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SNOMED CT
Mapping Guide

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Leading healthcare terminology, worldwide

SNOMED CT is a clinical terminology with global scope covering a wide range of clinical specialties and requirements. To support the implementation of SNOMED CT, there is often a need to create maps from current in-use, local and proprietary code systems to SNOMED CT. Similarly, there is often a need to create maps from SNOMED CT to classifications and reporting code systems to support reporting, billing and statistical purposes.

The SNOMED CT Mapping Guide describes the best practice and guidelines for mapping between other code systems and SNOMED CT. Specialized mapping guidance designed for specific source and target code systems are available in other documents. For example, the ICD-10 Mapping Technical Guide.

Web browsable version: http://snomed.org/mapig

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1. Introduction

Background

SNOMED CT is a clinical terminology with global scope covering a wide range of clinical specialties and requirements. To support the implementation of SNOMED CT, there is often a need to create maps from current in-use, local and proprietary code systems to SNOMED CT. Similarly, there is often a need to create maps from SNOMED CT to classifications and reporting code systems to support reporting, billing and statistical purposes.

What is a map?

A map is a collection of associations between codes, concepts or terms in one code set (the 'source') to codes, concepts or terms in another code set (the 'target') that have the same (or similar) meanings.

Maps are developed in accordance with a documented rationale, for a given purpose and as a result there may be different maps between the same pair of code systems to meet different uses cases.

A code set can be

- A list of codes and/or terms
- A vocabulary
- A terminology

A map is often published as a table but can also be published in RF2 as a map reference set or a FHIR ConceptMap.

What is mapping?

Mapping is the process of defining a relationship between the source and target codes, concepts or terms.

Purpose

The SNOMED CT Mapping Guide describes the best practice and guidelines for mapping between other code systems and SNOMED CT. Specialized mapping guidance designed for specific source and target code systems are available in other documents. For example, the ICD-10 Mapping Technical Guide.

Audience

The target audience of this document includes any users who are involved in the mapping process including

- SNOMED CT National Release Centers;
- eHealth system designers and developers, including designers and developers of EHR systems, information models, data entry interfaces, storage systems, decision support systems, retrieval and analysis systems, communication standards and terminology services;
- SNOMED CT terminology developers, including concept model designers, content authors, map developers and release process managers.

2. Use cases

There are a variety of use cases where a may be map useful.

2.1 Interoperability

For interoperability, it would be ideal for all systems in the healthcare ecosystem to implement the same terminology in the same way with the same information model. However, this is not realistic, as there are many systems with historical proprietary clinical systems already in existence.

In these situations, maps can be useful in different ways.

- Maps can be useful to allow systems that have implemented different terminologies or code sets to communicate temporarily while the systems migrate to the same terminology. These maps will not alter the UI for data entry but can be implemented alongside the data entry to allow users to see the term that is mapped to their entry term, or implemented in the back end when the information is being sent, received or retrieved and reported.
- Maps can also be used to help migrate legacy code systems to standard code systems like SNOMED, by providing a way to translate historical terms to the new standard; this would be a one-time one-step migration strategy
- Maps may be required to allow systems with legacy code or proprietary code systems work with knowledge resources which uses standards like SNOMED CT to allow decision support.

2.2 Integration

As secondary users of data, it is often not possible to influence how data is collected as it is often historical data, or is data collected for a variety of use cases. Where data may be collected from different sources containing different code sets and/or different versions, maps allowing the comparison of different code sets by converting the codes to a single code set of SNOMED CT is useful.

2.3 Categorising and reporting

Data that is collected for one purpose is often required to be used for other purposes, and not just the original intention; this would be data re-use and re-purposing. Codes collected might need to be assigned to higher level groups for reporting, funding, cohort identification, etc. Maps can be used to assign higher level grouper code sets to the original code set to allow data to be categorised and reused.

2.4 Conformance

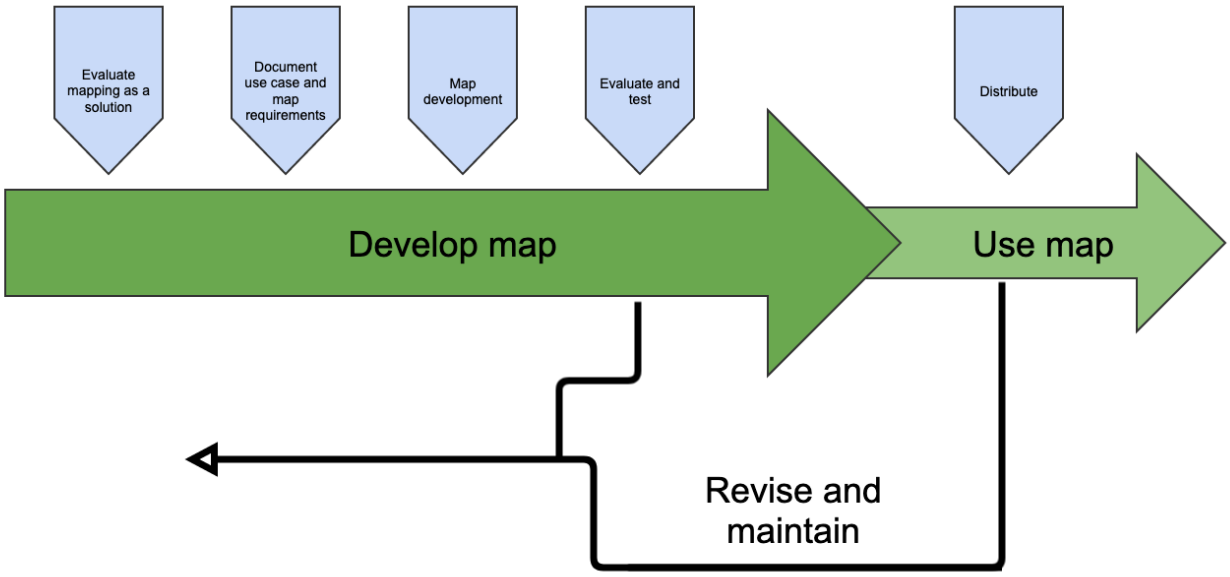
Data conformance is about ensuring the data collected meets a set of defined data quality measures. Maps to a standardised clinical terminology such as SNOMED CT can provide consistent representation for data collected in disparate systems using differing measures, or methods. Providing accuracy, completeness and consistency to data that would otherwise not be standardised. This does not mean though that maps will transform 'dirty', or poor quality data into high quality data they potentially will add to the quality through standardisation through enhanced quality measures.

3. Mapping methodology

These guidelines were developed to assist map developers to produce a map which benefits all the users of the map and ensures that the downstream users of data produced as a result of a map are able to use the information consistently and reliably.

A robust mapping methodology will assist in producing quality maps that are useable, reproducible and understandable.

- Useable
  - Quality mappings will support the use cases they were intended for
  - there is a maintenance in meaning of source and target code systems
  - Mapping needs to be able to be maintained where
    - there are updates to source code system
    - there are updates to target code system
    - there are updates to user requirements or use cases
- Reproducible
  - Clear methodology ensures a repeatable quality approach to mapping
  - Mappings need to employ authoritative reference sources uniformly
  - Documentation defines all assumptions, rules, and procedures required to manage context and create the map
- Understandable
  - All mappings should have a stated purpose and audience
  - Map documentation is complete, clear, and unambiguous
  - Mappings define source and target domain scope for the map
  - Consider also possible instances where MIS–USE of the map may influence data quality, reporting or interpretation of data /analytics



4. Evaluating mapping as a solution

Feasibility and implications of mapping

Mapping often appears to be the simplest or quickest solution for transforming data from one code system to another; however it is important for developers and users of maps to be aware of the implications of developing and using a map.

While mapping can solve some problems, there are some instances where mapping is not suitable or useful and may be more problematic.

When considering the creation of a map, the first step is to understand the data which needs to be transformed or migrated and the requirements for use of that data.

Key questions to address include:

- Are the business requirements well understood?
- Are there other options for meeting the business requirements without mapping?
- What are the potential risks arising from using the maps?
- To what extent can the source data contribute value to the target data? Will it limit the utility of data being collected in the future? How should this be mitigated?
- What is the data quality and compatibility of the source and target code systems?
- What are the expert resource requirements and costs of creating, quality assuring and **maintaining** the maps over some period of time?

Careful consideration should be given to care settings, worker skills sets and their existing workflow, available infrastructure or tooling. Importantly, the business requirements for a map might mean that different map types or map directions should be preferred.

1. For instance, in care settings where there are trained clinical coders, they will routinely abstract and transform SNOMED CT concepts and encode them in ICD-10 (or similar); they are trained to do this, in context, to meet operational and business needs, including funding models. Here SNOMED CT replaces only the clinicians hand written notes and narrative the coders have always had available in patient records.
    - In this scenario, the clinical coders **are** the map authors, constructing meaningful transformation of SNOMED CT to ICD as part of their normal/usual workflow - prospectively. It may be more advantageous, and provide more accurate and comparable statistical data if the clinical coder workforce, rather than a map, is utilised to produce ICD or DRG data outcomes. This is a choice-point that individual jurisdictions can evaluate for themselves, taking workforce, resourcing and budgets into account.
2. If we are trying to update an existing code set and migrate to a standard SNOMED CT reference set going forward, there are a number of considerations that jurisdictions might consider.
    - How formal, widespread and entrenched is the existing code set?
    - How well is it working? How well is it documented?
    - Is the existing code set constructed to serve a single (CIS) delivery system, perhaps with search or navigation functionality that is unnecessary for a SNOMED CT implementation?
    - How MUCH of the existing code set has ever been used and appears in a longitudinal Patient data collection?
    - Is it worth ONLY mapping the terms that have ever been used in Patient records? If some terms have never been used, does this mean users found them unhelpful or unnecessary?
        - If yes, then consider map direction; it might be more feasible to map backward from SNOMED CT to the existing code set to provide a retrospective map for existing patient data collections
        - If yes, then perhaps use the existing code set and frequency of use (in data) measures to merely scope a new SNOMED CT reference set and then make a retrospective map to join historical data when that becomes necessary for trend analyses.

As well as the above considerations the following points should be considered **before** choosing to map

4.1 Clinical risk

Whenever the meaning of one code is being translated into another, there is always a potential change or loss of meaning due to the differences in semantic structures of the source and target code system.

If a map is being used to either map to or from data collected for clinical purposes, there is a level of risk being introduced that can have clinical impacts.

During development

When developing a map, consideration of the implementation setting that the map is being intended should occur. Where a map is intended for implementation in a clinical setting, further consideration is required; it may be the case that mapping is deemed to be not suitable.

Clinical review during the mapping process may be required to support safe clinical practice. Testing against real patient data is also recommended to evaluate the impact of mapping on data outcomes, particularly if there are concerns around clinical safety.

Prior to implementation

Before implementing a map in a clinical setting, it is important to do a risk assessment including (but not limited to):

- Identification of all patient safety risks that arise from using the map in a clinical setting
- Perform and document a risk assessment
- Implement risk mitigation measures
- Undertake and document the risk management activities for both the mapping process and for ongoing maintenance of the map

4.2 Maintenance burden

Maps intended for ongoing use often require a commitment of resources and tools and so can be quite costly to maintain.

Maintenance may be required whenever there is a change to the source or target code sets. Some terminologies are more dynamic than others, with a faster update cycle which can increase the maintenance burden - for example Medication releases can be monthly, whereas some classifications have only a two yearly cycle. The more dynamic the code sets, the greater the maintenance burden.

During maintenance, the following should be considered:

- for new source codes, new map rows need to be created
- for retired/removed source codes, map rows need to be removed
- for retired/removed target codes of maps, map rows need to be updated to find suitable targets
- for non-equivalent maps, map targets should be re-evaluated to check if there is a more suitable target

Maintenance can be non-trivial and consideration needs to be undertaken before beginning the mapping process on whether it is worthwhile developing, implementing and maintaining a map or whether a different implementation pathway is more appropriate.

4.3 Compatibility of source and target code systems

Mapping can be a bridge between two different code systems, but there is a prerequisite that the two code systems being mapped have compatible semantic domains.

The semantic meaning of a concept or code can be made up of a combination of

- the representation in the code system, e.g. the description associated with a code

- the meaning provided by its structural representation in the code system, e.g. attributes inherent in the modelling within the code system
- the context of use e.g. the clinical information model or clinical workflow

Prior to mapping, it is important to understand these things and assess the compatibility of the two code systems to mapping. Where the two code systems do not have compatible semantic domains, it may not be possible to build a meaningful or useful map.

4.4 Data quality

Mapping cannot solve issues with data quality.

Poor data quality

Poor data quality in source codes or insufficient information for the map development team to understand the source code and find an appropriate target code, will result in poor or patchy data quality with many source codes being unable to be mapped.

Also, "dirty" data e.g. abbreviations, shorthand, use of symbols, free text sentences, can be expensive to process and map. "Dirty" data is difficult to process and incorrect maps can be created if the true intent of the author is unclear.

Unknown, unfamiliar or undocumented source code sets

Often legacy code sets have been in existence for some time, and have themselves been locally developed, and may not be well documented. The original intent of the source code set may be vague or not not well understood or agreed. There may only be informal documentation or the documentation may have aged. Understanding both the source and target vocabularies is essential; guessing at the intended meaning of either of source or target will result in a less robust and safe map product.

4.5 Intended or unintended consequences of mapping

Even a dual authored, dual reviewed, clinically assured equivalence map may not provide a **comprehensive and long term solution in every case**.

This example shows a well formed map.

Source ID	Source term	Relationship type	Target ID	Target term
A01	Asthma	equivalent	195967001	Asthma
C11	Common cold	equivalent	82272006	Common cold
D58	Dislocation of joint	equivalent	108367008	Dislocation of joint
E123	Ear infection	equivalent	129127001	Ear infection

But the consequence here is that the new SNOMED CT content reflects only what was pre-existing, with no change in scope or range of clinical content, and with the features of the legacy source system maintained (and these may be 'convenience' terms, or hand-picked favourites, with none or some internal structure or they may be disjoint. Sometimes these source code sets are arbitrary or idiosyncratic.

Despite investing effort in producing a well formed map we achieve only what we already have, with merely a change in codes/identifiers. There is no improvement in clinical utility, standardisation, interoperation with other standard SNOMED CT-enabled systems, and analytics that might exploit the logical definitions of SNOMED CT are not so readily performed using subsumption or ECL queries.

In this scenario, the SNOMED CT map target concepts can be regarded as the minimum viable 'mapset' of concepts that will support migration or longitudinal data analyses. But to provide future utility, for integration, interoperability among and between systems and settings, and to support SNOMED CT-aware analytics, this

mapset would need to be expanded to form a more comprehensive and sustainable ValueSet. Mapping is a great first step but it is not the whole journey.

Map products that contain broader or narrower relationships may influence how data is analysed and interpreted. Reports of patient data that are formulated using such maps will likely reflect at least some of those map features This may result in some slippage in understanding or direct comparability between reports formed directly using the old source code set and mapped data reports, and/or between mapped data reports and reports that are formulated using SNOMED CT encoded data directly. It may appear that data analyses are 'skewed' when a map product is in use. It is recommended that map performance is evaluated and compared with both retrospective and prospective analysis options to determine the impact of the map product.

Again, all of these consequences, intended or not, are choice-points that jurisdictions and users might consider when embarking upon and designing a roadmap for their mapping strategies.

5. Developing use case and requirements

Once the decision to map is made, it import to understand and document the intended use case and the requirements of the map itself.

This involves:

5.1 Map documentation

Documentation of mapping methodology and decisions made is important

- To allow reproduction of the mapping process for updates
- As evidence of the mapping process undertaken and rules applied for compliance assessment

A map is not necessarily static, future versions of a map may require a change of decisions or rules which need to be clearly defined and applied consistently.

Clear documentation will allow the correct usage of the map and allow users to identify when the meaning of the results of the map have changed

Documentation should include

- Identification of source and target code systems (include versioning)
- The purpose and use case of the map
- Intended users of the map
- The scope and rules of the map
- Pre-processing undertaken
- Processes undertaken to modify data
- Rules and reasons for changes
- Personnel involved
- Tools used
- The mapping process used
- Issues resolution process
- Validation process
- Risk Assessment
- Risk Management process

5.2 Defining use case and purpose

The method of creating a map, the rules and processes associated are tightly bound to the map's purpose, use case and requirements.

It is important that the map's use case and purpose are well defined prior to beginning map development and documented clearly for reference during development and for implementations. The map's use case and purpose have flow on effects through the maps lifecycle.

When thinking about this, consider:

- What is the main purpose of this map?
- Who is the intended audience?
- What is the scope of content (source and target)?
- Who is responsible for developing and maintaining the map?
- How will the map be implemented?

Use case and purpose

- A map must have a defined and specific purpose
- Provides context to the map
- Influences decisions/rules made when mapping and how to map when there is discrepancies between the source and target code systems

Example: The purpose of this map is to allow for Emergency Department SNOMED CT principal diagnosis codes to be mapped to the national Emergency Department National Minimum Data Set for funding.

CAUTION: Beware when reusing maps or repurposing mapped data, as even though the source and target code systems may appear the same and the healthcare setting may be the same, the purpose (and hence the rules used to build the map) may differ and can give unexpected and/or unwanted results!

Examples:

- Coding for a clinical purpose vs a financial/funding purpose
- Two different funding maps

Example use case, purposes and considerations

Use case	Purpose	Considerations
Interoperability	Retrospective maps for backward compatibility when migrating a legacy code system to a national standard code system • For historical data • To define code systems for use based on existing legacy code systems	What data do you need to map? • Only codes/terms that exist within the historical data collection Maintenance • Is this a single use/snapshot map?
Interoperability	Prospective maps for continuing use to transform codes from a local code system to a national standard code system	What data do you need to map? • All valid codes from the source code system as you cannot predict what is required by users Maintenance • Continuing use means continuous maintenance is required • Consider how dynamic these code systems are to understand maintenance burden/costs • Is there an option to migrate in the longer term to phase out maintenance burden? • Who needs to carry the maintenance burden? The implementer of the local code system or a national body?
Integration	Maps to allow the comparison of different code sets by converting codes to a single code set: collection of data sets from different implementations of the same system which has different terminologies	Which code system is your target code system? What will get the best results? Are the code systems compatible? • How different (content, structure, semantics) are the code systems and can you get a sensible map? • What rules and conventions need to be applied to get a best match?

Use case	Purpose	Considerations
Categorising or reporting	Maps for assigning codes to higher level groups for • reporting - KPIs, priority health areas • funding – billing, access, service planning • cohort identification, research, analytics – epidemiology, surveillance • safety/efficacy audits • workflow or CDS – linking a patient journey,	Rules of the map • Mutual exclusivity (can 1 source code map to more than 1 target code?) • Does every source code require at least 1 map? Maintenance • Consider how dynamic these code systems are to understand maintenance burden/costs

5.3 Map requirements and planning

Prior to building the map, it's important to define the scope, processes and mapping rules to have consistency between all personnel involved.

These should be documented clearly and updated frequently as required.

These include

5.3.1 Defining the scope of the map

The scope of a map is tightly bound to the map's use case and purpose.

Once the use case and the purpose has been defined, the scope of the source and target code systems of the map can then be defined.

When considering the scope of the source and target code systems of the map, consider

What is the scope of the source code system?	• Does the whole source code system need to be mapped, or is a subset sufficient? ▪ If it is a historical code system, is the subset of codes that have been used in practice sufficient? ▪ Is there a need to map historical or inactive terms? ▪ Is there a need to exclude some terms if ambiguous, duplicates, not within the required scope?
How is the source code system used in the implementation?	• Is the source code system appropriate for the data model it was implemented in? • What is the meaning of the codes in the context of the data model?
How will the map targets be implemented?	• Is the target source code system appropriate for the new data model?
What is the scope of the target source code system?	• Is the whole target code system appropriate or is a subset more appropriate?

Are the scopes of the source and target code systems compatible?	• Do they match? should they match? • Requirements for exclusions or specific rules about how the scopes will be translated. • Is there need for contextual information (e.g. from the information model) to be included in the decision for what the map target should be ▪ if mapping from a source code system for a "Family History" field (source) to a new data model that was an "Other information" field (target) then |*A123 Breast cancer*| in a Family History field may need a map to a single term like *429740004 |Family history of malignant neoplasm of breast|* • At what level do the terms need to be mapped? Is equivalence the goal, or are we grouping things to a broader target? This will be determined by the use case.

	What is the scope?	How is the code system implemented?	Are the scopes compatible?
Source code system	Does the whole source code system need to be mapped, or is a subset sufficient? • If it is a historical code system, is the subset of codes that have been used in practice sufficient? • Is there a need to map historical or inactive terms? • Is there a need to exclude some terms if ambiguous, duplicates, not within the required scope?	• Is the source code system appropriate for the data model it was implemented in? • What is the meaning of the codes in the context of the data model?	• Do they match? should they match? • Requirements for exclusions or specific rules about how the scopes will be translated. • Is there need for contextual information (e.g. from the information model) to be included in the decision for what the map target should be ▪ if mapping from a source code system for a "Family History" field (source) to a new data model that was an "Other information" field (target) then |*A123 Breast cancer*| in a Family History field may need a map to a single term like *429740004 |Family history of malignant neoplasm of breast|*
Target code system	Is the whole target code system appropriate or is a subset more appropriate?	• Is the target source code system appropriate for the new data model?	

5.3.2 Mapping rules

Mapping rules should be decided and documented from the beginning of the process and available to all personnel to reference during the mapping process. As mapping continues, there may be a need to update or add new rules, so documentation should be kept up to date.

Mapping rules are specific to the map being developed and should include the following

Map direction

The map direction is determined by the use case that it is intended to cover when implemented. It is important to consider the direction of the map, particularly for non-equivalent maps.

During the mapping process, it is natural to map from source to target, which results in a unidirectional map. Unidirectional maps are not intended to be used "flipped" and used in the reverse direction. "Flipping" a map can

lead to nonsensical maps or lead to unintended consequences such as the assumption of additional clinical information which may not be correct when reversing the direction of a SNOMED CT to ICD map.

Map patterns

Depending on the use case, different map patterns may be required.

Prior to mapping, it may not be known what the final map pattern might end up being, rules need to placed to decide what is allowed.

For example, in a funding case scenario, we would expect a N:1 (including 1:1) pattern, but not a 1:N as we would expect that a single code should only belong in one single category (requirement for mutual exclusivity).

Notation	**Map pattern**	**Explanation**
1:1	One to One	One source term is related to one target concept
1:N	One to Many	One source term is related to two or more target concepts
N:1	Many to One	Two or more source terms are related to a single target concept
1:0	One to None	One source term has no available target concept

Map correlation and types of map relationships (degree of equivalence)

The degree of equivalence between the source and target of the map is determined by the use case of the map. Each map between source and target should have a defined type of map relationship describing the type of relationship or degree of equivalence of source and target code

Example map relationship types include

Relationship type	Description
Equivalent	The definitions of the concepts mean the same thing (including when structural implications of meaning are considered) (i.e. extensionally identical).
Broader	The target mapping is broader in meaning than the source concept.
Narrower	The target mapping is narrower in meaning than the source concept.
Inexact	The target mapping overlaps with the source concept, but both source and target cover additional meaning, or the definitions are imprecise and it is uncertain whether they have the same boundaries to their meaning.
No match/ unmatched	There is no match for this concept in the target code system.

Allowable relationship types should be determined for the map. Some maps may require equivalence only. Use cases like grouping or funding may require broader (target to narrower source), but rules on how broad to go should be considered.

For example source code Acute myocardial infarction can be mapped to target codes *Myocardial infarction* or *Cardiovascular disease*, *Amoxil 500 mg capsule, 20* can be mapped to *amoxicillin* or to *penicillin* - these decision would be made based on the use case and what would make a useful map.

Narrower (target to source code) may also be required to increase coverage and allow greater content usage in some use cases like mapping a legacy code system to a new target code system for implementation for data entry.

Examples:

Purpose	Relationship type
Categorising SNOMED CT codes to ICD 10AM codes for funding in the ED	Broader
Migrating legacy code set in CIS to SNOMED CT	Equivalence, narrower, broader
Translating a medication order to a Trade Product Pack for stock check	Narrower

Using post coordinated expressions as targets

If mappers are not able to find an existing term within the target terminology to map to they may be able to map to a post coordinated expression.Post coordinated expressions can be a solution, however they can be difficult to implement.

Consider if the system that the map is being implemented in is capable of implementing post coordinated maps and whether other downstream users are able to consume and use post coordinated expressions.

All mappers must bee familiar with the rules of creating a concept model compliant post coordinated expression if this is an approach being taken.

5.3.3 Personnel

Mapping requires a multidisciplinary group of people to

- Develop the map
- Undertake the actual mapping
- Verify content
- Test
- Document, and
- Release

A wide range of expertise is required for the development of a map including:

Expertise	Details
Clinical subject matter expertise	Clinical expertise of the discipline and the way that the result of the map will be used in clinical practice (including workflow). Provide decisions on the clinical safety and appropriateness of the results of each individual map
Source code system expertise	Expertise and understanding of the source scope, coverage, purpose, content and structure
Target code system expertise	Expertise and understanding of the target scope, coverage, purpose, content and structure
Technical implementation expertise	Expertise and understanding of the implementations where the source data originates, the target data will be used and the automated processes used to transform the data from source to target
Administrative expertise	Management of the process and project, ensuring repeatability, quality, risk management and consistency

Requirements for mappers (and reviewers)

Personnel doing the mapping (mappers) should

- Understand and be able to apply the structure, content and relationships for the source and target code systems
- Understand the purpose of the map
- Understand the way the map will be implemented
- Understand the processes associated with new releases of the source and target code systems

5.3.4 Mapping and review approach

There are a number of different mapping and review approaches that can be done.

Considerations when choosing an approach include:

- team resources
    - size of team
    - time resources
    - personnel/expertise levels
- project time lines
- map content
    - use cases
    - clinical risk

SNOMED International does not recommend ONE specific approach for mapping, but independent approaches are typically a feasible approach to achieve high quality maps. Alternatively, or additionally, a combination of review methods can be recommendable to ensure a reliable and usable review process. Ideally, reference sets should be reviewed iteratively until the users are satisfied. Examples of the approaches to take are illustrated in the following table.

Approach (each source)	Description
Single author no review	In this approach, each source row is authored by a single author with no review process. This approach could have a single user completing all source rows, or the source rows shared across multiple users. This may be suitable for very small teams for maps that are not intended for clinical use and have very low clinical risk.
Single author, single review	In this approach each source row is authored by a single author and reviewed by a single reviewer. This approach could have a single user completing authoring or reviewing of all source rows, or the source rows shared across multiple users. Example scenarios: One user authors maps for each source code, one user reviews all maps A group of users authors maps for each source code, another group of users reviews all maps A group of users are responsible for both authoring and reviewing all maps, each user authors maps and also reviews other users' maps. In a really small team, an author and reviewer may be the same person. However this is not ideal, and it is highly recommended to include two or more people in the map development process. These approaches may be suitable if there is sufficient resources and there is appropriate personnel to complete a review to mitigate clinical risk, however independent author/review processes is considered gold standard and should be considered if there is clinical risk and resources allow.

Approach (each source)	Description
Dual (or multi) independent author with adjudicator (no review)	In this approach each source row is independently authored by two or more authors. This approach could have users each authoring all source codes or shared across multiple users. After authoring, mappings are compared. Where there is conflict between the authors, then a) the authors can work together to solve the conflict and come to an agreement. There may be need for an external adjudicator when agreement cannot be reached. b) an independent adjudicator can act to review and resolve conflicts. This approach can produce higher quality maps, because each author is independently cross-checking each other's material without being biased by the decisions of the other author. As adjudication is only required where there is conflict, this approach can be quicker than completing a full review.
Workshop	Validation workshops is workshops dedicated to review and validate the design and/or content of a reference set. In these workshops the content or uncertainties are discussed in details, or test-persons are asked to prioritize and assess specific subset members etc. The participants may have had a chance to review the reference set individually prior to the workshop to prepare questions and comments for discussion. The number of people in the workshop and their roles should be considered and selected dependent of the format and the scope of a specific workshop. This approach is time consuming which should be acknowledged already in the planning stage. However, this approach may also be rewarding. Workshops often give rise to detailed discussions or unplanned discussions of relevant issues, but at the sametime workshops provide an opportunity of increased ownership and participation among the participants, which may have a positive effect on the adoption of the reference set. It is recommended to plan these workshops in detail and to include a set of workshops. The number of workshops necessary depends on the size of the reference set, and how the feedback sharing is conducted.
Other	Single author, dual (or multi) independent review Dual (or multi) independent author with single reviewer Dual independent author with dual independent review

6. Map development

After documenting the use case and requirements of the map, map development can then begin.

6.1 Data preparation

To get the best mapping results, it's important to prepare your data prior to beginning the mapping process.

Data in the real world is rarely clean and tidy.

Data may have:

- An underlying data structure and that could be represented with indents
- White space (leading, trailing)
- Truncated text
- Data types
- Headers, footers
- Non text characters (? # / , - + * @ =)
- Misspelling
- Abbreviations

Even when data is coded, the data may not be as clean and tidy as expected.

Data could be

- Used out of context (repurposed fields)
- Used as proxy – best/easiest closest thing
- Underlying coding often organic and uncontrolled
    - Duplicates
    - Erroneous synonymy
    - Conjugated terms
    - Ambiguous
        - different meanings interpreted depending on the context/reader

Other data quality checks include

- Are all the terms uniquely identified?
- Are there any duplicates?
- Are there any null values?
- Is there any meaningful metadata that needs to be accounted for.

All of these things should be considered and rules should be developed and documented on how these things will be handled so that there is consistency through the process and between personnel. Sometimes these decisions require expertise of workflow within the implementation and not just clinical expertise.

For example:

If this is in your data	Possible meaning 1	Possible meaning 2	Possible meaning 3
#	fracture	number	
/	and	or	
?	possible	probable	suspected
++	moderate severity	getting better	increased
Disease 1, Disease 2	Both (co-morbid)	Disease 1 causes Disease 2	Disease 2 underlies Disease 1

6.2 Authoring

Authoring is the process of defining the relationship between concepts in the source code system and the target code systems.

Authors can assign none, one or more target codes to a source code and assign a relationship type.

When assigning a target code, authors need to take into account the map use case and purpose as well as the code systems structure, rules, term composition and granularity when developing a map.

Automated mapping tools

Once data has been pre-processed, automated mapping tools may be useful. Automated mapping is when computer algorithms are used to create maps between code systems. Lexical mapping, where the structure of the words in the clinical term is compared and analyzed as to whether the words are the same, similar or different, is often incorporated within automatic mapping.

Maps generated by a tool need to be checked by a specialist mapper. Significant care must be taken with automated mapping, because severe mapping errors can result if not done in a controlled way. Automated mapping, in conjunction with human review (and manual remapping where necessary), is likely to achieve better results than automated mapping alone.

Appropriate filters or scope constraints should be used on the tool to increase accuracy of the automated mapping tools. A record of the tool, the scope constraint and matches should be kept to test reproducibility of methods

Manual/human mapping

Human mapping is the use of human knowledge and skill to author maps. Each map is built singly and individually. The process requires examination of each and every concept in the coding system. Informed judgments or decisions are made about the shared meaning of concepts. Electronic or computational tools are used, but only in support of work process.

There are a some tools available to assist in this process, however manually mapping into tables without tooling support (e.g. spreadsheets) is time consuming and can be error prone due to needing to copy and paste from a browser and into the table.

Editorial guidelines

Defining firm guidelines for mappers will save time and go a long way towards ensuring higher levels of inter-rater reliability in situations where there is more than one mapper. These guidelines will also be valuable in highlighting the reasons why certain target concepts were chosen over others. Editorial Guidelines are very important to users of the maps and are a necessary development step in the creation of useful, reliable and usable maps.

Also a map is not necessarily static, future versions of a map may require a change of decisions or rules which need to be clearly defined and applied consistently.

Tips

Organising your terms by grouping together terms of a similar nature, for example: all terms referring to fractures together, all the diabetes terms together can make the mapping process easier and aid in consistency of the maps. Once this is done also consider if the source code system contains terms that might be considered “synonyms” or duplicates of other terms.

It may be possible to request new content from the code system suppliers (e.g. SNOMED International) to deliver a better map

6.3 Validation and review

The level of quality assurance required is dependent on the practical use case of the map.

There are a number of different methods that can be used for validation of a the accuracy of the content of the map.

Dual/multiple user independent mapping

Dual independent mapping is often considered the "gold standard" approach for mapping and should be considered when a high quality map is required.

In this approach, each source code is independently mapped by 2 (or more) authors, and the results are then compared. When there is agreement between the authors for a mapping, then the mapping is accepted. If there is a conflict, there is a conflict resolution process between the authors to come to an agreement on the correct mapping.

Agreement is achieved for a given source code when all targets (or no map) and their respective relationship types that have been selected are the same between the authors of the mapping.

The conflict resolution process may involve a workshop between the authors, or the use of an adjudicator/subject matter expert to make a decision.

Full review process

Reviewing is the use of human knowledge and skill to review maps.

Each and every map row is reviewed singly and individually. It is preferred that users performing the review are not involved in authoring of the map to ensure an unbiased validation, however due to resourcing constraints, this is not always possible and in these cases, it is recommended that user performing the reviews do not review their own authoring work.

Sampling review process

In this approach, a sample set is selected from the whole map. The sample set is then reviewed. Like the full review process, it is preferred that users performing the review are not involved in authoring of the map to ensure an unbiased validation, however due to resourcing constraints, this is not always possible and in these cases, it is recommended that user performing the reviews do not review their own authoring work.

If taking a sampling review approach, care should be taken in picking the set and acceptable error rate depending on the risk rating of the map. This approach may not be suitable for most maps as it does does not necessarily validate a whole map, but may be more suitable for ongoing maintenance of maps.

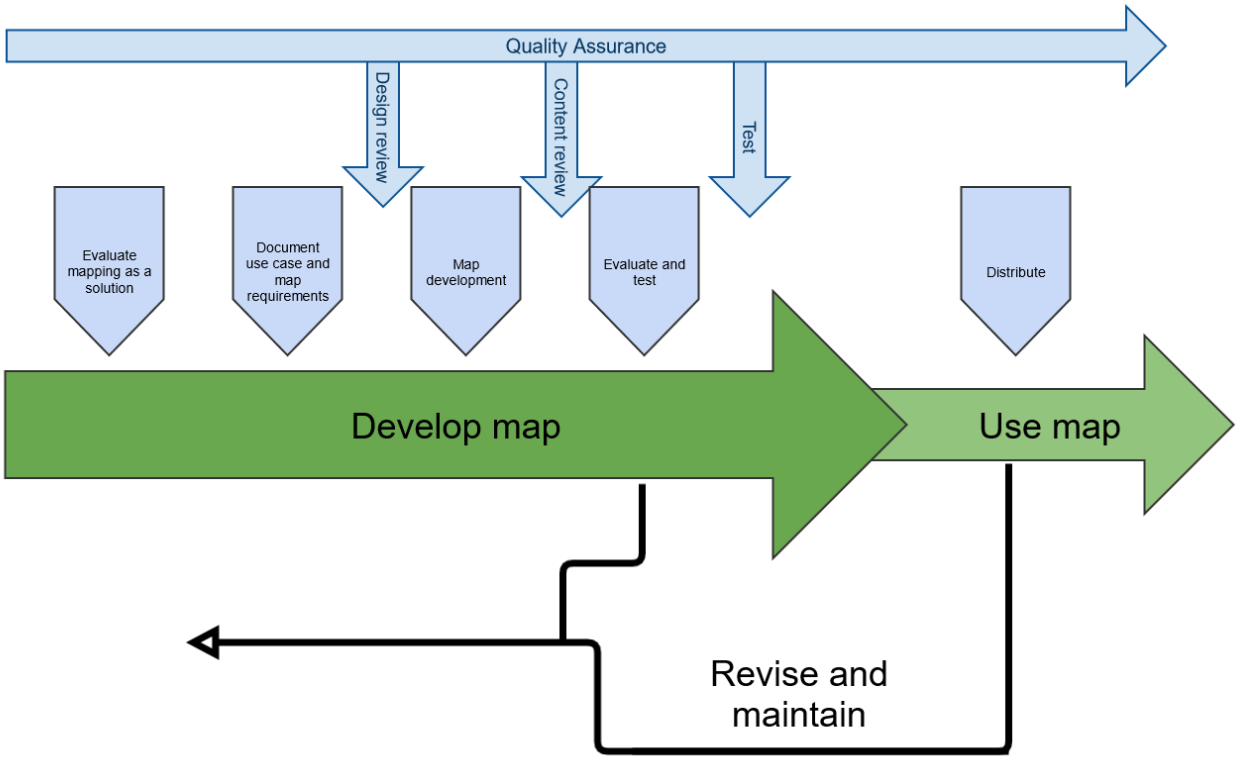
7. Evaluate and test

Ensuring the quality of a map is important for the successful use of SNOMED CT. It is crucial that the content of the map references the concepts which represent the meaning of the source data it is to be linked to. In addition, it is important that the human interpretation of the concepts referred to aligns with the logical definition provided by SNOMED CT. Even when using maps for less patient safety critical purposes, the quality of the map needs to be sufficient to be trusted to serve its purpose.

Stages of Quality Assurance

Reviewing a reference set is important throughout the reference set development process, however at least three types of validation should be emphasized, see illustration below.

- Design review: The overall objective with this review is to verify whether the map design meets the requirements.
- Content review: The overall objective with this review is to verify whether the selected targets are appropriately mapped to the source codes.
- Test: The overall objective with testing the map is to validate the map in the context where it is to be used. Testing is done to assure that the map meets the needs of the involved stakeholders.



Test

In addition to the abstract assurance of the subset in isolation, there may be a requirement for a level of testing to be undertaken in healthcare systems, and tested under the exact circumstances of intended use. This may be undertaken by releasing a technology preview targeted at specific bodies for feedback. An impact assessment and, most importantly, safety testing will need to take place upon deployment of the subset into systems, particularly where significant changes have taken place.

8. Revise and maintain

Maps developed for ongoing use may require maintenance.

When developing or evaluating a change management process it is important to take different factors into account. Some of these factors are introduced in the table below.

Change management considerations:

Topic	Description
Request for change	Where will the need for change come from? This could be any of the stakeholders involved in the development or use of the map
	How will change requests be expressed and submitted? These may be submitted directly by users, or may be collated and edited by suppliers. The maintainers of the subset may be proactive in looking for improvements, or may wait for requests for change to be submitted.
	What lead time is acceptable for the processing of a change request?
	What should users of the map do in the period between recognizing the need for a change, and that need being met by a new release of the map? Options may include manual work arounds
Revision cycle	Will there be a predictable revision cycle with regular releases, or will changes be made on an as-needed basis? Maintenance may be required when there are changes to • source code system • target code system • use case/user and system requirements Some use cases may also require maintenance of retired/deprecated content, with addition of new content. Impact of changes need to be considered, as well as impact on delaying updates.
Resources	What editorial and technical resources are needed?
Documentation	Which associated documentation also require updates with the map itself?

9. Mapping to SNOMED CT

Defining the map scope

SNOMED CT contains a number of hierarchies, each representing different types of concepts. When mapping to SNOMED CT, it's important to understand the scope of the source content that you are mapping so you can define the SNOMED CT scope appropriately. When mapping to SNOMED CT, you should constrain the target scope to a specific hierarchy, subhierarchy or subset of SNOMED CT. This will improve the accuracy of any automated mapping tools you may be using and also reduce the risk of errors from users developing the map.

Example scopes:

- If you are mapping a type of organ or body site, then the map scope might be the ‘Body structure’ hierarchy (< 123037004|Body structure|)
- If you're mapping conditions, judgements or assessments about a patient, the scope might be the Clinical finding hierarchy (< 404684003|Clinical findings|)

Mapping process

During the map process, once the target scope has been defined to the appropriate hierarchy, subhierarchy or subset of SNOMED CT, authors and reviewers can then search for an appropriate code to map to.

When selecting a code, the user must review the concept’s Fully Specified Name and defining relationships to understand the intended meaning of each concept, and use the use case and rules of the map (such as requirements for equivalence, allowance for 1:many maps, context of implementation, etc) to determine what is an appropriate match.

An example process a user may conduct is

- Search SNOMED CT for a matching concept
- Find an appropriate candidate concept
- Assign it to the source code with a relationship type

There may be instances that there is more than one candidate concept, depending on the rules of the map, it may be appropriate to select more than one. It may also be appropriate to select the most general supertype concept that completely matches the required semantics.

Where there are no appropriate SNOMED CT concepts available, it may be appropriate to

- Create or request an appropriate precoordinate concept in an extension to be used in the map
- Use a SNOMED CT postcoordinated expression that captures meets requirements if the use case of the map can support this
- Define the map as having no map target