An introduction to SNOMED Clinical Terms®

Tutor – David Markwell
The Clinical Information Consultancy Ltd
www.clininfo.co.uk

SNOMED Introduction

- What is SNOMED CT?
  - Background information
- Requirements for clinical terminology
  - Making sense of clinical information
  - Codes, classifications and terminologies
  - Why terminology is “interesting”
- Features of SNOMED CT
  - Overview of contents
  - Design and structure
  - Localisation and extension
  - Cross Mapping
- Using SNOMED in clinical records

SNOMED Clinical Terms® Introduction

What is SNOMED CT?

Background information

SNOMED CT® - The name

- SNOMED
  - The Systematized Nomenclature of Medicine
- CT
  - Clinical Terms
SNOMED CT® – The objective

- SNOMED CT is a clinical terminology designed to be the global standard terminology for use in clinical information systems
- Its principal objective is to contribute to improvement of the quality and safety of healthcare by enabling consistent recording, retrieval and reuse of clinical information

SNOMED Clinical Terms® - Background

- SNOMED CT arose from two strands of work
  - NHS Clinical Terms Version 3 (in the UK)
  - SNOMED RT (in the US)
- Both these strands of work were
  - Addressing similar requirements
    - Provision of effective terminology support for electronic health records
    - Building on the experience of existing coding solutions
    - Applying similar approaches
  - Slightly different priorities placed emphasis of different aspects
- The two strands of work came together in 1999
  - The merged product (SNOMED CT) was first released in 2002
  - The ownership of this work was transferred to a dedicated International body (the IHTSDO) in 2007

The sources of SNOMED Clinical Terms

IHTSDO

- The International Health Terminology Standards Development Organisation was founded in 2007 to:
  - Acquire, own and administer the rights to SNOMED CT and other relevant assets
    - The IHTSDO “Terminology Products”
  - Develop, maintain, promote and enable the uptake and correct use of its Terminology Products around the world
  - Undertake activities required to achieve these purposes
Status of the IHTSDO

- The Association is a registered not-for-profit entity in Denmark
- Articles of Association detail the who, what, where and how of the Association
- Intellectual property in SNOMED CT and related works transferred to the IHTSDO in April 2007

IHTSDO Members:
- Australia
- Canada
- Cyprus (2009)
- Denmark
- Lithuania
- New Zealand
- Netherlands
- Singapore (2008)
- Spain (2009)
- Slovak Republic (2009)
- Slovenia (2009)
- Sweden
- UK
- USA

Licensing of SNOMED CT

- Aim of IHTSDO approach to licensing
  - Simplicity, transparency and cost minimisation
- Common form of license - “IHTSDO Affiliate License”
  - Obtained via an IHTSDO Member or direct from IHTSDO
  - Permits world-wide use of SNOMED CT
- Charges
  - No fees for use in any IHTSDO Member countries
  - Charges set by the IHTSDO for use in non-member countries
    - Non-Member Country charges published on IHTSDO web site
    - Based on broad categories of use
    - World Bank GNI Atlas metrics used to help poorer countries

To find out more about the IHTSDO visit the web site at www.ihtsdo.org

To get involved in IHTSDO working groups - request access to the collaborative space by emailing: support@ihtsdo.org
Effective delivery of health care requires us to make sense of clinical information in ways that allow information reuse.

**The requirement for a clinical terminology**

Clinical terminology is required to enable the effective reuse of clinical information.

Clinical information needs to be reused to answer questions about...

- One or more items of health related information that apply to
  - An individual patient
  - A selected population

**Questions about an individual**

- For any clinical condition many questions may be posed which require information to be selectively retrieved from the records of an individual.
- For example:
  - Do this patient's symptoms suggest swine flu?
  - Should this person be tested for swine flu?
  - Should this person be treated with oseltamivir?
  - Does the patient have a history of renal problems that may require dosage adjustments?
  - Does the patient have a personal or family history of allergic reactions?

**Questions about populations**

- For any clinical condition many questions may be posed which require information to be selectively retrieved from the records of members of a selected population.
- For example:
  - How many patients have presented with flu like symptoms this week?
  - How many of these were tested for swine flu?
  - How many of these tests returned positive results?
  - What has been the outcome in patients prescribed oseltamivir?
Requirements for processing clinical information

- The ability to respond to questions about ...
  - One or more items of health related information
  - An individual patient or a selected population
- With answers that are ...
  - Accurate – no false negatives
  - Precise – no false positives
  - Timely – available when needed
  - Efficient – without disproportionate cost, time and effort
  - Consistent – independent of how the data was entered

Exeter System – 1970 ... (in 1980 the first clinical system I saw)
Text based records

- Exeter System
  - Trail-blazing NHS based GP system in the 1970’s
  - Text based records stored on a mainframe computer in Exeter used by several practices in the area
  - Linked by landline to a demonstrator practice in W. London
- After a few years of use they asked the question
  - How many patients were diagnosed with Otitis Media? (middle ear infection)
  - The answer was much lower than they expected
  - So they asked the question ‘Why?’

Exeter System – 1970 ... 
Text based records – the problem

- Why did so few patient’s have a record of Otitis Media?
- Answer ...
  - Because doctors use the following ...
    - Otitis Media, Otitis Media (and other spelling errors)
    - Ear Infection, Middle ear infection, Mid ear inf.
    - OM, O.M., Ot.Med. (Otitis Media)
    - AOM (Acute Otitis Media)
    - ROM, LOM, BOM, (Right/Left/Bilateral Otitis Media)
    - Etc ...
  - Required manual scanning of records and enquiry into the recording habits of different doctors
- Text-based records did not meet electronic record requirements

1982 Flags

- Computer record replaced alert stickers on paper record folders
- Compact storage
  - Flags used just 12 bytes per patient
- Flexibility
  - Each practice chose its own set of 96 favourite items to flag
- Comparability
  - No comparability between practices due to local flag selection
- Useless for day to day record keeping
  - Could not record individual clinical encounters
- Very limited reporting
  - Could count prevalence of flagged chronic conditions
  - Could not count incidence (e.g. ‘otitis media’)
1983
Mnemonics

- Computer record looks more like a written record
- Flexible
  - Simple structure
  - Extendable expressivity using codes
- Retrieval possible
  - If you had a list of all the codes relevant to your query
    - Incidence of left otitis media could be determined provided you know the codes
      are ALOM and AROM
  - But there were other codes like ABOM (‘Acute bilateral otitis media’) that could easily be overlooked
- Comparable
  - Same codes used in all practices with this system

1984
Hierarchical Codes

- Retrieval possible in more cases
  - Incidence of otitis media can be readily computed
    - All codes starting ‘F52’ are types of otitis media
  - Retrieval is liable to be incomplete
    - ‘Acute suppurative otitis media’ is a bacterial infection of the ear
      - Its code starts with ‘F5’ = ‘Ear diseases’
      - It does not start with ‘A’ = ‘infectious disease’
    - Similarly in ICD10 (a WHO classification) bacterial ear infections
      - Are counted as ear diseases but not as bacterial infections
      - H66: ‘Suppurative and unspecified otitis media’
      - H50-59: ‘Diseases of the ear and mastoid process’
      - ‘A00-A79’ ‘Bacterial infections, other intestinal infectious diseases, & STDs’
  - This is reasonable for statistics but it creates risks of overlooking significant clinical patterns that may influence treatment

Structured forms & data

- Another approach to clinical information is based on replicating a structured paper form
- Specify a data set
  - Create a separate field for every data item
  - Works well as a user interface design approach
  - Ideal for recording repetitive patterns
- If the same approach is applied to database record design
  - Record structure matches the screen form
  - Minimal dependency on coding
- Unfortunately it only works for tightly defined use cases
  - If the same data are collected for different purposes this approach leads to divergent representation of the same information
- It does not meet the requirement for reusable clinical information
Meeting the requirement for a clinical terminology

Why use SNOMED CT rather than another coding scheme or classification?

Simple Coding Schemes
- Assign a code value to a code meaning
  - e.g. "IFL" = "influenza", "RTD" = "respiratory disease"
- Represent a meaning in a form that is
  - Simple, Concise and Consistent
- Allow selective retrieval of matches for
  - A single code or a specified set of codes
- Meet requirements for
  - Representing small sets of unrelated meanings
- Less valuable for
  - Representing large sets of interrelated meanings

Codes, classifications & terminologies
- Coding schemes
  - Assign a code value to a code meaning
- Classifications
  - Group together concepts for a specified purpose
- Terminologies
  - Reference terminologies
    - Inter-relate and define concepts
    - Interface terminologies
      - Support for ease/consistency of entry and display
- Classifications (single-axial)
  - Group meanings for a specified purpose
    - e.g. "J10" = "influenza", "J" = "respiratory disease"
  - Represent a meaning in a form that is
    - Simple, Concise and Consistent
  - Allow selective retrieval of matches for
    - Sets of codes that are in a specified classification category
  - Have semantic limitations
    - Only represent one view of relationships between meanings
      - e.g. flu cannot be classified as viral and respiratory disease
    - Categories that are dependent and changeable
      - e.g. "Lung disease NEC" (not elsewhere classified)
  - Meet requirements for
    - Aggregating information based on a specified requirement
  - Less valuable for
    - Retrieving information based on inherent meaning
**Classifications (multi-axial)**

- Group meanings for multiple specified purposes
  - e.g. flu can be classified as both *viral* and *respiratory disease*
- Represent a meaning in a form that is
  - Simple, Concise and Consistent
- Allow selective retrieval of matches for
  - Sets of codes that are in specified classification categories
- Have semantic limitations
  - Only represent grouping relationships between meanings
    - e.g. cannot represent relationship between flu and influenza virus
- Meet requirements for
  - Aggregating information based on various requirements
- Less valuable for
  - Statistical purposes (due to double counting)
  - Retrieval based on inherent relationships between the meaning of concepts of different types

**Reference Terminologies**

- Represent a large range of possible meanings in a consistent manner
- Specify many relationships between different concepts
  - Tuberculous pneumonia
    - Is a type of → lung infection
    - Is a type of → tuberculosis
    - Caused by → mycobacterium tuberculosis
    - Finding site → lung
    - Morphology → inflammation
- Meet requirements for
  - A semantic foundation for reliable retrieval
    - Based on inherent meaning
    - Independent of initial purpose of collection
- May not meet requirements for
  - Ease of data entry *

**Interface Terminologies**

- Assist entry and display of information
  - Link alternative user-friendly ways of expressing the same meaning
    - E.g. "influenza", "flu", "grippe", "gripe"
  - Subsets of concepts common to a speciality or community
  - Alternative hierarchical views for navigation between concepts
  - Provisions of rational qualifier and refinement options
- Meet requirements for
  - Consistent data entry within and between
    - Clinical disciplines and specialties
    - Institutions, organizations and countries
    - Language groups
- Do not meet requirements for
  - Data retrieval based on implicit meaning *
- A combination of Interface & Reference Terminology features is required to meet data entry and retrieval requirements
What is SNOMED Clinical Terms?

- A Coding Scheme ✓
  - Codes (identifiers) for concepts
- A Classification ✓ / ×
  - Subtype multi-axial classification
  - Not a statistical classification
  - But includes mappings to statistical classifications
- A Reference Terminology ✓
  - Defining relationships
  - Subtype hierarchy
- An Interface Terminology ✓
  - Synonyms – including multi-dialect/multi-lingual support
  - Subsets
  - Navigation hierarchies
  - Search support resources

What makes clinical terminology interesting?

The way people use words and phrases makes language “interesting” rather than precise

Words and semantics

- People behave like Humpty Dumpty
  - It’s not what you say, it’s what you mean
- The meanings of words and phrases change
  - In context
  - Between places
  - Between disciplines and specialties
  - Between different times
- SNOMED CT encodes meaning, not just words

'I don't know what you mean by “glory,”’ Alice said.
Humpty Dumpty smiled contemptuously.
'Of course you don’t -- till I tell you.'
'I meant “there's a nice knock-down argument for you!”'
'But "glory" doesn't mean "a nice knock-down argument.,”’ Alice objected.
'When I use a word,' Humpty Dumpty said in rather a scornful tone, 'it means just what I choose it to mean -- neither more nor less.'
The problem with words and meaning (1)

- What is a “pyogenic granuloma?”
  - Pyogenic = pus forming
  - Granuloma = a collection of inflammatory cells of a particular type

- But
  - Pyogenic granuloma = a benign tumor of small blood vessels of the skin
  - It is neither pyogenic nor a granuloma.

Combinations are frequently very different from the sum of their parts.

Words can be misleading

This spot is called:
- a pyogenic granuloma

pyo \rightarrow pus
genic \rightarrow forming

pyogenic: refers to bacterial infections that make pus

granulomatous: refers to diseases or inflammatory reactions characterized by granulomas

So ... pyogenic granuloma: ought to be a granulomatous inflammation caused by bacteria and creating pus

The problem with words and meaning (2)

Individually each step in this hierarchy seems ok

psoriasis

- psoriasis with arthropathy
  - juvenile psoriatic arthritis
  - juvenile psoriatic arthritis without psoriasis

Taken a logical whole it clearly contains an error
The leg and the arm

- Where do arms and legs begin and end
  - Normal usage and medical dictionaries differ about this
  - Most doctors use these words with their general meanings
  - Anatomists and specialists use the more specific meanings

The leg and the arm

- The average person assumes
  - Leg = lower limb
  - Arm = upper limb

- Health professionals also often use the word “leg” and “arm” in this way
  
  *but is this correct?*

The leg and the arm

- Medical dictionaries take a different view of the leg
  - Stedman’s: “the segment of the inferior limb between the knee and the ankle”
  - Dorland’s: “that section of the lower limb between the knee and ankle”
- ... and the arm
  - Some sources suggest is only from the shoulder to elbow

Vagueness and understanding

“You say you’re not nostalgic; then give me another word for it you who are so good with words and at keeping things vague”

*Joan Baez (Diamonds and Rust)*
Vague but intelligible – by humans

Height of the fundus is consistent with dates

Several stones seen in the fundus

A small ulcer was seen in the fundus

Microaneurisms and exudates in the fundus

The fundus appears normal

Vague and ambiguous in the absence of appropriate context

“The fundus appears normal”

The ‘Language Police’ perspective

Everyone must say it the same way

Do not use vague terms like ‘fundus’

Leg is leg as in the anatomy books

Do not use terms that are misleading like ‘pyogenic granuloma’

Arm is arm as in the anatomy books

SNOMED Clinical Terms is not the Language Police

SNOMED CT tries to capture what people mean - rather than tell them what terms they must use to express a particular meaning

Features of SNOMED CT?

Design and structure
SNOMED CT design features

- **Comprehensive content**
  - Coverage of broad scope of health record information
  - Driven by clinical rather than statistical analysis requirements
  - Criteria for content addition
    - Understandable
    - Reproducible
    - Useful

- **Concept orientation**
  - Separation between representation of concepts and user interface terms

- **Subtype hierarchy**
  - Polyhierarchy that is not dependent on identifiers
  - Multiple granularities and multiple consistent views

- **Defining relationships**
  - Relationships between concepts
  - Support for use of Description Logic for autoclassification
  - Ability to ‘post-coordinate’ more specific expressions
  - Integrated representation of ‘clinical situations’ (context)

- **Component permanence**
  - History tracking
  - Recognition of redundancy and ambiguity
  - Graceful evolution

- **International**
  - Multi-lingual support
  - Open global standard

- **Implementable**
  - In software applications

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How big is SNOMED CT?

- **International Edition** *(approximate numbers of components)*
  - **Concepts**
    - 315,000 Concepts (380,000 including inactive concepts)
  - **Descriptions**
    - 805,000 English Descriptions (1,134,000 inc. inactive)
    - Includes 55,000 US/GB dialect specific Descriptions
  - **Relationships** *(1.3 Million)*
    - 500,000 Subtype Relationship
    - 420,000 Defining Relationships
    - 45,000 Part of Relationships
    - 300,000 Qualifier Relationships
    - 75,000 Historical Relationships (applied to inactive concepts)

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How often is SNOMED CT updated?

- Currently the IHTSDO release and update to the International Edition of SNOMED CT twice a year
  - January and July
- Some IHTSDO Members release more frequent updates in particular fast changing areas
  - E.g. The UK release of related to the ‘dictionary of drugs and devices’

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Is SNOMED CT perfect?

- “The man who makes no mistakes does not usually make anything.”
  - E J Phelps (1822 - 1900)
  - … so SNOMED CT is not “perfect”
- The goal is fitness for purpose not perfection
- **SNOMED CT**
  - Is more complete than other clinical terminologies
  - Is the focus of a major International collaboration on clinical terminology

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Building blocks of SNOMED CT

- Concepts
- Descriptions
- Relationships

Concept data structure

- Each concept
  - Is described by a set of descriptions
  - Has a set of relationships to other concepts

Concept

- A single clinical meaning identified by a unique numeric identifier (ConceptId)
  - The meaning is permanent and unchangeable
  - The meaning is specified by a unique human readable name (Fully Specified Name)

Description

- A term that names or describes a concept
  - Human readable
  - Identified by a unique DescriptionId
- Each concept has several descriptions
- In each dialect a concept has
  - One Fully Specified Name (FSN)
  - One Preferred Term
  - Optionally any number of Synonyms
Description types

- Fully Specified Name
  - A phrase that names a concept in a manner intended to be unambiguous.
    - Includes 'hierarchy suffix' in brackets to indicate the type of concept and help to disambiguate it
      - Example: gastric ulcer (disorder)
- Preferred Term
  - Common word or phrase used by clinicians to name a concept
    - Varies by language and dialect
- Synonym
  - Another word or phrase that is sometimes used to represent the same concept

Fully Specified Names and Preferred Terms – Examples

Concept (id: 22298006)
  - Fully specified name: Myocardial infarction (disorder)
  - Preferred term: Myocardial infarction

Concept (id: 54987000)
  - Fully specified name: Repair of common bile duct (procedure)
  - Preferred term: Choledochoplasty

In the second example, the Preferred Term expresses the natural way a clinician describes this procedure while the FSN give an unambiguous phrase describing the meaning of the concept.

Concepts and Descriptions (1)

- Several concepts may have descriptions that include the same term

Concepts and Descriptions (2)

- Several concepts may have descriptions that include the same term
**SNOMED CT Introduction (HIQA Cork 2010-01-27)**

**Relationships**
- Define concepts in terms of other concepts
- Defining relationships
  - Subtype hierarchy ("is a") relationships
  - Attribute (role) relationships
- Also …
  - Qualifiers and additional relationships

**Relationships between concepts (1)**
- Subtype relationships
  - Also known as "is a" relationships
  - For example
    - "Infective pneumonia" is a type of "infection"
    - "Infective pneumonia" is a type of "respiratory disease"

**The supertypes of “Viral Pneumonia” (1)**

**The supertypes of “Viral Pneumonia” (2)**
Relationships between concepts (2)

- **Defining relationships** – these express the difference between a concept and its supertypes
  - Only relationships that are necessarily true are defining relationships
  - E.g. "viral pneumonia" has "causative agent" = "virus"

### Concept

- **Concept ID**: 397925008

- **Descriptions**:
  - 1765744015: gastric ulcer (disorder)
  - 1777420014: gastric ulcer
  - 1786986013: stomach ulcer
  - 1785986014: GU - Gastric ulcer
  - 1785987017: gastric ulceration

- **Relationships**:
  - Definition: Fully Defined as...
  - 116680003: is a
  - 29384001: is a finding site
  - 116680003: is a disorder of stomach
  - 40845000: gastrointestinal ulcer
  - 11676008: is a Group
  - 50208002: is a associated morphology ulcer
  - 363698007: is a Finding site
  - 69695003: is a stomach structure

### SNOMED CT International Edition Content Summary (July 2008)

- Clinical finding: 35%
- Other: 2%
- Physical object: 1%
- Situation with explicit context: 2%
- Social context: 2%
- Observable entity: 2%
- Event: 3%
- Qualifier value: 3%
- Pharmaceutical / biologic product: 6%
- Substance: 7%
- Organism: 10%
- Body structure: 10%
- Procedure: 17%
- Other: 2%
**SNOMED CT Concept Model**

**Subtype Hierarchy Top-level**

- **SNOMED CT Concept**
  - body structure
  - clinical finding
  - context-dependent category
  - environments and geographical locations
  - event
  - linkage concept
  - observable entity
  - organism
  - pharmaceutical / biologic product
  - physical force
  - physical object
  - procedure
  - qualifier value
  - record artifact
  - social context
  - special concept
  - specimen
  - staging and scales
  - substance

**Clinical finding**

- Result of a clinical observation, assessment or judgment
- Includes both normal and abnormal clinical states

**Examples**
- Normal breath sounds
- Poor posture
- Abdominal tenderness

**Clinical Finding concept model (part)**

**Clinical finding**

- Finding site
- Associated morphology
- Associated with
  - Clinical finding
  - Substantence
  - Physical object
  - Physical force
  - Events
  - Organisms
  - Pharmacological / Biological product
  - Procedure
- After
  - Clinical finding
  - Procedure
- Due to
  - Clinical finding
  - Event
- Causative agent
  - Organism
  - Substance
  - Physical object
  - Physical force
- Clinical Course
  - Values of onset and/or duration
- Finding method
  - Procedure
- Finding informer
  - Performer of method, Subject of record
  - Provider of history other than subject, Subject of record or other provider of history

**Disease/Disorder**

- Clinical findings that are essential abnormal

**Examples**
- Gastric ulcer
- Fracture of femur
- Congenital cystic kidney disease
- Hypertrophic cardiomyopathy
### Observable entity
- Represent a question or a feature which can be given an answer or result
- Things that can be measured or observed
- Examples:
  - Heart rate
  - Head circumference
  - Body temperature
  - Ability to walk

### Procedure
- Activities performed in the provision of health care
- Includes administrative, invasive, diagnostic, imaging and education procedures
- Examples:
  - Appendectomy
  - Removal of urethral catheter
  - Intravenous injection
  - Physiotherapy
  - Diet education

### Procedure concept model (part only)
- Procedure site
- Procedure site - direct
- Procedure site - indirect
- Procedure morphology
  - Direct morphology
  - Indirect morphology
- Procedure device
  - Direct device
  - Indirect device
  - Using
- Access instrument
- Endoscope and subtypes
- Method
- Action
- Direct substance
- Substance, Pharmaceutical / Biologic product

### Body structure
- Anatomical concepts used to specify the site of procedures & clinical findings are found in this hierarchy
- Examples:
  - Bone structure of tibia
  - Lobe of liver
  - Mitral valve structure
  - Stomach structure

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Morphological abnormal structure

- Abnormal subtypes of body structure
  - Used to specify associated morphology related to disorders and morphology affected by or involved in procedures
  - Examples
    - Open fracture
    - Polyp
    - Plaque
    - Adenosarcoma

Organisms

- Any organism of interest in human or veterinary medicine
  - Examples
    - Bacteria, fungi, viruses, parasites, prions
    - Animals, plants
  - Use
    - Causal agents for disorders
    - Subjects of findings or procedures in veterinary medicine

Substances

- Any kind of substance
  - Includes
    - Generic drug ingredients
    - Basic chemical elements and their isotopes
    - Chemical compounds & industrial products
    - Plant and animal products and toxins
  - Uses
    - "Causal agent" values for some findings/disorders
    - "Active ingredient" values for drugs

Pharmaceutical/biologic product

- SNOMED CT core includes Virtual Medicinal Products
  - Products with dose and form but without a specified manufacturer or pack size
- Supports addition of National formularies as extensions
  - NHS Directory of Medicines and Devices (dm+d)
  - US-specific extension, based on FDA data is maintained by SNOMED
- Examples
  - amoxicillin 250mg capsule
  - tetanus vaccine
Situations with explicit context

Concepts that explicitly declare the context associated with a finding
- Examples include
  - Family history
  - Uncertainty
  - Absent finding
  - Planned procedures

Examples of situations that can be expressed using the SNOMED CT Context Model
- Findings in clinical situations such as ...
  - Subject of record has asthma
  - Subject of record has a family history of asthma
  - Father of subject of record has asthma
  - Subject of record has no family history or asthma
  - Subject of record may have asthma
  - Subject of record does not have asthma
  - Subject of record has a past history of asthma
- Procedures in clinical situations ...
  - Subject of record has had a hip replacement
  - Hip replacement has been requested for the subject of record
  - Hip replacement is planned for the subject of record
  - Hip replacement not carried out on the subject of record
  - Wife of subject of record has just had a hip replacement

Features of SNOMED CT

Localisation and Extension

Localization capabilities and policies
- SNOMED CT design enables localization at a variety of levels
  - Localization by configuration – ‘Reference Sets’
  - Addition of local content – ‘Extension’
- SNOMED CT localization capabilities need to be constrained by policies that
  - Facilitate effective use
  - Minimize unnecessary divergence
Reference Set Types

- **Language Refsets**
  - Enhanced support for description preference, acceptability, completeness and correctness

- **Simple Refsets**
  - Subsets – included in or excluded from searches
  - Prioritised – highlighted in searches

- **Hierarchical Refsets**
  - Navigational – alternative tree views to allow ease of entry
  - Aggregation – groupings to support alternative analyses

Hierarchies in terminologies

- **Two uses for hierarchies**
  - **Subtype Hierarchy**
    - To aid appropriate retrieval by retrieving subtypes of a specified concept
    - Need to be accurate
  - **Navigation**
    - To aid data entry
    - Need to reflect the way people think when entering data

- In the past single hierarchies were used to address both requirements
  - This always involves a compromise
  - An accurate subtype hierarchy is rarely efficient for human navigation

SNOMED CT supports separate hierarchies to avoid the problems caused by different requirements

SNOMED CT hierarchies
The best of both worlds

- SNOMED CT is a Reference Terminology
  - For effective precise and complete retrieval it needs to represent the subsumption of concepts by one another
  - The subtype hierarchy is derived by auto-classification to meet this requirement

- SNOMED CT is also an Interface Terminology
  - At the user interface the auto-classified subtype hierarchy is not intuitive
  - Separate navigation hierarchies address the interface requirement without compromising the subtype hierarchy

- Navigational hierarchies are represented as subsets
  - They can be created to meet specific user needs
  - They need not represent subtypes or logical relationships

Hierarchies and usage

<table>
<thead>
<tr>
<th>Subtypes (automatic)</th>
<th>Navigation (hand-crafted)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SNOMED CT Concept</td>
<td>common viral disease</td>
</tr>
<tr>
<td>clinical finding</td>
<td>common cold</td>
</tr>
<tr>
<td>disease</td>
<td>herpes simplex</td>
</tr>
<tr>
<td>infectious disease</td>
<td>human immunodeficiency virus infection</td>
</tr>
<tr>
<td>viral disease</td>
<td>infectious mononucleosis</td>
</tr>
<tr>
<td>diseases due to Orthomyxoviridae</td>
<td>influenza</td>
</tr>
<tr>
<td>encephalitis due to influenza</td>
<td>require influenza</td>
</tr>
<tr>
<td>influenza</td>
<td>rubella</td>
</tr>
<tr>
<td>myocarditis due to influenza virus</td>
<td>enteroviruses</td>
</tr>
<tr>
<td>Thogoto virus disease</td>
<td>avian-human influenza virus infection</td>
</tr>
<tr>
<td>rotavirus infection</td>
<td>human respiratory infection</td>
</tr>
<tr>
<td>viral gastroenteritis</td>
<td>viral disease (all)</td>
</tr>
</tbody>
</table>
Reference Set Features

- Extensibility
  - Refsets can be created as part of a local Extension
- Scoping
  - Refsets can apply to particular input fields and data entry templates

Extensions: Requirements

- SNOMED CT design allows requirements not met by the International Edition to be met by Extensions added at National or Local levels
- Extensions can include various types of content
  - Addition of primary content
    - Concepts, descriptions, relationships
  - Addition of cross maps
  - Addition of reference sets (subsets) and navigation hierarchies

Extensions: Features

- Extensions have the same structure as equivalent Components in the main body of SNOMED CT
  - Special requirements can be met without special software
  - Encourages implementation of SNOMED CT structures
- Extension components have SCTIDs that include
  - Partition & namespace identifiers
  - These are part of the ComponentId and thus remain distinct & traceable when stored in a record

The SNOMED CT Identifier

SCTID | 123456789012345
---|---
Check-digit | 00 9

SCTID | 999999999
---|---
Extension Namespace Identifier | 0989121 10 2
Check-digit |
Extensions: Creation & maintenance

- SNOMED CT Extension can be created by any organization with an allocated SNOMED namespace
  - IHTSDO Members
    - National bodies
  - IHTSDO Affiliates
    - Health providers at a local level
    - Application developers and implementers
- Are there any limits to Extensions?
  - The design supports allocation of millions of namespaces
  - National or organisational policies may constrain use of extension content to specified namespaces

Extensions: Benefits & Risks

- Potential benefits of Extensions
  - Extending the effective scope of SNOMED CT
  - Integrating multiple terminology resources
  - Greater SNOMED CT acceptance/implementation
- Potential risks of Extension
  - Threat to quality control from uncontrolled Extensions
    - Users need to recognise what is/is not SNOMED CT
  - Duplication and confusion due to overlap with main body
  - Risk of namespace violation (& reuse of identifiers)
    - Errors in namespace management
    - Unauthorised breaches of namespace

Cross Mapping requirements

- SNOMED Clinical Terms is a clinical terminology
- Health statistics are reported using
  - Classifications (e.g. ICD10)
  - Groupers (e.g. HRGs)
  - Administrative or financial codings (e.g. OCPS4)
- Mapping is necessary to minimise re-entry of data
- Mapping is not trivial
  - Different uses = different levels of detail & grouping
  - Mapping is rarely one-to-one and may be many-to-many

Features of SNOMED CT

Cross Mapping to classifications
SNOMED CT - Cross Maps

- Cross Map Set
  - Full set of Cross Maps for a target scheme
  - Identifies target scheme and SNOMED CT version

- Cross Map
  - A SNOMED CT concept may one or more* Cross Maps
    - If there is more than one Cross Map this indicates a choice that needs to be resolved based on other information

- Cross Map Target
  - Representation of the mapped SNOMED CT concept in the target scheme
    - This may be a single code in the target scheme or a set of codes.
    - A set of codes is used where the target scheme uses allows combinations of codes to represent more specific meanings

Cross Map Examples - simple

Cross Map Examples - multiple choices

Cross Map Examples - multiple targets
Resolving multiple mapping options

- Some Concepts have several Cross Maps
  - Choice may depend on
    - Post coordinated representations
      - Equivalent to a pre-coordinated Concept or with added qualifiers
    - Other statements in or absent from the patient record
      - Particularly for classifications and groupers
- Rules to automate resolution of multiple maps are being developed for some target classifications

Cross Mapping
Available Cross Maps

- ICD10
- ICD9.CM
- ICD-O3
- OPCS-4
- Nursing classifications
  - NIC, NANDA, PNDS
- LOINC (different map file structure)

- Most of these do not make use of the facility for mapping rules
  - ICD9.CM map now uses a limited set of rules

SNOMED CT Concepts and Expressions

- Concept
  - A clinical idea to which a unique ConceptId has been assigned
  - Concepts are distributed as part of the SNOMED CT terminology
- Expression
  - A collection of references to one or more concepts used to express an instance of a clinical idea
  - Expressions are used to represent clinical information in patient records

SNOMED CT in clinical records

Using ‘post-coordinated expressions’ to represent detailed information
SNOMED CT Expressions

- SNOMED CT coded information consists of references to SNOMED CT Concepts
  - These references are called SNOMED CT Expressions
  - The meaning of an Expression depends on the situation in which it is used

Example
- The SNOMED CT Concept “fracture of femur” refers to the idea of a break in a femur
- In a patient record an Expression that refers to the Concept “fracture of femur” may indicate that the patient:
  - has a fractured femur (default context)
  - does not have a fractured femur (context indicates absent)
  - has a past history of a fractured femur (context indicates past)
  - ... etc

Expressions can be pre-coordinated or post-coordinated

- Pre-coordinated expression
  - A single ConceptId represents the required meaning
    - Example
    - 31978002
      - (fracture of tibia)

- Post-coordinated expression
  - A combination of ConceptIds represents a concept
    - Example
    - 31978002 : 272741003 = 7771000
      - (fracture of tibia : laterality = left)
      - In human readable form … “fracture of left tibia”

A post-coordinated expression may be created by refining a defining relationship

- Refinement means applying a more specific value to one or more of the defining relationships

Example
- “Fracture of femur”
  - Defined as: “finding site” = “bone structure of femur”
  - May be refined to: “finding site” = “structure of neck of femur”
  - → “Fracture of neck of femur”

Pros and cons of post-coordination

Advantages

- Scope coverage
  - Coverage of scope to an adequate level of specificity does not require every possible concept to exist

- Terminology size
  - Reduces the need for “combinatorial explosion” in concept numbers to cover every eventuality

- Data entry
  - Allows concepts to be constructed rather than searching through hundreds of similar terms for precisely the correct one

- Retrieval
  - Provides greater consistency between sets of similar variants for different concepts
    - For example ability to specify “severity” for any disorder or “laterality” for any bilateral body structure
### Pros and cons of post-coordination

#### Disadvantages

- **Human readability**
  - Extreme post-coordination can lead to loss of natural terms
    - “Appendicectomy” might be expressed as “Procedure, with method excision and procedure site appendix”

- **Data entry**
  - Users may need to construct concepts by selecting multiple options rather than simply typing or choosing the term they want

- **Storage**
  - Expressions that have an unspecified number of refinements are less easy to store and manipulate than simple codes

- **Retrieval**
  - Several post-coordinated expression may mean the same
    - Queries need to consider expressions rather than simple code list predicates

#### Pros and cons of post-coordination

#### Conclusion

- Both pre and post-coordination have benefits
  - Enable post-coordination to add flexibility
  - Include pre-coordinated concepts that express concept with commonly used terms
  - Avoid attempting to identify an absolute boundary of what may or may not be pre-coordinated
  - Deal with the issues raised by alternative representations
    - The key issue is detection of equivalence and subsumption of alternative expressions

### Pre & post-coordination with SNOMED CT

- **SNOMED CT Supports both pre and post-coordination**
  - No absolute boundaries between them

- **SNOMED CT enables computation of equivalence and subsumption between alternative representations**
  - For example, a post-coordinated expression
    - pain : finding site = foot
  - can be retrieved by a query for the pre-coordinated concept
    - pain in the lower limb
  - because the pre-coordinated concept is defined as
    - pain : finding site = lower limb structure
  - and
    - foot is defined as a subtype of lower limb structure

### SNOMED CT in clinical records

How the features of SNOMED CT help to enable effective representation of meaningful clinical information
Relationships between concepts

- **Subtype relationships** — represent a hierarchy of subtypes
  - E.g. “viral pneumonia” is a subtype of “infective pneumonia”
- **Defining relationships** — express the differences between a concept and its supertypes
  - E.g. “viral pneumonia” has “causative agent” = “virus”

How subtype relationships help

- When you selectively retrieve information you usually want to include subtypes
  - Consider clinical guidelines that apply to patients with particular conditions such as:
    - A guideline for “respiratory disease” should apply to people with “viral pneumonia”
    - A guideline for “viral infection” should apply to someone with “viral pneumonia”
    - A guideline for “bacterial pneumonia” should not apply to a person with “viral pneumonia”
  - Whether retrieving records for follow up, audit, epidemiology or research; selection criteria usually assume the inclusion of subtypes

How defining relationships help (1)

- Confirm & enhance subtype hierarchy completeness
  - A “pneumonia” with a “causative agent” that is a subtype of “virus” is a subtype of “viral pneumonia”
  - E.g. a new concept “rubella pneumonia” defined as …
    - “pneumonia”
    - “causative agent” = “rubella virus”
    - It is auto-classified as a subtype of “viral pneumonia”

How defining relationships help (2)

- Enable information to be recorded even when the specific concept does not exist in SNOMED CT
  - This is done by refining the value of a defined relationship
    - For example, if a patient is found to have “pneumonia” caused by “rubella virus” this can be expressed by refinement even if the concept “rubella pneumonia” does not exist in SNOMED CT
    - The concept “viral pneumonia” is selected and the value of its defining relationship (“causative agent”=“virus”) is refined to (“causative agent”=“rubella virus”)
    - This result is called a post-coordinated expression
      - For example
        - 75570004:246075003=5210005
        - or including the relevant terms …
        - 75570004 | viral pneumonia | :
          - 246075003 | causative agent | = 5210005 | rubella virus |
How defining relationships help (3)

- Allow comparison of different ways of expressing the same information
  - For example, the post-coordinated expression
    - 75570004 | viral pneumonia | : 246075003 | causative agent | = 5210005 | rubella virus |
    - Can be computed to be equivalent to
      - A new concept called “rubella pneumonia” (if this new concept is correctly defined)
    - or
      - Another post-coordinated expression, such as 233604007 | pneumonia | : 246075003 | causative agent | = 5210005 | rubella virus |
  - It can also be computed to be a subtype of 51490003 | disease due to Rubivirus |
  - It is not necessarily a type of 36653000 | rubella |
    - (because rubella is a disease characterised by ‘exanthema’ which may or may not be a feature of this newly specified condition)

Representing context & clinical situations

- SNOMED CT represents different clinical situations such as
  - Subject of record …
    - has asthma
    - may have asthma
    - does not have asthma
    - has a past history of asthma
    - has a family history of asthma
    - has no family history or asthma

How the SNOMED CT context model helps

- Provides an unambiguous way to express different clinical situations
- Uses the same logical modelling approach as other aspects of SNOMED CT
  - Subtype relationships within a hierarchy of clinical situations
  - Defining relationships that
    - Specify the contextual differences between situations; and
    - Relate them to ‘clinical findings’ and ‘procedures’
- Supports post-coordinated refinement of context
  - Enables any relevant context to be applied to any ‘clinical finding’ or ‘procedure’
  - Allows computational testing of equivalence and other relationships whether or not these include explicit statements of context

SNOMED CT in clinical records

Combining SNOMED CT with an appropriate structured clinical information model to enable retrieval and reuse based on meaning
Requirements for structure & terminology

- Effective representation of clinical information requires
  - A common structure to represent record entries in a consistent manner
    - To relate each record entry to a subject, author, time, place and other specific data items
  - A terminology to represent clinical concepts used in record entries
    - To relate the meanings of different concepts used in record entries, protocols, and queries in ways that facilitate consistent processing and reuse

Historical misconceptions about terminology and structure

Our information model is terminology independent
Our terminology can be used in any health record information model

Recognising interdependencies

- Practical consequences of interdependency between terminology and structural information models are often underestimated
  - Information models cannot be terminology neutral
  - SNOMED CT implementation is dependent on tight integration with standard information models
- Developers of clinical terminologies and clinical information models should adopt policies that facilitate ‘dependency aware evolution’ of their contributions

How easy is it to fully understand SNOMED CT?

SNOMED CT is engineered to address requirements for meaningful reuse of clinical information

There must be collaborative development between the SNOMED CT Concept Model and an information model in order for effective implementation of SNOMED CT
Health professionals' misconceptions about clinical terminology

I must understand how SNOMED CT works before I agree to use it.

I is too complex for me to understand. Therefore, I do not need it.

Complexity and clinical terminology

- KISS
  - ‘Keep It Simple Stupid’

- A delightful acronym but not a universal truth
  - It presumes it is ‘simple’ in the first place
  - If something is complex, you cannot keep it simple

Clinical information is inherently complex

- Clinical information consists of many interwoven threads including ...
  - The stories of individual patients
  - Current knowledge based on previous stories
  - Interconnections at anatomical, physiological and psychological levels
  - Perceptions of individual clinicians and patients and the cultures within which they live and work

Dealing with inherent complexity

‘Everything should be made as simple as possible, but no simpler.’

Albert Einstein
To do this ...

... do you need to understand this ...

... or just this

Thank you for your interest in SNOMED Clinical Terms

Any questions?

Contact details:
- David Markwell - david@clininfo.co.uk
- CliniClue browser www.cliniclue.com
  - A freeware SNOMED CT browser
- IHTSDO - www.ihtsdo.org
  - The owners of SNOMED CT