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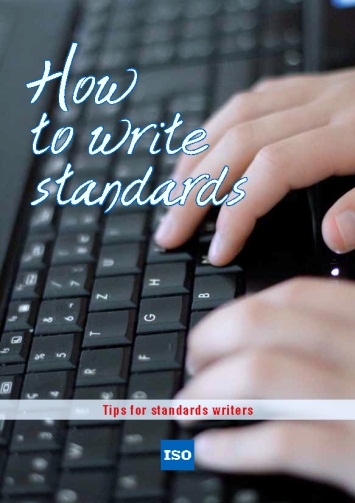
**Title** Health Informatics — Terminology resource map quality measures (MapQual)

WD stage

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# Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2. [www.iso.org/directives](http://www.iso.org/directives)

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Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: [Foreword - Supplementary information](http://www.iso.org/iso/home/standards_development/resources-for-technical-work/foreword.htm)

The committee responsible for this document is ISO/TC 215.

# Introduction

Note: this is a working draft and considerable additional work is still required. This document is provided to define the scope and intent of the work item.

Healthcare organizations and software vendors are increasingly using maps to convert data from one code system to another code system. In the past data in health information systems was largely used for organizations’ administrative planning and decision making. Data captured in electronic health records (EHR) systems for patient care has significant impact on patient safety. The use of this data as the source of data for other purposes and for information exchange in clinical care through the use of information technology is an emerging problem. Where that data is translated through maps from one code system to another the safety and quality issues associated with data use can be significant. The increasing use of maps is costly.

Maps are widely used but the quality of these maps are not able to be accurately and consistently assessed and compared against their intended use. It is not currently possible for decision makers to assess whether a map will be worth the cost of building it and whether it will meet the intended use case.

This Technical Specification will assist decision makers and map developers to provide a measure of the utility and quality of a map. The quality assessment may indicate the quality of the map design to deliver a usable outcome. For example, some terminological resources are so different in their content and purpose that they will never map closely to a resource designed and structured differently. Therefore the decision maker might need to consider whether to map at all or to move to a new terminological resource.

**Title** (Health Informatics — Terminology Resource map quality measures)

# Scope

This Technical Specification (TS) defines the quality requirements for a terminology resource map set. It is based upon the existing Technical Report ISO TR 12300 - Principles of mapping between terminological systems. The Technical Specification will establish measures which can be used to assess the quality and utility of a map between terminological resources, determine the level of measure required for common use cases in healthcare which can be used to support conformance assessment.

The quality measures will address mapping processes used (including manual and tool based mapping), as well as the type of map set delivered as a result of that process.

## Objective

The objective of this work is to support the definition of quality requirements for map sets to:

* Establish standard quality conformance requirements for a map for a purpose
* Assess quality of a map for a purpose
* Guide decision makers in map project requirements and processes
* Establish pathways to improvement

## Stakeholders and Audience

This Technical Specification is focused on the needs of:

* Implementers and software vendors developing and implementing maps
* Health information and data managers developing and using maps
* Data users such as researchers, government, decision makers
* Developers of maps including all in mapping teams including terminologists, coders, clinical users, epidemiologists and statisticians, project managers

Additionally, the target audience for this Technical Specification may include

* Procurement officer to establish requirements of map product capacity and quality
* Decision makers to determine and assess resources needed in projects and services associated with map produce, maintenance or use.

## Challenges of Mapping

Healthcare organizations and software vendors are increasingly using maps to convert data from one code system to another code system. In the past, data in health information systems was largely used for organizations’ administrative planning and decision making.

Today maps are being used for a much broader range of use cases and the challenges of their use include:

* Map purpose – a map built for one purpose may but also may not suite use for other purposes. This dilemma arises as decisions are made when building a map and these decisions impact the choice of the result of the individual map from one source code to a target code. When the purpose changes the result may also need to be different
* Map accuracy – there are two aspects to accuracy. The first is whether the map is as well development and maintained as possible, the second is how closely the results of applying the map deliver an outcome consistent in meaning to the original source data.

Map effectiveness – Information retrieval is a critical functionality of maps. The actual consequence of assigned map links imposed between terms of different code schemes impacts the effectiveness of information retrieval searches. Map purpose and accuracy both impact the potential safety and appropriateness of the use of that map in healthcare. If the original meaning is changed through the ‘translation’ using a map this may impact clinical safety if the data is used in that context. There is also the consideration of whether the map is applied consistently to defined data elements in the health record. The data element in which the original source data is recorded may add meaning to the code allocated (e.g. Family history of condition versus clinical diagnosis of the individual).

Another significant issue is the cost of creation and maintenance of a map and the ongoing risk and difficulties of maintaining currency of the map.

More information on this topic is available in ISO TR 12300 Principles of mapping between terminological systems.

## Bundle of .. Standards and Documents

If map quality is neglected, maps will continue to be classified in non-standard ways increasing barriers to establishing the purpose, accuracy, effectiveness of the quality of terminological mappings. The longer the international community is without a technical specification in this area, the more expensive the problem will be to resolve due to the persistence legacy metadata and the cost of modifying existing mapping processes to fit an agreed ISO/ TC specification; therefore an TS solution is highly desirable.

# Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO #####‑#:20##, *General title — Part #: Title of part*

*ISO 20943-5 Semantic metadata mapping procedure*

# Terms and definitions

## Auto-matching

Computational mapping task, undertaken using an algorithm based upon the relationship between concepts

## Cardinality

number of times a data element may repeat within an individual occurrence of an object view

## Categorial

relating to the part of the base component that contains rules for establishing syntactic categories and the ordering of elements within.

## Classification

exhaustive set of mutually exclusive categories to aggregate data at a pre-prescribed level of specialization for a specific purpose

## Coding system

combination of a set of concepts, a set of code values, and at least one coding scheme mapping code values to coded concepts

## Concept

unit of knowledge created by a unique combination of characteristics

## Context

related conditions and situations that provide a useful understanding and meaning of a subject

**Coverage**

the fraction, of data which should be translated, that is actually translated

## Data aggregation

process by which information is collected, manipulated and expressed in summary form

## Determinant

influencing or determining element or factor

## Equivalence

condition of being equal or the same in value, worth or function

## Individual map

index from one term to another, sometimes using rules that allow translation from one representation to another indicating degree of equivalence.

## Lexical equivalence

condition of concepts with contextual evidence, e.g. identicallexical equivalence deals with translation of terms and concepts rendering meanings consists of two components – denotation and connotation.

Priority Map Content

Consider whether a definition is needed for priority content (map priority content)

consider percentage of 0, 1,2,3,4 equivalence within the tested set (priority or complete).

Map

index from one term to another, sometimes using rules that allow translation from one representation to another indicating degree of equivalence

## Map quality determinant

attribute of a map, map development process, or map metadata that is considered a reliable measure of the suitability of the map to a use case

## Map Quality Measure

quantitative measure of the characteristics and attributes of a map

## Map source

In this document – Source

terminology, coding scheme or classification used as the starting point for map production

## Map set

Map table

group of individual maps used to convert a range of entries from source to target code system

## Map target

In this document – Target

Terminology, code system1 or classification that is the end goal of map production

## Mapping

process of defining, building or using a relationship between concepts in one coding system to concepts in another coding system in accordance with a documented rationale, for a given purpose.

**Map specification**

Denotes measurable empirical evaluation criteria  grounded in the context of use and aimed at quality in use.

## Scenario

formal description of a class of business activities including the semantics of business agreements, conventions, and information content.

## Semantic domain

**Synonym: Semantic space**

Area of meaning covered by a terminological resource

Note 1: The semantic domain identifies the meaning represented by the terminological resource. This is used to evaluate the lexical or formal overlap between such resources. In value set specification this might also be called a value set domain.

Note 2: Terminology resources may include value sets, code systems, and subsets.

Example: one code system may have the domain of anatomy while another of disease. Though these are related concepts the semantic domain of each code system is different.

## Semantic equivalence

condition of being equal or the same in meaning

## Semantic correspondence

measure of similarity between two concepts

## Term

linguistic representation of a concept

## Terminological resource (in healthcare)

controlled set of terms in healthcare

## Terminology

structured, human and machine-readable representation of concepts

## Translation

the process of rendering text originally written in one language (source language) to another language (target language)

IHTSDO.org 2014.

**Validation**  
the process of confirming or approving the translation of the mapping of one language (source language) to another (target language)

## Vocabulary

sum or stock of words employed by a language, group, individual work or in a field of knowledge

Code Systems Referenced in the Document

|  |  |
| --- | --- |
| **ICD** | International Statistical Classification of Diseases and Related Health Problems. |
| **ICPC** | International Classification of Primary Care (ICPC). |
| **CCC** | Clinical Care Classification System. |

|  |  |
| --- | --- |
| **SNOMED CT** | abbreviation for SNOMED Clinical Terms (see www.ihtsdo.org |

# Determinants of map quality

## General

A set of quality determinants are defined here which cover the development and maintenance of the map content, the precision of the map between source and target content. Each determinate shall be measured separately in order to allow evaluation of purpose for use case, and in that sense stands alone.

The required level of conformance for each determinant differ according to the use case for which the map is used. Clause 5 covers map quality measurement and requirement specification for specific use cases, applying the determinants of map quality.

## Terminological Resource Capacity

To assess the quality of a map it is necessary to understand the capacity and intent of the source and target and the relationship between how each represents concepts.

### Determinant 1: Common categorial structure

Evaluate whether the target and the source code system share a common categorial structure.

This determinant seeks to specify whether the structure of each system is common.

Example:

If one code system has a structure which includes

* + - Clinical findings
    - Substances
    - Events

And the other has a structure of

* Body systems

The code systems do not share a common categorial structure.

Shared structure supports ability to provide a map. If there is no categorial structure, or such a structure is not applied to the terminological resources the ability to map between terminological resources is less likely to deliver a high quality product. The impact upon quality may differ depending on the intended use case.

### Determinant 2: Shared semantic domain

The ability to mapping of one code system to another assumes that each code system share a common scope of meaning, i.e. that you are mapping apples to apples. It is necessary to assess whether the semantic domains are the same, overlapping, inclusive or without overlap. To evaluate the likely utility of a map it is necessary to consider the amount of overlap.

**Same semantic domain**

The same semantic domain is where both code systems describe the same content, though they may describe it in different ways, with different categorial structures.

Example:

Code system 1 describes apples as eating or cooking apples, this might include additional attributes such as apple colour, origin etc.

Code system 2 describes apples by colour, also including details of suitable uses.

Each code system describes apples though the categorial structures are different. They share the attribute of colour, which is an area of overlap, but do not share all key attributes.

**Measures of semantic domain**

*1: Exact match on semantic domain*

One code system includes the same semantic domain entirely to the other code system.

**Overlap of semantic domain**

In this case some of the content of one code system is included in the other code system, in full or in part.

*2: Fully inclusive overlap of semantic domain*

In this case one code system covers all of the other and also other concepts.

For example a classification of fruit would include apples. This is a fully inclusive overlap.

*3: Non inclusive overlap of semantic domain*

In this case one code system covers some of the other, and either may have additional content beyond the scope of the other.

For example a classification of Red edible items – does not include green apples and includes items which are not fruit, such as red onions.

In each case it is necessary to assess how much the areas which do not overlap will be relevant to the map required. If the map only requires the mapping of red apples the lack of complete overlap between the two different code systems would not impact the quality of the result.

*4: No overlap*

Where the concepts described by one terminological resource are not covered by the second terminological resource a map will be difficult. It might be possible to map concepts at a very high level of abstraction or by establishing some guidance and rules to be applied when making mapping decisions but the outcome will not retain the meaning of the source when represented in the target.

In each of these cases it is necessary to determine the impact of this compatibility on the outcome of the map for the purpose it is being developed or used.

### Determinate 3: Language and Translation

A source terminological resource may be available in a specific language (such as English) is the target also available in that language (English). If one is available in the language required and the other is not a translation of language effort must be undertaken. It would be necessary to consider the cost of that translation and its maintenance and the potential impact upon accurate representation of meaning. If translations have been published by the terminology resource owner, they are more likely to be accurate than those developed in smaller projects. The governance of the translations process may be relevant to your assessment of the language quality requirement for your use case.

It is difficult to judge the semantic equivalence in linguistic translation (semantic equivalence). Use the measures for semantic equivalence that are used in 4.3.

Different standards environments use the term translation and in some such as HL7 FHIR it means to map. A common use case for translation is where a value set is published in English and is translated and mapped for use in another language. Similarly if a code system source is in French and there is a desire to use that code system in English the code system source must first be translated into English. In this way the map is between concepts in the same language.

The translation process firstly requires the translation of the target and or source into the required language, thereby producing a version of the concepts to be mapped in the required language. Only after this has been done and verified should the map be created.

Translation of existing maps -

Otherwise this document assumes that maps are between concepts represented in the same language.

## Equivalence of individual maps

### General

A map between two different code systems will involve a certain amount of compromise. Identification of equivalence criteria is therefore crucial to establishing a level of acceptability and safety for use of that map.

### Determinant 4: Equivalence Identification / Publication

Each individual map (i.e. each source concept to target concept (or concepts)) must have equivalence identified. This indicates whether the concepts in the source are represented by different codes in the target, but the meaning intended when the source was recorded has been retained. If the meaning is not retained, the equivalence can be used to assess the level of difference between the original source and the resultant representation after applying the map. If equivalence is not published with the map set then it is not possible to assess the quality of the map for a specific purpose nor to alert the user of the map where the meaning of a concept may have changed when converted to the target concept representation.

### Determinant 5: Equivalence Assessment

There are two types of equivalence assessment. For a given use case one of two equivalence methods should be selected to assess the quality and utility of the map for a specific purpose.

Either use:

* the average equivalence for the map set, or
* average equivalence for priority map content.

Equivalence measures are based upon ISO TR 12300 represented in a numeric measure (rather than a code). This measure can then be arithmetically calculated.

**Equivalence measure**

* 0 = equivalent meaning – the highest quality equivalence is represented by the lowest number, 0 is the ‘best score’
* 1 = source is wholly included in target
* 2 = source is partially included in target
* 3 = source is mapped however there were many options. Source map is the best comparison rather than an actual correspondence.
* 4 = no map possible

Map set equivalence - average equivalence (sum equivalence measure for each individual map (from the full or priority set) divided by the number of individual maps).

Table 1 Example of Equivalence Measures

|  |  |
| --- | --- |
| Individual Map Row | Equivalence |
| A | 0 |
| B | 0 |
| C | 1 |
| D | 1 |
| E | 2 |
| Average | 0.8 |

#### Average equivalence for priority map content

Where a map is created for a large number of concepts a subset of the whole map might be considered of priority, perhaps because it is used extensively, the most common conditions. In some situations, it is relevant to assess the average equivalence for this priority component of the map as this impacts the majority of cases rather than to consider the average equivalence of the whole map.

Example: Diagnosis map from SNOMED CT to ICD (variant)

This map may be used to support clinical coding, reporting and financial claims and the most common conditions are those which will most impact the results obtained. It may be agreed by the map users and developers that these common conditions (e.g. 10,000 of a potential 30,000) need to be accurate and represent high equivalence while the additional conditions are less important and would not significantly impact the utility of the map for the use case defined.

### Determinant 6: Map Set Outliers

This determinant is used to indicate how much of the map set evaluated for equivalence is within a pre-determined acceptable range of equivalence. In this way it is possible to assess that whether the majority of the map has the level of equivalence required, and only a small number are outside this limit, or whether there are many outside that limit.

The percentage applies to which ever (full or priority) map set group the equivalence has been calculated.

Example: To calculate an outlier value for Table 1. Identify the measure level at which the entry is considered an outlier (in this case 2 or over). There is one entry out of 5 entries with an equivalence of that level. The map shown in Table 1 has an outlier value of 20% (1/5)

Example: 5% of individual map entries which have equivalence of 2 or higher (i.e. equivalence which is not an exact match or aggregated match) may be acceptable for service planning purposes.

The measure associated with this determinant should be specified as

* 0 = no outliers
* 1 = < x percentage to be determined according to the use case)
* 2 = >=x and < y
* 3 = >=y and < z
* 4 = z or greater

## Building a map set

### Map development process

The quality and utility of a map is affected by the processes used to build and maintain the map. These quality determinants will impact quality according to the intended use of the map. Where a map is used for one-time conversion of data from a legacy system to a new system the documentation of the map process and decisions may be of less importance as there is a low requirement to be able to replicate the building process to maintain the map.

### Determinant 7: Clear documentation of the purpose of the map

A map is developed for a purpose which may or may not be associated with a clinical information model as well as the code system used. The clear specification of the use case is essential to determine how to map from source to target, and also to know how and where the application of such a map is appropriate.

The criteria which should be included in assessing your requirements and map conformance include:

use case has a single purpose which is precisely described.

reason for using the map and its intended use

benefits expected from using the mapped data

stakeholders including implementers (such as vendors), and users of the mapped content.

Each of these criteria may impact the utility and quality of the map for a use case. It is necessary that the evaluation of the map consider the importance of each criterion based upon the business case of the map.

### Determinant 8: Currency of the map

### Evaluation should include consideration of the importance and impact of the currency of the map. If the map represents existing target and source code systems consistent with those used in the current source and target information systems, the accuracy of the map application should be as high as possible given the equivalence measures of the map. If any of the existing and current target and source code systems are not consistent there may be difficulties in achieving the equivalence required.

### Determinant 9: Business arrangements

The business arrangement under which a map is developed may impact its quality or maintenance. If the map is developed by the owner/s of the terminological resources with open harmonisation efforts, the likely quality may be higher than that done by a single commercial arrangement.

It is necessary to assess whether this determinant may impact the quality of the map for the specific use case involved.

### Determinant 10: Methodology Documentation

The methodology for development of the map must be specified clearly and documented. There are many methods which can be applied and each should be described to a level where that method could be reliably repeated in order to maintain the map. This determinant reflects the quality of methodology specification, not the actual methodology which is assessed by other determinants. Documentation should clearly indicate the versioning and update processes to be used to maintain the map. This documentation is important if the map is to applied to historical data or to data which changes into the future, but if the map is applied once to convert data to the source terminological system and the ‘old’ data is no longer maintained this may not impact the quality of the map for this use case.

For example: descriptions of validation, tooling, consensus management used.

### Determinant 11: Validation

#### General

Introduce the concept of validation

Validation is the process of explicit confirmation and/or approval of the precision of the ‘Equivalence Assessment”. A consistent requirement for validation of a map product is vital to assure semantic interoperability and the accuracy of data capture and representation. Currently, map products are produced by: 1) Experts using tacit individual knowledge, 2) Consensus using Delphi or IRR: InterRater Reliability techniques, or as a 3) Combined approach using properties of each method. In addition, time-constraints are frequently imposed on the validation process due to the volume of data element concepts in the medical terminologies, such as SNOMED CT which involves over 300,000 concepts. Each validation process becomes time consuming. Below are validation methods and techniques for use at a semantic level to support the explicit confirmation of a mapping product’s accuracy, data representation and implied quality, portability, and reuse).

Serial quality assurance

Dual process

Assurance model used

Map content validation

Metadata Registry: ISO/IEC 11179

In terminology mapping, the process of creating data mapping between two distinct data models may be automated; however, the semantic translation of healthcare terminologies can be difficult to automate if the terms in a particular data model do not have a direct one-to-one mapping to data elements in the other data model. One method to connect clinical information effectively and efficiently and manage the complexities of healthcare data involving the volume, velocity, variety, veracity, and value of big data sets the use of the ISO/IEC 11179 Metadata Registry standard, an international standard.

In contrast to an ontological, often used in health informatics applications, where each subclass is part of a specification for a representational vocabulary for a particular domain; terminology data element concepts may not derive meaning from a concept’s position in a complex hierarchy. Thus, using metadata repository in practice to facilitate mapping, the repository would store the information about the data element concepts, such that multiple terminologies can be used to represent the concept domain of the data element as well as the data element’s permissible values. In essence, the ISO/IEC 11179 metadata standard used to represent data from different sources or settings provides a method for data element mapping, portability, and reuse. The use of a metadata repository in terminology mapping is extremely valuable for data fields (i.e. element concepts, variables) and value sets (i.e., permissible values) used to encode the actual clinical data within the data fields and becomes practical and efficient when ISO/IEC 11179 is used as the structure for the validation of healthcare terminologies.

#### Example: Cancer Data Standards Registry and Repository

The Cancer Data Standards Registry and Repository (caDSR) developed by the National Cancer Institute (NCI) defines a comprehensive set of standardized cancer research data elements used in clinical research. The NCI and partner organizations developed the caDSR by registering data element concepts in clinical research vocabularies based on the ISO/IEC 11179 Metadata Repository (MDR) standard. The caDSR approach to mapping data elements to terms and concepts from standardized terminologies using a metadata registry allows searching for an exact data element string match for data variables. If no match is found, an approximate search is performed to normalize the original search string (e.g., eliminate underscores, hyphen variations) as well as add a wildcard (\*) to the beginning and end of the string. At NCI, the entire process is automated, and the search stops as soon as a match is found. If the data element has an enumerated list of permissible values for its value set, the procedure finds the corresponding terms and concepts. For the csDSR, using the ISO/IEC 11179 standard to model metadata registration decomposes the essence of a data element into well-formed parts, separating the conceptual entity (data element concept) from its representation (value domain). (See Figure 1).

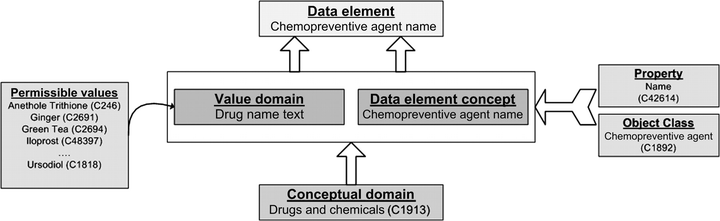
[](https://d2qphtmbcjv60w.cloudfront.net/content/jaminfo/18/4/376/F1.large.jpg?width=800&height=600&carousel=1)

Figure 1

Cancer Data Standards Registry and Repository (caDSR) and ISO/IEC 11179 model for metadata registries. (Pathak, J., et al., 2011)

Comparison methodology

Rules applied

#### Determinant % of map validated

Progressive development impact upon validation assessment - Where a map may have different validation quality in different areas of individual content - e.g % of commonly used concepts well defined, while less common concepts

Relationship to frequency of use - applicability of high frequency content to the use case.

#### Method of validation

Translations between languages double blind map validation shall be used.

### Determinant 12: Decision making

Where source concepts are mapped to target using rules or agreed decisions these need to be included in the documentation in a manner which is consistent and applied throughout the map.

Criteria relevant to decision making include

### Consensus building process DELPHI: This is 1950’s consensus building technique, originally developed to forecast the impact of technology by the RAND Corporation on warfare. The DELPHI method involves convening a group of experts who anonymously render opinions on subject matter and subsequently receive feedback in the form of a statistical representation of the "group response," after which the process repeats itself. The goal is to reduce the range of responses and arrive at ‘expert consensus’. The Delphi Method has been widely adopted and has an objective to obtain the most reliable consensus of opinion of a group of experts. Inter-Rater Reliability (IRR): Inter-rater reliability is a numeric score of the consensus among reviewers (‘raters’). There are a number of statistics used to determine the IRR including Cohen’s kappa and Cronbach's alpha as a measure of internal homogeneity i.e. how closely related a set of items are as a group. For example, items contained (group) in an Equivalence Assessment)

If there is disagreement what and how is it managed

Documentation of rationale behind decisions

Consistent application of the rationale

Access to this documentation

Integrated into tooling

Final decision making – absence of undue pressure or singular influence

Example: Decisions made about mapping of conditions which are not an exact match should be documented, including the rationale for the decision. The intention of this documentation is to support future use of mapped data and to support consistent ongoing map maintenance.

### Tools used to develop or maintain the map

ISO TS21564 emphasizes a recommendation for the standardized representation of healthcare data using metadata resources as a techniques for data element mapping. The International Organization for Standardization/International Electrotechnical Commission (ISO/IEC) 11179 Metadata Registry (MDR) standard provides a framework that enables the semantic interoperability of data originating from various sources with exact definitions of data elements. The utility of the MDR standard has been widely recognized, and an increasing number of healthcare stakeholders have been adopting ISO/IEC11179 for the management of metadata for clinical trials and the aggregation of clinical research data, sharing, reuse, and clinical documentation in Electronic Health Records.

Human and tooling resources used to produce the map

* Known knowns, known unknowns, unknown unknowns - all sets need to be able to be defined and handled.

Established data cleaning before use of tool

Process used to choose the tooling – selection of vendor

How to use ISO 11179 compliant metadata registries to assist with semantic mapping [See Section 4.4.6.1: Validation]

* The ISO/IEC 11179 Metadata Registry (MDR) standard approach to mapping data elements to terms and concepts from different standardized terminologies provides an automated search for an exact string match for data element translations. If no exact match is found, an approximate search can be performed normalizing the original search string (e.g., eliminate underscores, hyphen variations) as well as adding a wildcard (\*) to the beginning and end of the string. An automated MDR-based search stops as soon as a match is found. If the data element has an enumerated list of permissible values as a value set, the MDR identifies the corresponding terms and concepts and decomposes the essence of a data element into well-formed parts, separating the conceptual entity (data element concept) from the data element representation (value domain). (See Figure 1).

### Skills available for the development and maintenance of the map

The development and application of maps requires considerable specialised skill. The following skill requirements should be assessed to determine their importance to any mapping project. The skills are presented based upon the role an individual might be playing in the map development process. ISO/TR 12300:2014 Section 5.4 indicates that skilled mapping personnel are required to ensure the quality and integrity of map development and mapping rules. This section of the Technical Specification specifies how this may be assessed.

Broadly there are 5 role groups involved in map development or application

Map Decision Maker / Sponsor

The person or group of people who are responsible for the decision to map and the identification of the purpose and quality requirements of the map

Map project leader

The person leading the mapping project, this individual may be a manager and is not always a mapping specialist as well as a manager. This person is responsible for establishing map methodology, developing the mapping team (project leader, specialist and governance team) to obtain the highest quality map for the purpose of the project.

Map specialist

These individuals have skills in both the source and target code systems as well as the process of mapping and are responsible for building and maintaining the map

Map implementer

The individual responsible for taking the published or completed map and implementing the map in computer systems to obtain the intended data conversion.

Map governance team member

This includes members of advisory groups, those providing clinical, linguistic or other forms of guidance to resolve conflict where the alternative map results could be different.

When considering the skills needed it is important to understand that a description of the topic of knowledge is insufficient. There are two common methods used to determine the level of skill being defined in a skill or competency statement. The international Skills Framework for the Information Age (SFIA Foundation, 2016) is widely used in IT as an internationally recognised skill level representation. This documents uses the SFIA levels.

Follow

Assist

Apply

Enable

Ensure, advise

Initiate, influence

Set strategy, inspire, mobilise

In this document general skills such as project management, are not included, but there are some personal skills which have been included as these are useful to include in the development team.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Skill/Role | Map Decision Maker / Sponsor | Map Project Leader | Map Specialist | Map Implementer | Map Governance Team Member |
| General Skills |  |  |  |  |  |
| Works independently |  | Apply | Apply | Apply | Assist |
| Works in a team |  | Apply | Apply | Apply | Apply |
| Good communicator |  | Apply | Apply | Assist | Apply |
| Availability and ability to meet timelines |  | Apply | Apply | Apply | Apply |
| Seek and assess advice provided on mapping skills, tools, process and quality | Set strategy | Enable | Ensure | Ensure | Apply |
| Mapping Process Skills |  |  |  |  |  |
| Create individual maps using a standardized, scientifically validated and consistently applied mapping methodology |  | Initiate | Enable | Apply | Assist |
| Appropriately used mapping tools |  | Ensure | Apply | Apply | Assist |
| Practice within a standardized operational framework to develop process reliability |  | Ensure | Ensure | Apply | Apply |
| Provide support to map implementers |  | Apply | Apply |  | Apply |
| Develop simple, complex and rule based map content |  | Enable | Apply |  | Assist |
| Implement simple, complex or rule based map content |  | Enable |  | Apply |  |
| Target/Source Skills | Follow | Follow | Advice | Advice | Assist |
| Obtain accurate coded values to represent a concept in the target code system, applying all relevant rules |  | Assist | Ensure | Assist | Assist |
| Obtain accurate coded values to represent a concept in the source code system, applying all relevant rules. |  | Assist | Ensure | Assist | Assist |

**Education or skill confirmation process**

The quality of a map is dependent upon the capability of those who build and implement the map. A method of confirmation of those skills shall be established in order to support that evaluation.

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## Governance

The combination of information and communication technology (ICT) has the potential to change the work organization and business practices by creating new opportunities for IT implementation. The ISO/IEC 38500:2008 - Corporate governance of information technology process model and framework provides specific practices and implementation advice for IT management, controls, and assurance. Governance is not a one-and-done process, but a system that comprises processes that may be executed whenever needed (Racz, Weippl & Seufert, 2010). The ISO/IEC 38500:2008 standard recommends three process steps – evaluate, direct, and monitor – to be applied across six principles: responsibility, strategy, acquisition, performance, conformance, and human behavior**”**. The framework putting corporate governance in context with business processes is drawn out in figure **1** (Racz, Weippl & Seufert, 2010).  
The implementation of IT governance during the MapQual process should facilitate alignment between IT and business strategy. This governance can be facilitated through existing controls frameworks, such as the IT Infrastructure Library (ITIL). The ISO/IEC TR 20000-11:2015 *Information technology — Service management — Part 11: Guidance on the relationship between ISO/IEC 20000-1:2011 and service management frameworks: ITIL®*IT Infrastructure Library is a framework focusing on best practices for delivering IT services and can be used to manage and evaluate the IT function and processes within an organization. The ITIL framework can provide standards, benchmarks, and metrics that can be used by an IT audit function. MapQual governance is essential to ensure strong coordination among process initiatives and eliminate misalignment between organizational strategy and process endeavors (Korhonen, 2007). The MapQual focus on governance is to harmonize process, process designs and strategies to achieve alignment among all three (Jeston & Nelis, 2008).

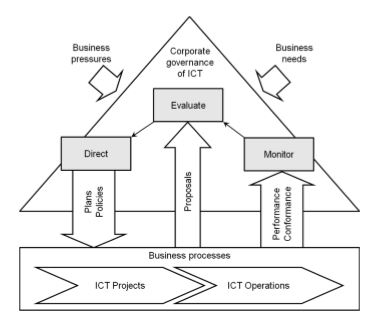


Figure 2: ISO/IEC 38500:2008 model for IT governance (Racz, Weippl & Seufert, 2010).

#### Team

The ITIL framework offers guidance for senior directors, managers, and practitioners on a self-assessment of the risks and controls related to information technology services whether the services are provided in-house or obtained from third parties. The ITIL framework describes in detail those parts of enterprise IT that are service enablers (process activities, organizational structures, etc.). A process map is a visual representation of process steps and can be a valuable tool for project team from which to adapt a high-level framework view during the define process to focus on particular details or sections during operation process or improve processes views.

Sample Roles

#### Change Manager

* Responsible for the lifecycle of all mapping changes.

#### Configuration Manager

* Responsible for maintaining information about Configuration Items and MapQual required delivering IT services.
* Maintains a logical model containing the components of the IT infrastructure and their associations.

#### Knowledge Manager

* Ensures the IT organization is able to gather, analyze, store and share knowledge and information.
* Primary objective is to improve efficiency by reducing the need to rediscover knowledge.

#### Project Manager

* Responsible for planning and coordinating the resources to deploy a major Release within the predicted cost, time and quality estimates.

#### Release Manager

* Responsible for planning and controlling the movement of Releases to test and live environments.
* Primary objective to ensure that the integrity of the live environment is protected and correct components are released.

#### Test Manager

* Ensures deployed Releases and the resulting services meet customer expectations, and verifies that IT operations is able to support the new service.

#### Process

The data quality of terminology mappings are a persistent concern in practice with MapQual: accuracy, completeness, consistency, and timeliness important processes for systems and data warehouses, which are often used as the primary data source for the analyses of terminology maps. (Figure 2) (Racz, Weippl & Seufert, 2010).The role of the ITIL framework is in defining a best practice process framework for IT service management and support. The ITIL processes to coordinate improve mapping quality and satisfaction by implementing a standard system of processes to control IT services. There are five ‘processes’ in the ITIL Service Management Lifecycle:

## 1. Strategy Process Objective: Assessment of capabilities and strategy to serve customers; responsible for strategy implementation when defined.

2. Design:  
Process Objective: Identification of new service requirements and improvements to existing ones.z

3. Transition:

Process Objective: Implementation of management processes in a coordinated manner.

4. Operation:  
Process Objective: Ensure effective and efficient delivery of services, resolving of service failures, fixing problems, as well as carrying out routine operational tasks.

5. Continual Improvement:  
Process Objective: Lessons Learned and continual improvement of the effectiveness and efficiency of IT processes and services, in line with the concept of continual improvement adopted in ISO 20000.

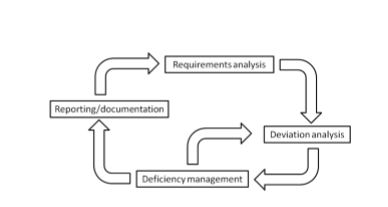


Figure 3: IT compliance process (Racz, Weippl & Seufert, 2010)

## Maintenance

New version for each new version of source / target

Frequency –

Identify frequency clearly

If map decoupled from the release cycle of the scheme – this may be forgivable if the version management is explicity.

The use case then evaluates how important that is to this use.

How maintenance versions etc are communicated to users

Publication – what is included

Source / target

Inclusion of equivalence

Rationale publication

## Implementation

### Version management

### Communication to users

### Documentation available

# Using Map Quality Determinants

## Required determinants

Consider which determinants are essential for the specific use case. For example these may be rules or conventions associated with the use of the source or target scheme, attributes which imply specific meaning or documented principles which have been applied to maps in certain circumstances. Determinants should be unambiguous. Some determinants such as tooling may not be relevant, if automated tools are not being used, others may not be important as the map is to convert data once such as maps used when changing from one version of a code system to another.

## Level of quality

This Technical Specification has a simple framework of measures used to evaluate and determine the quality of the map for each quality determinate. This standard method is used as it is reliable, viable, efficient, encourages best practice, and highlights key areas impacting the quality and utility of a map for a given purpose.

Each determinant must be rated -zero is the highest quality and 4 is the worst.

Each quality determinant should be allocated a required value based upon the use case to which the map is to be applied (Quality required). The map is then reviewed and each determinant is scored (Quality Actual). A comparison of requirement vs actual can then be made.

It is important to note that the required and actual scores will differ according to the use case to which the map is to be applied. A map which is considered low quality for one purpose may meet requirements for another purpose. Few maps can be considered of high quality for all purposes.

### Step 1:

For each required determinant establish the required level of quality based upon the specific use case.

* 0 = perfect, complete, totally meets specified criteria (all criteria are met whether essential or not)
* 1 = meets all essential criteria (specify any criteria which are not essential). It is necessary to consider the use case to establish which criteria for each determinant are essential.
* 2 = meets most essential criteria, but not all
* 3 = meets few essential criteria
* 4 = does not meet essential criteria

### Step 2:

Assess the map against each determinant to gain the actual scores

### Step 3

When complete add up the score for each key area and assess whether the map will suit the intended purpose or not and what action may be required.

|  |  |  |  |
| --- | --- | --- | --- |
| Area | Determinant | Required | Actual |
| Terminology Resource Capacity | 1 | 0 | 0 |
|  | 2 | 1 | 2 |
|  | 3 | 1 | 1 |
| Equivalence (priority) | 5 | 0 | 1 |
|  | 6 | 1 | 2 |
| Etc |  |  |  |
| Total |  | 23 | 31 |

Use Cases

## General

This clause provides a template for quality requirement determination and defines the scope measures which shall be achieved to be considered compliant with this Technical Specification.

## Determining requirements for a purpose

### General

This subclause defines the process to be undertaken when measuring the quality of a map required for a specific purpose and how this can then be used to assess a given map product or process. These processes and measures are used to:

* Evaluate level of conformance to quality map standards,
* Establish vendor conformance requirements,
* Establish ongoing improvement pathways, and
* Provide quality and safety benchmarks to industry.

## Direct patient care use case

MM is a 64-year-old construction company superintendent and wrestling coach, complained of pain in his right knee that limited function and caused sleep problems. His medical history included left total knee replacement. **Diagnosis:** MM was diagnosed with severe right knee osteoarthritis. Non-operative modalities such as activity modification, ambulatory aids, injections, ibuprofen and Tylenol had failed to ease his discomfort. He was scheduled for right total knee arthroplasty. **Treatment:** Following total knee replacement, the patient was transported to the Joint Replacement Center within an hour. He progressed well with the rapid recovery physical therapy program, and had excellent range of motion and walking ability by the second postoperative day. The multimodal pain protocol kept his pain scores very low, and his narcotic pain medicine use was minimal. **Outcome**: After two nights in the hospital, the patient was discharged home with outpatient physical therapy, and continued to progress with his recovery over the subsequent months. He said. "My whole way of life has changed. I can go hunting again, I can go fishing again. I can play with my grandson. Before, I could barely walk."

### General

This subclause defines the range of quality measure results appropriate for the use of maps in safe and efficient clinical care. Today, there are numerous and diverse quality improvement initiatives underway at all levels of the health care system – federal, state, regional, local, and within health care organizations – that are putting quality measures to use. Quality improvement initiatives within and across health care organizations are core to these efforts. The initiatives require clinical terminologies in all clinical areas to identify opportunities for improvement, enable providers to assess and track how their patients are doing in terms of key aspects of care and potential complications in order to identify areas for improvement.

This use case is for the translation from electronic medical record lexicon to the Clinical Care Classification System, nursing terminology standard. The translation coverage is 100% to the target source for nursing care plans. The benefits expected are coded patient plans of care for clinical research and the exchange of patient-centric nursing care diagnosis and intervention/actions.

Note: inclusion of the importance of domain scope relevant to the map use case

### Direct patient care level of conformance required and rationale

The required level of conformance is for each lexicon concept to have an equivalence identified in the target concept. If an equivalence is not published with the map set then it is not possible to assess the quality of the map for a specific purpose nor to alert the user of the map where the meaning of a concept may have changed when converted to the target standard concept representation.

**Equivalence measure**

* 0 = equivalent meaning, 0 is the ‘best equivalence’
* 1 = source concept is wholly included in target
* 2 = source concept is partially included in target
* 3 = source is mapped however there were many options. Source map is the best comparison rather than an actual correspondence.
* 4 = no map possible

For Example:

* 0 = Pain and Pain
* 1 = Sleep problem and Sleep Pattern Disturbance
* 2 = Limited function and Physical Mobility Impairment
* 3 = Non-operative modalities with source options: Knowledge Deficit, Knowledge Deficit of Disease Process, Knowledge Deficit of Medication Regimen, Knowledge Deficit of Therapeutic Regimen.
* 4 = No map possible

## Indirect patient care use case

This use case is for a map from a terminology to a classification with a specific statistical and epidemiological use case.

Administrative, financial or service planning use case

**Equivalence measure**

* 0 = equivalent meaning, 0 is the ‘best equivalence’
* 1 = source concept is wholly included in target
* 2 = source concept is partially included in target
* 3 = source is mapped however there were many options. Source map is the best comparison rather than an actual correspondence.
* 4 = no map possible

For Example:

* 0 = Terminology concept| Streptococcal tonsillitis maps to ICD-10 Classifiction J03.0 Streptococcal tonsillitis
* 1 = Concept | Gastric varices maps to ICD-10 I86.4 Gastric varices
* 2 = Terminology concept| Edema of finger maps to ICD-10 Classification R60.0 Localised oedema
* 3 = source is mapped however there were many options. Source map is the best comparison rather than an actual correspondence

4 = Terminology concept| ECG normal maps to ‘No map possible’

RR is an 84-year old man whom lives in the community with his wife and daughter. He has issues of stability and falls frequently. He refuses to go to a nursing home. He refuses home health physical therapy and refuses to go to a senior community center with his wife for daytime activities. The last time he went to the community center, he cursed at people and was told he is not welcome anymore if he continued to exhibit inappropriate behavior. His family no longer goes out anymore to stay at home to take care of him.

**Equivalence measure**

* 0 = equivalent meaning, 0 is the ‘best equivalence’
* 1 = source concept is wholly included in target
* 2 = source concept is partially included in target
* 3 = source is mapped however there were many options. Source map is the best comparison rather than an actual correspondence.
* 4 = no map possible

For Example:

* 0 = equivalent meaning, 0 is the ‘best equivalence’
* 1 = Fall and Fall Risk
* 2 = Inappropriate social behavior and Social Interaction Alteration
* 3 = Family Caregivers and Caregiver Role Stain, Community Special Services, Adult Day Care, Home Health Aide Service
* 4 = no map possible

### General

Where the source may well be direct patient care but the target is not used in that environment

### Administrative, financial or service planning level of conformance required and rationale

In this environment the interface terminologies vs the classification for financial purposes will be considered. There may be rules applied to classification and maps used for financial purposes which are not applicable in the general or service planning use case. Example which can be used: ICD-10 to DRG

## Research use case

### General

### Research level of conformance required and rationale

## Public health use case

### General

Public health includes epidemiology but also the use of quality indicators or performance indicators which may be dependent upon or apply maps.

### Public health level of conformance required and rationale

### 

# Bibliography

[1] ISO #####‑##:20##, *General title — Part ##: Title of part*

[2] McColloch, E., Shiri, A., & Nicholson, D. (2005). Challenges and issues in terminology mapping: A digital library perspective. *The Electronic Library,* 23.6: 671-677.

SFIA Foundation. (2016, July 27). *SFIA responsibilities and skills*. Retrieved from https://www.sfia-online.org/en/how-sfia-works/responsibilities-and-skills

Data Mapping. Available at <https://en.wikipedia.org/wiki/Data_mapping>

# [4] ISO/IEC 11179-5:2015 Information technology -- Metadata registries (MDR) - Part 5: Naming principles. Available at http://standards.iso.org/ittf/PubliclyAvailableStandards/index.html

[5] World Wide Web Consortium (W3C). Available at http://www.w3.org/standards/semanticweb/)

[6] ISO/IEC 38500: 2008, Corporate governance of information technology. Avaiable at https://www.iso.org/obp/ui/#iso:std:iso-iec:38500:ed-1:v1:en

[7] Racz, N., Weippl, E. & Seufert, A. (2010). A process model for integrated IT governance, risk, and compliance management. Available at <http://www.grc-resource.com/resources/racz_al_grc_process_model_balticdbis2010.pdf>

[8] ISO/IEC TR 20000-11:2015 Information technology — Service management — Part 11: Guidance on the relationship between ISO/IEC 20000-1:2011 and service management frameworks: ITIL® Available at https://www.iso.org/obp/ui/#iso:std:iso-iec:tr:20000:-11:ed-1:v1:en

[9 Korhonen, J. (2007). On the lookout for organizational effectiveness–requisite control structure in BPM governance. Available at

http://www.jannekorhonen.fi/rcs.pdf

[10] Jeston, J. & Nelis, J. (2008). *Management by process*. Routledge.

### [11] Jeston, J. & Nelis, J. (2006) Business Process Management: Practical guidelines to successful implementations Available at https://www.sgb.gov.tr/Kontrol%20Standartlar/Dok%C3%BCmanlar/Yararlan%C4%B1lan%20Yabanc%C4%B1%20Yay%C4%B1nlar/Business%20Process%20Management%20Practical%20Guidelines%200750669217.pdf

# [12 ISO/IEC 20000-1:2011 Information technology -- Service management -- Part 1: Service management system requirements. Available at <http://www.iso.org/iso/catalogue_detail?csnumber=51986>

[13] Merhout, J. W. & Havelka, D. (2008). "Information Technology Auditing: A Value-Added IT Governance Partnership between IT Management and Audit," *Communications of the Association for Information Systems*: Vol. 23, Article 26. Available at http://aisel.aisnet.org/cgi/viewcontent.cgi?article=3386&context=cais&sei-redir=1&referer=https%3A%2F%2Fscholar.google.com%2Fscholar%3Fq%3DITIL%2Bgovernance%2Bstrategy%2Bfor%2Binformation%2Bmapping%26btnG%3D%26hl%3Den%26as\_sdt%3D1%252C47#search=%22ITIL%20governance%20strategy%20information%20mapping%22

14] Radovanovic, D., Radojevic, T., Dubravka, L. & Sarac, M. (2010). Analysis of methodology for IT governance and information systems audit. Proceedings of the 6th International Scientific Conference - Business and Management, May 13-14, Vilnius, Lithuania. <https://www.researchgate.net/profile/Dalibor_Radovanovic/publication/215548410_Analysis_of_Methodology_for_It_Governance_and_Information_Systems_Audit/links/0912f50b76153ab077000000.pdf>

# 15] Simonsson, M. & Johnson, P. (2006). Defining IT Governance – A consolidation of the literature. Proceedings of the 18th International Conference on Advanced Information Systems Engineering. June 5-9, Luxembourg, Luxembourg. Available at <http://www.ics.kth.se/Publikationer/Working%20Papers/EARP-WP-2005-MS-04.pdf>

16 Blake, R. & Mangiameli, P. (2011). The effects and interaction of data quality and problem complexity on classification. Journal of Data and Information Quality, Vol 2. No 2. Article 8 (February). Available at <https://www.researchgate.net/profile/Roger_Blake/publication/220918870_The_Effects_and_Interactions_of_Data_Quality_and_Problem_Complexity_on_Data_Mining/links/5465ee8d0cf2052b50a13ac0.pdf>

# [17] Palm, R. & Flexa, R. (2011). Process Governance: Definitions and Framework, Part 1. Available at http://www.bptrends.com/publicationfiles/11-01-2011-ART-Process%20Governance-Def%20&%20Framework-Paim-Flexa%20reviewed%20v1.pdf

# [18] ITIL Process. Available at http://wiki.en.it-processmaps.com/index.php/ITIL\_Processes

* [19] Pathak,J., Wang, J., Kashyap, S., Basford, M., Li, R., Masys, D., & Chute, C. (2011). [Mapping clinical phenotype data elements to standardized metadata repositories and controlled terminologies: the eMERGE Network experience](https://jamia.oxfordjournals.org/content/18/4/376). J Am Med   
   Inform Assoc, 18 (4): 376-386

[20] Dalkey, N. & Helmer, O. (1963). An Experimental Application of the Delphi Method to the Use of Experts. *Management Science* , Vol. 9, No. 3, pp. 458-467. Available at: http://www.jstor.org/stable/2627117 Accessed: 22-08-2016 20:45 UTC

[21] Vossen, P.H. & Maguire, M. (1998). Guide to Mapping Requirements to User Interface Specifications: D4.2 Version 1.1. Available at <https://www.researchgate.net/profile/Paul_Vossen/publication/243533328_Guide_to_mapping_requirements_to_user_interface_specifications/links/00b495327424948da1000000.pdf>

[22] Jeong, S., Kim, H.H., Park, Y. R, & Kim, J. H. (2014). Clinical Data Element Ontology for Unified Indexing and Retrieval of Data Elements across Multiple Metadata Registries.[Healthc Inform Res](http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4231180/). 2014 Oct; 20(4): 295–303.

[23] DELPHI method. Rand Corporation Available at http://www.rand.org/topics/delphi-method.html