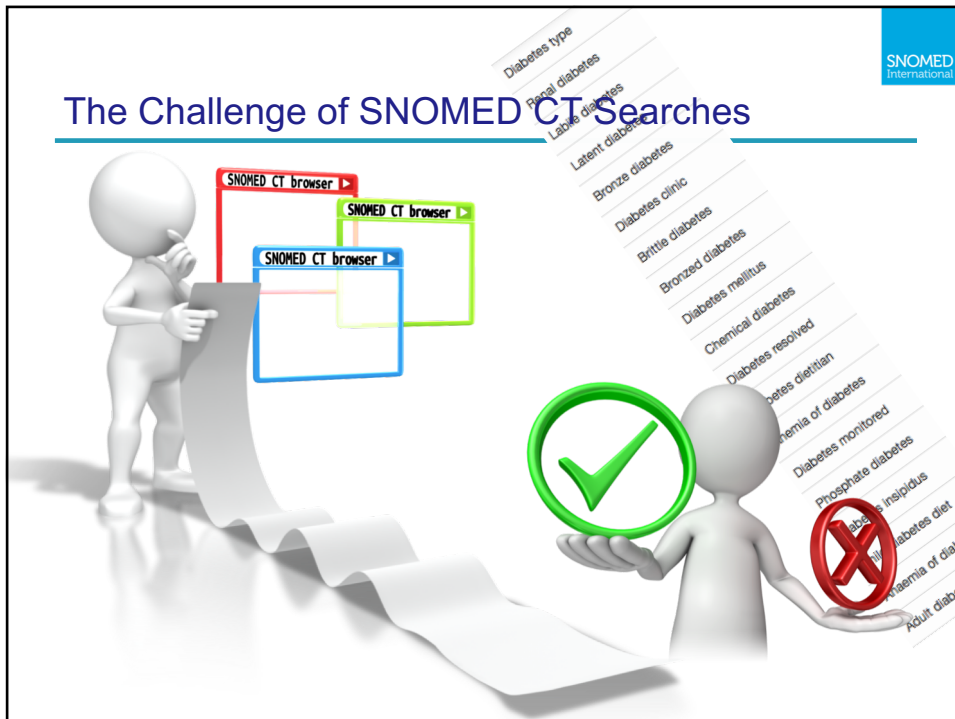
### Who Perform SNOMED CT Searches?




"I author SNOMED CT content"

"I am implementing SNOMED CT in a clinical system"

"I capture clinical data using SNOMED CT"






## 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*

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) |

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## Phrase Match

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

334 matches found in 1.016 seconds.

|                                     |  |
|-------------------------------------|--|
| ☰ <u>Myocardial infarct</u>         | Myocardial infarction (disorder)                     |
| ☰ <u>Myocardial infarction</u>      | Myocardial infarction (disorder)                     |
| ☰ Old <u>myocardial infarction</u>  | Old myocardial infarction (disorder)                 |
| ☰ FH: <u>Myocardial infarction</u>  | Family history: Myocardial infarction (situation)    |
| ☰ MI - <u>myocardial infarction</u> | Myocardial infarction (disorder)                     |
| ● ECG: <u>myocardial infarction</u> | Electrocardiographic myocardial infarction (finding) |
| ● EKG: <u>myocardial infarction</u> | Electrocardiographic myocardial infarction (finding) |

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## Group by Concept

---

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

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) |

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## Group by Concept

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

Myocardial infarct

129 matches found in 0.802 seconds.

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

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## Search by Identifiers

68978004 | hyperventilation |

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

68978004

|                            |                            |
|----------------------------|----------------------------|
| HV - Hyperventilation      | Hyperventilation (finding) |
| Overbreathing              | Hyperventilation (finding) |
| Hyperventilating           | Hyperventilation (finding) |
| Hyperventilation           | Hyperventilation (finding) |
| Hyperventilation (finding) | Hyperventilation (finding) |

**Search by Identifiers**  
68978004 | hyperventilation |

**Hyperventilation (finding)**

SCTID: 68978004, Primitive, Active

English

| Term   | Acceptability (en) |               |                   |                |                    |                |          |           |         |    |                  |          |                    |
|--|--------------------|---------------|-------------------|----------------|--------------------|----------------|----------|-----------|---------|----|------------------|----------|--------------------|
| F ☆ Hyperventilation (finding)   | Preferred          |               |                   |                |                    |                |          |           |         |    |                  |          |                    |
| <table border="1"><thead><tr><th>DescriptionId</th><th>Type</th><th>Language</th><th>Case Significance</th><th>Effective Time</th><th>ModuleId</th></tr></thead><tbody><tr><td>114571014</td><td>Synonym</td><td>en</td><td>Case insensitive</td><td>20170731</td><td>900000000000207008</td></tr></tbody></table> |                    | DescriptionId | Type              | Language       | Case Significance  | Effective Time | ModuleId | 114571014 | Synonym | en | Case insensitive | 20170731 | 900000000000207008 |
| DescriptionId  | Type               | Language      | Case Significance | Effective Time | ModuleId           |                |          |           |         |    |                  |          |                    |
| 114571014  | Synonym            | en            | Case insensitive  | 20170731       | 900000000000207008 |                |          |           |         |    |                  |          |                    |
| S ✓ HV - Hyperventilation  | Acceptable         |               |                   |                |                    |                |          |           |         |    |                  |          |                    |
| S ✓ Hyperventilating   | Acceptable         |               |                   |                |                    |                |          |           |         |    |                  |          |                    |
| S ✓ Overbreathing  | Acceptable         |               |                   |                |                    |                |          |           |         |    |                  |          |                    |

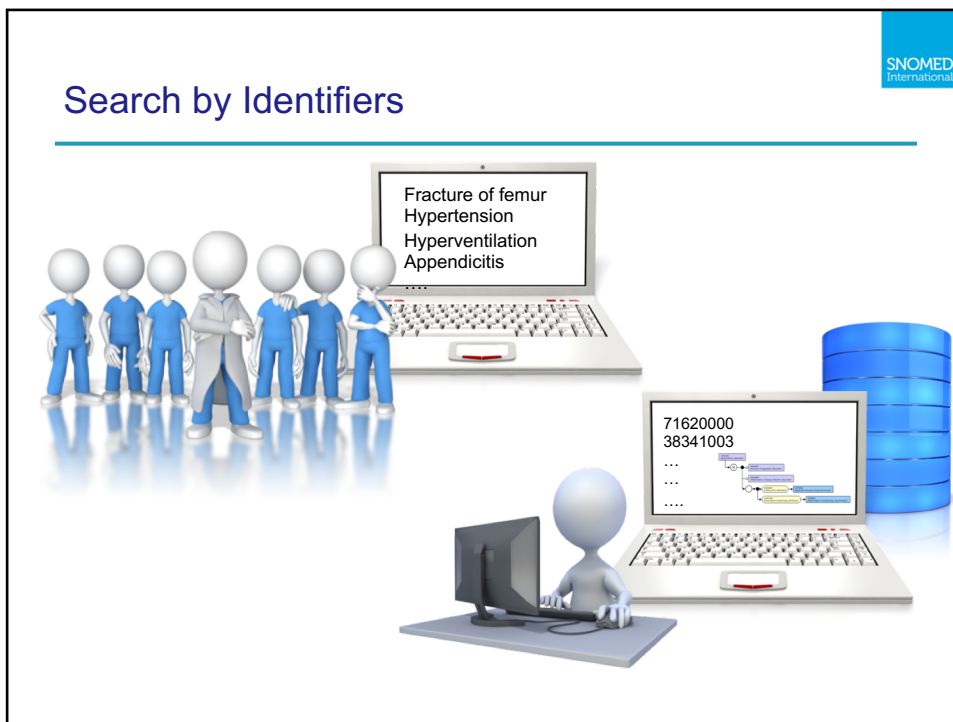
**Search by Identifiers**  
Description Identifier 114571014

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

114571014

☰ Hyperventilation





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## Rationalize Display of Search Results

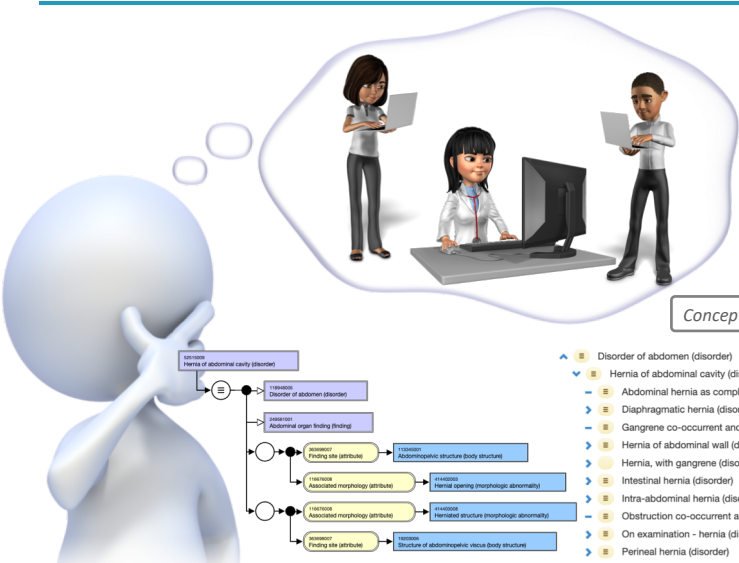
Search string: "Hernia"

| Position | Alphabetic order of results   | 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

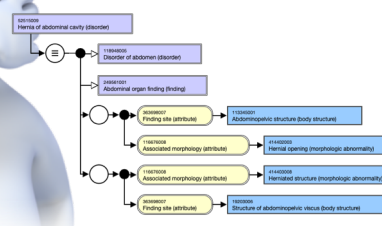
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## Display of Search Results

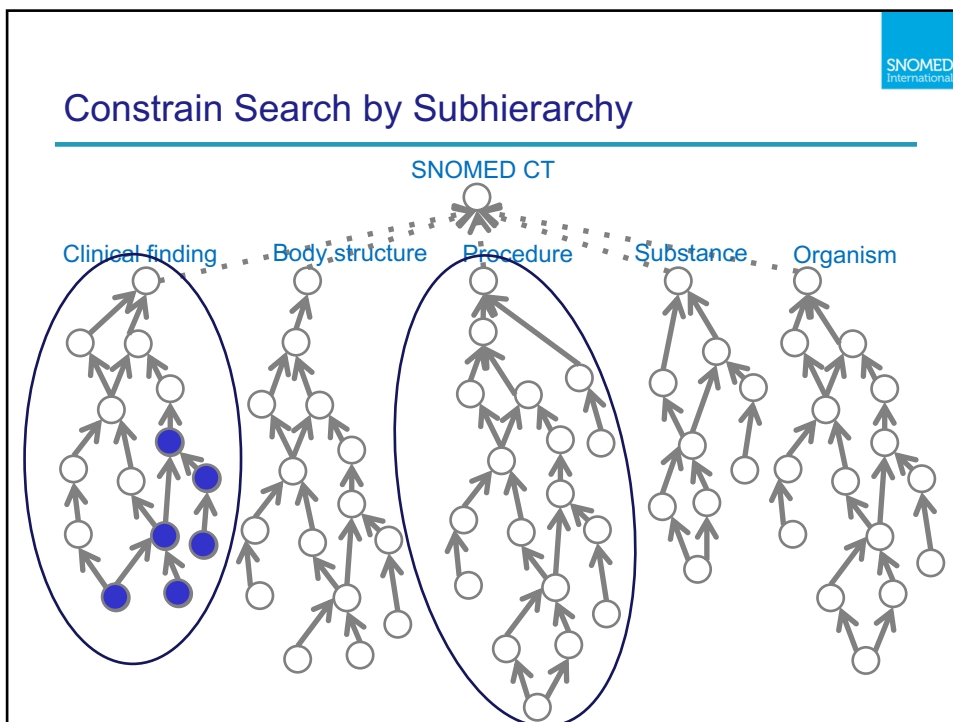


herniation  
hernia sac  
hernia belt

Concept search



- Disorder of abdomen (disorder)
- Hernia of abdominal cavity (disorder)
  - Abdominal hernia as complication of peritoneal dialysis (disorder)
  - Diaphragmatic hernia (disorder)
  - Gangrene co-occurrent and due to internal hernia of abdomen (disorder)
  - Hernia of abdominal wall (disorder)
  - Hernia, with gangrene (disorder)
  - Intestinal hernia (disorder)
  - Intra-abdominal hernia (disorder)
  - Obstruction co-occurrent and due to internal hernia of abdomen (disorder)
  - On examination - hernia (disorder)
  - Perineal hernia (disorder)



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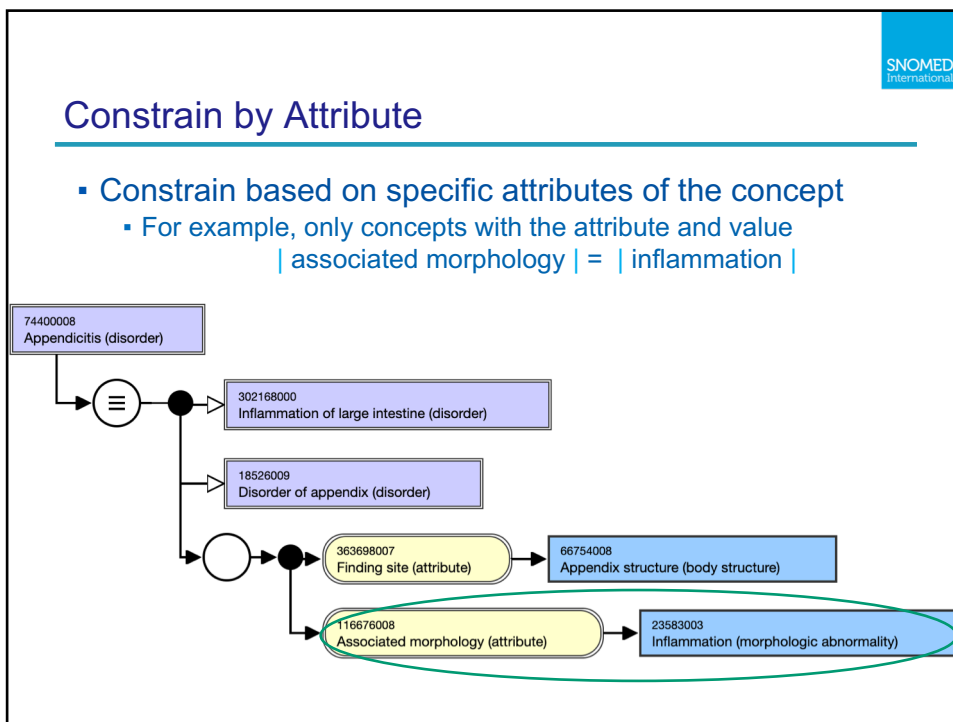
## Constrain Search by Hierarchy

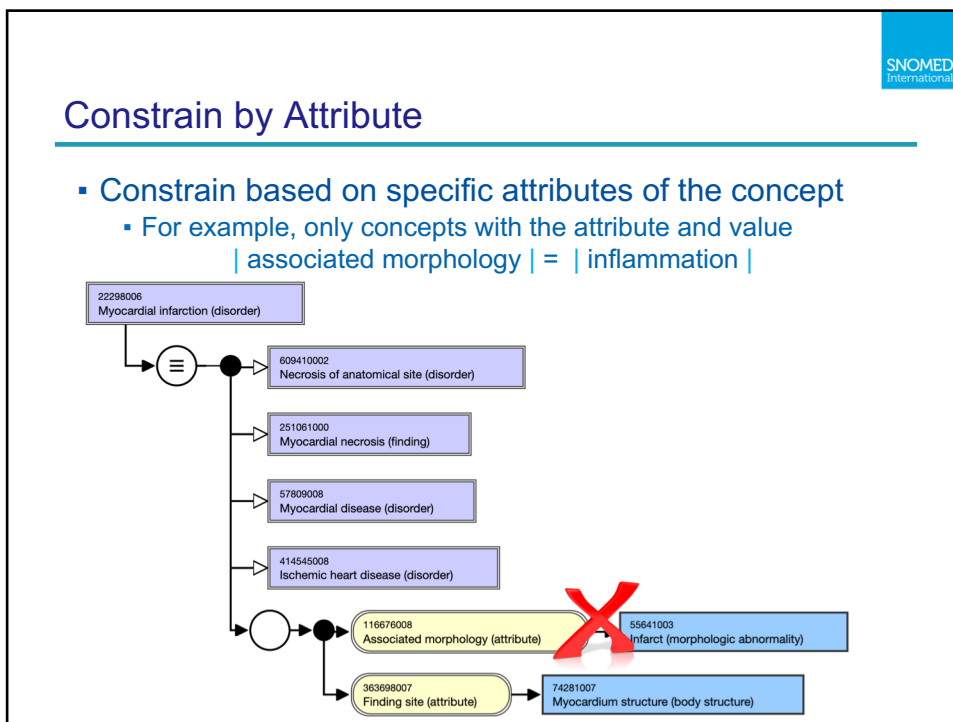
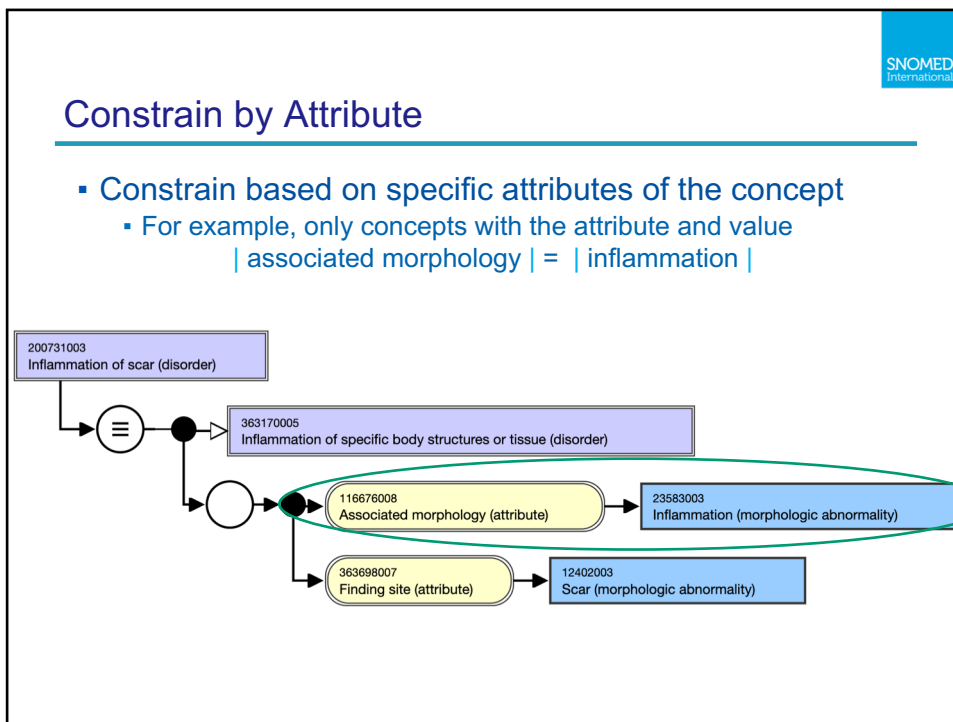
Type at least 3 characters ✓ Example: *shou fra*

blood pressure

458 matches found in 0.367 seconds.

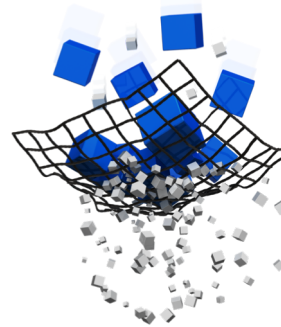
|                       |                     |  |
|-----------------------|---------------------|--|
| ☰ Blood pressure      | Blood pressure (ob  | <b>Filter results by Semantic Tag</b><br>regime/therapy 9<br><b>disorder 12</b><br>physical object 31<br>assessment scale 2<br>observable entity 75<br>procedure 30<br>finding 44<br>situation 7<br>record artifact 1<br>qualifier value 2 |
| ● 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  |  |





## 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 |

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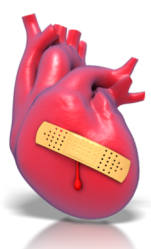
## Attribute Groups

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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       |

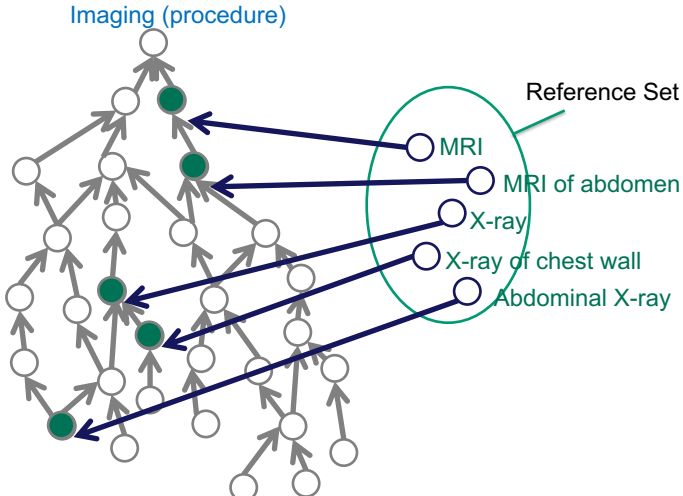


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## Constrain Search by Reference Sets

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Imaging (procedure)




### Constrain Search by Reference Sets

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

Search string "blood pressure"

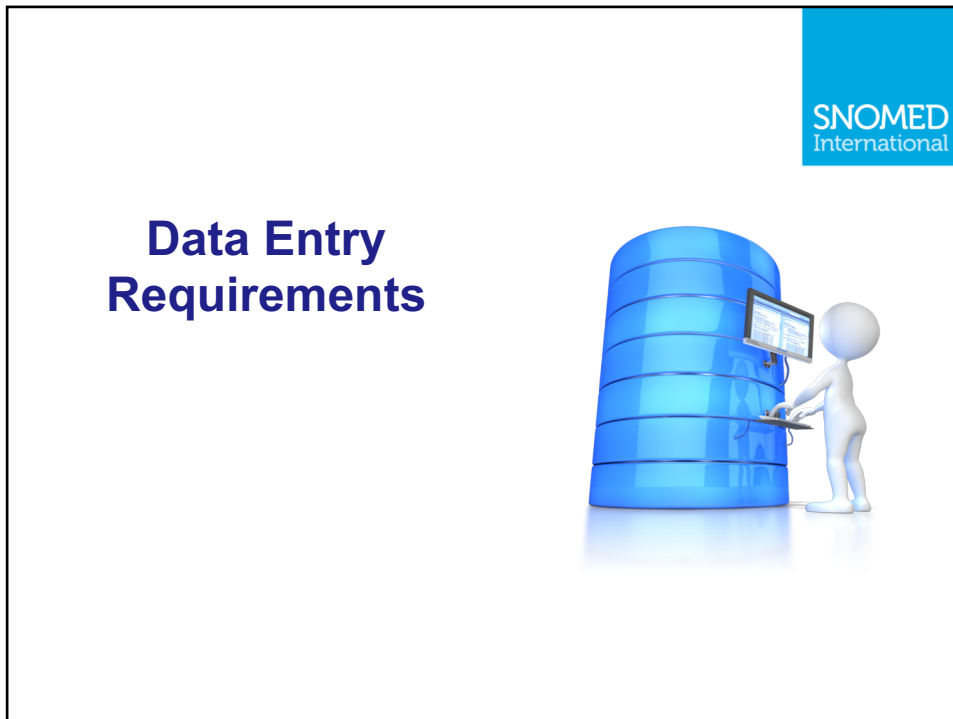
| Filter results by Refset   |     |
|--|-----|
| OWL axiom reference set (foundation metadata concept)  | 213 |
| CTV3 simple map reference set (foundation metadata concept)  | 213 |
| ICD-10 complex map reference set (foundation metadata concept)   | 64  |
| Global Patient Set (foundation metadata concept)   | 27  |
| General Practice / Family Practice reference set (foundation metadata concept)                                       | 7   |
| International Classification of Primary Care, Second edition complex map reference set (foundation metadata concept) | 7   |
| ICNP interventions simple map reference set (foundation metadata concept)  | 4   |
| Nursing Activities Reference Set (foundation metadata concept)   | 4   |
| ICNP diagnoses simple map reference set (foundation metadata concept)  | 1   |
| Nursing Health Issues Reference Set (foundation metadata concept)  | 1   |

## Demonstration



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## 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

The diagram shows a 3D white character at a computer workstation interacting with a blue cylindrical database. Three green arrows indicate the flow of data: one labeled 'Entry' points from the character to the database, one labeled 'Display' points from the database to the character, and one labeled 'Retrieval and analysis' points from the database to the left.



## Choosing Appropriate Data Entry Methods

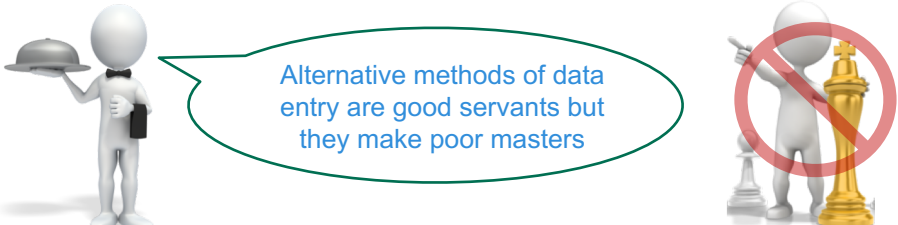
- Data entry methods should be tailored to the way different groups of clinicians think and work

*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

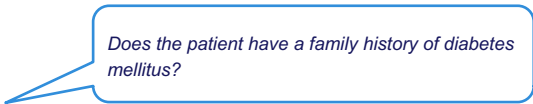


Alternative methods of data entry are good servants but they make poor masters



## 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

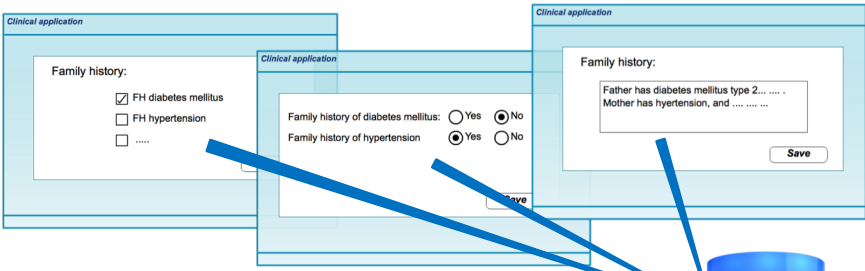
1. Is the code for *family history of diabetes mellitus* present?
2. Is *diabetes mellitus* ticked in a family history form?
3. Is there a note that a specific relative has *diabetes mellitus*?

... and there are many other possible representations to consider

36

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## Flexible Data Entry – Consistent Data Storage




The diagram illustrates three overlapping windows of a clinical application, each showing a different user interface for data entry. The first window shows a form with checkboxes for 'FH diabetes mellitus', 'FH hypertension', and '.....'. The second window shows a form with radio buttons for 'Family history of diabetes mellitus' and 'Family history of hypertension'. The third window shows a form with text input fields for 'Father has diabetes mellitus type 2...' and 'Mother has hypertension, and .....'. All three windows have a 'Save' button. Blue arrows point from each window to a central icon of a database cylinder.


- 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.

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## Data Entry Methods




The illustration shows a 3D white figure standing next to a large blue database cylinder. The figure is holding a monitor and a keyboard, suggesting interaction with the data storage system.




## 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*

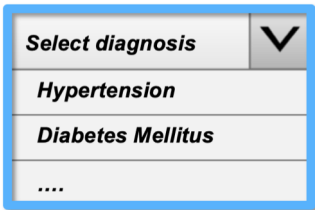


## Alternative Approaches to Data Entry

- 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



Yes     No



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## Using Check Boxes for Data Entry

*Symptoms:*

|                                     |          |   |       |                     |
|-------------------------------------|----------|---|-------|---------------------|
| <input checked="" type="checkbox"/> | Headache | ← | ..... | 25064002   Headache |
| <input checked="" type="checkbox"/> | Fever    | ← | ..... | 386661006   Fever   |
| <input type="checkbox"/>            | Cough    | ← | ..... | 49727002   Cough    |

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

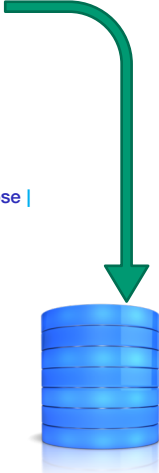
~~375066001 | Yes (qualifier value) |~~



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## Using Radio Buttons for Data Entry

|                                  |                 |   |       |   |
|----------------------------------|-----------------|---|-------|---|
| <input checked="" type="radio"/> | Fully conscious | ← | ..... | 162701007   On examination - fully conscious      |
| <input type="radio"/>            | Semi conscious  | ← | ..... | 162705003   On examination - semiconscious        |
| <input type="radio"/>            | Unconscious     | ← | ..... | 268913004   On examination - unconscious/comatose |



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## Using Selection Lists

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

**Procedure**

- Appendectomy
- Appendectomy with drainage
- Drainage of appendix abscess
- Emergency appendectomy
- Emergency excision of normal appendix
- Endoscopic procedure on appendix
- Excision of appendiceal stump
- Excision of ruptured appendix by open approach
- Incidental appendectomy
- Incision and drainage of abscess of appendix
- Incision and drainage of appendiceal abscess by transabdominal approach
- Interval appendectomy
- Laparoscopic appendectomy
- Laparoscopic emergency appendectomy
- Laparoscopic interval appendectomy

**Diagnosis**

- Abscess of appendix
- ✓ Acute appendicitis
- Acute appendicitis with appendix abscess
- Acute appendicitis with generalised peritonitis
- Acute appendicitis with localised peritonitis
- Acute appendicitis with peritoneal abscess
- Acute appendicitis with peritonitis

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## Defining List Options Using Constraints

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

< 71388002 | Procedure | :

<<363704007 | Procedure site |

= <<66754008 | Appendix structure |

**Procedure**

- Appendectomy
- Appendectomy with drainage
- Drainage of appendix abscess
- Emergency appendectomy
- Emergency excision of normal appendix
- Endoscopic procedure on appendix
- Excision of appendiceal stump
- Excision of ruptured appendix by open approach
- Incidental appendectomy
- Incision and drainage of abscess of appendix
- Incision and drainage of appendiceal abscess by transabdominal approach
- Interval appendectomy
- Laparoscopic appendectomy
- Laparoscopic emergency appendectomy
- Laparoscopic interval appendectomy

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### 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

**Appendectomy**

- Emergency
- Laparoscopic
- Laparoscopic fiberoptic
- Laparoscopic rigid
- Laparoscopic emergency
- Laparoscopic fiberoptic emergency
- Laparoscopic rigid emergency

1207798017 | Laparoscopic Appendectomy | :  
425391005 | Using access device |  
= 701098002 | Flexible fiberoptic laparoscope |

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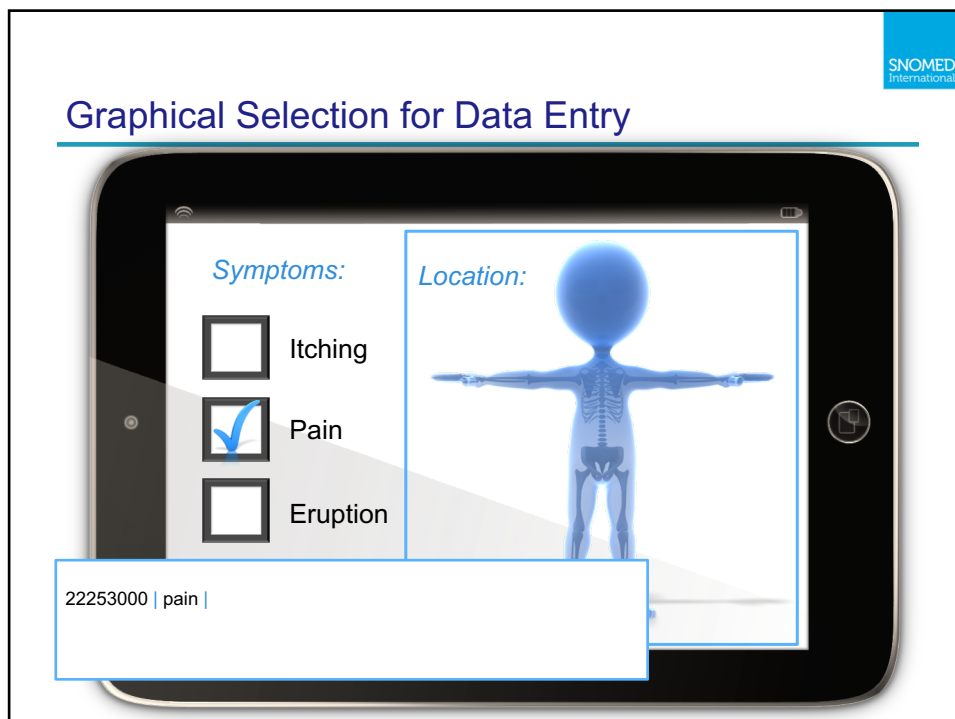
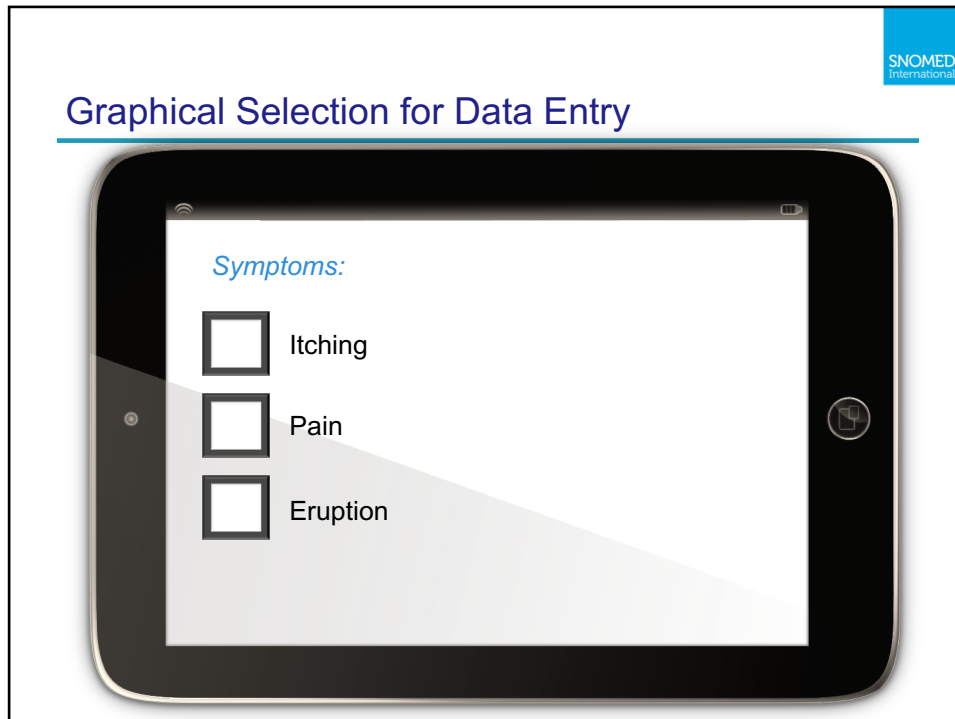
### Capturing Clinical Detail with Postcoordination

Total replacement of left hip joint  
Total replacement of right hip joint

Stanmore total hip prosthesis  
Charnley total hip prosthesis  
Elite total hip prosthesis  
Omnifit total hip prosthesis  
 Sheehan total hip prosthesis  
Exeter total hip prosthesis

770606008 | total replacement of left hip joint | :  
363699004 | direct device |  
= 314580008 | Sheehan total hip prosthesis |





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### Graphical Selection for Data Entry

*Symptoms:*

- Itching
- Pain
- Eruption

*Location:*

Left upper arm

22253000 | pain |

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### Graphical Selection for Data Entry

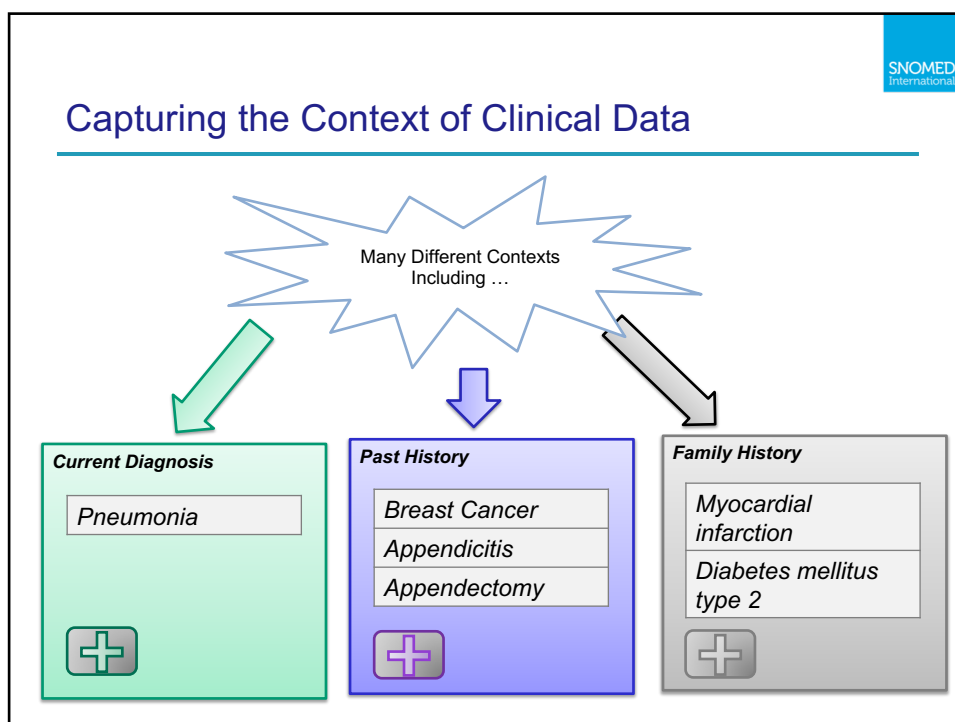
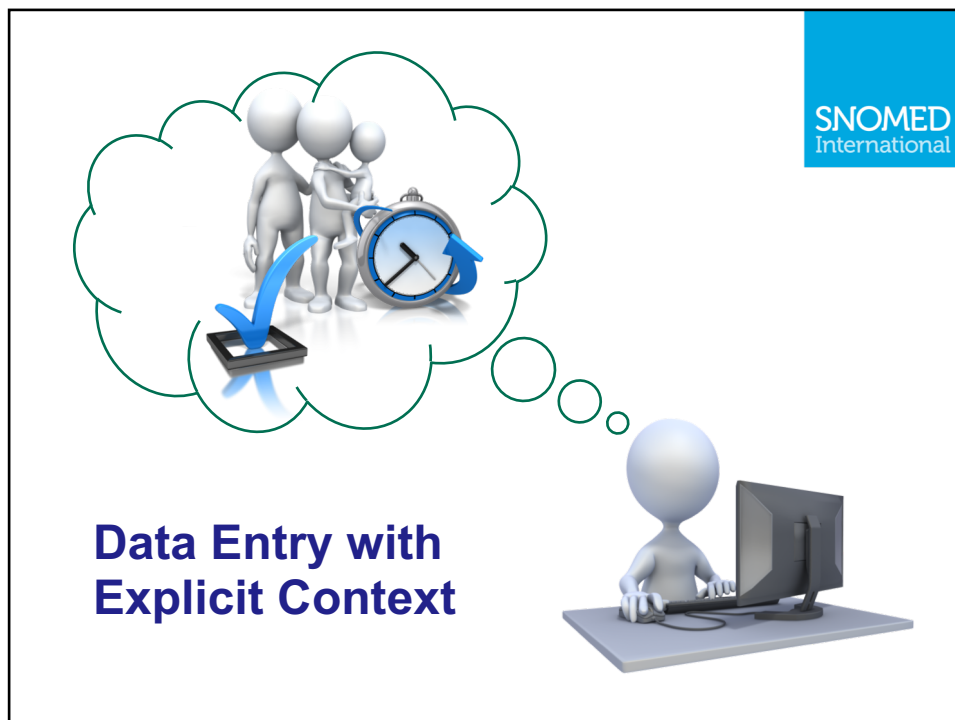
*Symptoms:*

- Itching
- Pain
- Eruption

*Location:*

Left upper arm

22253000 | pain |  
363698007 | finding site | = (40983000 | Upper arm structure | :  
272741003 | laterality | = 7771000 | left |)



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## 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**

**Past History**

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## Entering Context using Separate Context Fields

---

**Diagnosis:**

Finding context:

▼


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

---

- 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



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## 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.




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## 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 |




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## 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.

NLP with Context



SNOMED CT Expressions

```

243796009 |situation with explicit context|:
{408730004 |procedure context| =
  398166005 |performed|,
  423827005 |associated procedure| =
  95529005 |endoscopy|,
  408731000 |temporal context| =
  410513005 |in the past|,
  408732007 |subject relationship context|
  = 410604004 |subject of record|}

243796009 |situation with explicit context|:
{408729009 |finding context| =
  410515003 |known present|,
  246090004 |associated finding| =
  95529005 |acute gastric ulcer|,
  408731000 |temporal context| =
  410512000 |current or specified time|,
  408732007 |subject relationship context|
  = 410604004 |subject of record|,


```

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## 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.

NLP with Context




SNOMED CT Expressions

```

243796009 |situation with explicit context|:
{408729009 |finding context| =
  410516002 |known absent|,
  246090004 |associated finding| =
  61401005 |gastric bleeding|,
  408731000 |temporal context| =
  410512000 |current or specified|,
  408732007 |subject relationship context|
  = 410604004 |subject of record|}



243796009 |situation with explicit context|:
{408729009 |finding context| =
  410516002 |known absent|,
  246090004 |associated finding| =
  235674005 |perforation of stomach|,
  408731000 |temporal context| =
  410512000 |current or specified|,
  408732007 |subject relationship context|
  = 410604004 |subject of record|}

```



## Data Entry Demonstration

[Data Entry demo](#)  
[Data Entry demo script](#)



### Links to Further Information

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- 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/>

