UNIVERSITÀ DEGLI STUDI DI UDINE

Dipartimento di Scienze Matematiche, Informatiche e Fisiche

22/03/2019

Vincenzo Della Mea, *vincenzo.dellamea@uniud.it*

Mihai Horia Popescu, *mihaihoria.popescu@gmail.com*

# ICD-11 EVALUATION PROJECT FOR IRIS

## INTRODUCTION

In the 2019 ICD-11 will be presented to the WHO, with its approval, it will become the new standard for coding diseases and health problems. In mortality, ICD coding is performed with the use of automated coding systems, mainly Iris. The core component of Iris is the Decision Tables, which are based on ICD10 codes. Hence, the need for an evaluation project that will evaluate the transition of Iris to ICD11.

### Decision tables

The decision tables (DT) are a tool used for the selection of the underlying cause of death (UC), according to the rules of the International Classification of Diseases and Related Problems (ICD) of the World Health Organization (WHO). The decision tables are central to the function of Iris, which is an automatic system for coding multiple causes of death and for the selection of the underlying cause of death maintained by Iris Institute. The Iris Institute emerged from the international cooperation for the deployment, maintenance and development of the Iris software since 2011. The software and DT have been maintained by the Iris Institute for the inclusion of the annual WHO official updates of the ICD and based on the recommendations of groups of international experts, namely the Mortality Reference Group. The increasing international interest in the Iris software has made it necessary to provide an institutional foundation to secure the supply and support of the Iris software. Consequently, the cooperating partners from France, Italy, Hungary and Sweden approached the DIMDI with the request to establish the Iris Institute.

The knowledge database was first developed by the NCHS (US National Center for Health Statistics) for the ACME system (ACME tables) as relations between pairs of codes (representing the causes of death reported on the death certificate) that must be taken into consideration during the application of the steps for the selection of the underlying cause.

The decision tables represent the knowledge base for the coding, both manual and automated, which allows decisions for every step of the coding algorithm of Iris. They are a formalization of the instructions included in volume 2 of the ICD10. This formalization in practice consists of the translation of the provisions of the Classification into relationships between pairs of ICD codes. The different kinds of possible relations useful during selection are referred to as "rules-types". For each given rule-type, the tables list all possible relations between pairs ( "Rules").

## Mapping table

In June 2018, WHO released a version of ICD11 for starting programs for implementation. Along with the release of ICD11, the WHO releases the mapping table that can be used for the mapping between codes of ICD10 and ICD11. The mapping tables available are from both MMS and Foundation. Here, only MMS mappings are considered, although Foundation mappings could provide extra information.

The mapping table is a list of possible kind of relations between pairs of codes, where the relation defines the set relation between the entity of ICD-10 and the entity of ICD-11. From a logical point of view in the mapping table, the ICD codes are sets, where the relation between sets can be: equivalent, subclass, superclass and intersects.

| ICD10 Code | ICD11 Code | Relations |
|---|---|---|
| A01 | 1A07 | superclass |
| A01 | 1A08 | superclass |
| A01 | 1A0Z | subclass |
| A01.0 | 1A07 | equivalent |
| A01.1 | 1A08 | subclass |
| A01.2 | 1A08 | subclass |
| A01.3 | 1A08 | subclass |
| A01.4 | 1A08 | subclass |

Table 1: Example of some pairs with the relation taken from the mapping table of MMS.

The interpretation of a pair is the following:

> The ICD10 **A01** code is **superclass** of ICD11 **1A07** code.

The relation of superclass involves that the categories were split into multiple categories. The relation of subclass unifies different categories of ICD10 in a unique ICD11. With the equivalent relation, we have the same category of ICD11 as for ICD10. The intersects involve that the classification changed the structure and that categories intersect each other.

### Objectives

In summary, the aims of this evaluation project are:

- To evaluate the necessary post-coordinated codes to be used in Iris in order to arrive at the correct underlying and multiple cause outputs, the IT solution for integrating such codes in Iris processing and the impact of the flexibility of the post-coordination feature on Iris processing.
- Evaluate the possibilities of ICD-11 tool integration into Iris.
- In an iterating process, evaluation of the possible transition of the rules that can be done automatically, based on the ICD-10 to ICD-11 mappings, test the success of the automatic transition and evaluate the amount of refinement needed.
- Additionally, the maintenance of the decision tables should be visited to ensure that the maintenance process implemented for ICD-10 is sufficient for ICD-11.

## PRELIMINARY ANALYSIS

A preliminary analysis was made with the purpose of better compression of the decision tables and efficient planning. From the decision tables was emerged that one of the most used rules in the selection of the underlying cause is the "due to" that cover approximately 93% of the total rules. For the sake of clarity and relevance, the "due to" rule-type was decided to be used for the initial study of the transition.

The relation of "due to" can shortly be described as:

*Code A is "due to" relationship with respect to code B if B is an acceptable cause of A (according to ICD provisions), where A is the anchor code (also called codeDef) that is due to another code B (subcodeDef).*

A practical example:

| **codeDef** (XXX.X) | **Rule-type** | **subcodeDef** (YYY.Y) |
|---|---|---|
| **I46.9** (Cardiac arrest, unspecified) | "**due to**" | **R26.3** (Immobility) |


*Figure 1:Representation of "due to" rules. The green color is used to specify ICD10 codes.*

For the sake of translating, some rules can be ignored. The “due to” rule-type have some rules that can be generated on the new tables of ICD11 without the need of translating. The way the algorithm of Iris works, the decision tables need to contain all the “due to” rules with the same code as codeDef and subcodeDef. Those rules can be ignored for the translation and be generated directly on the new ICD11 tables.

Formally if *x* is an ICD10 code, then exists a “*due to*” rule where *x* is “*due to*” *x*.

Thus, if we consider the fig1, the XXX.X and YYY.Y are the same category.

This study aims at identifying the rules that can be automatically translated and which need manual support.

## Possible method

Given a rule, the basic idea is to verify whether a mapping exists between single codes for both codeDef and subcodeDef and of witch kind. A rule can be translated automatically if both sides can be translated automatically. In some cases, we could need to differ the translation of codes between codeDef and subcodeDef, since the consequences of the rule-type could be different.

Without considering the consequences of the rule-type, it is trivial to understand that the rules that can be translated automatically are the categories that has no changes between ICD10 and ICD11. This kind of map has the relation of equivalence.

With the assistance of some figures, let’s examine how the different kind of relation between the mappings can influence the translation of the rules.

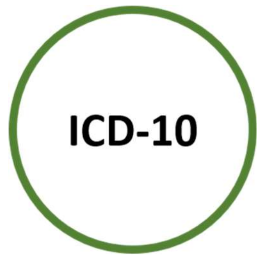


*Figure 2: Current decision tables, based on ICD10 category. Representation using green color.*


*Figure 3: Future decision tables, based on ICD11 category. Representation using orange color.*

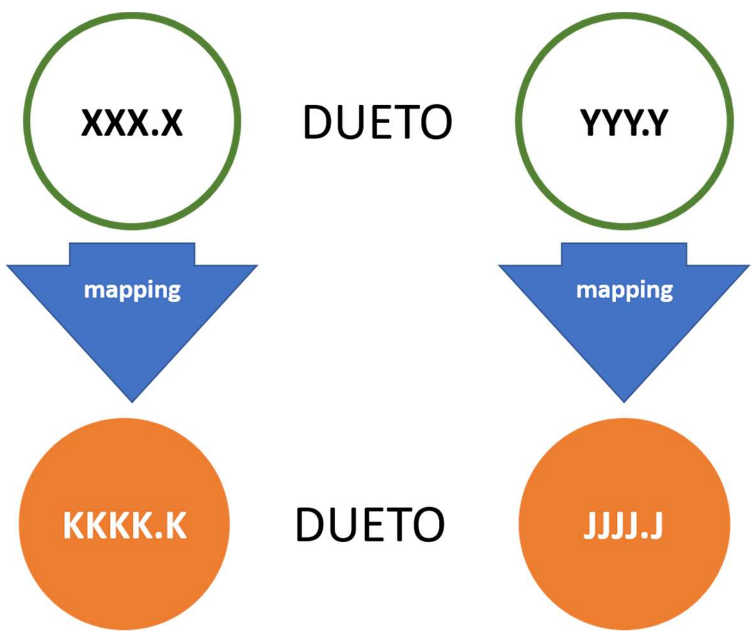


*Figure 4: General representation of the translation of a rule.*

Our goal is to translate the single rules from ICD10 to ICD11. In fig4 we tried to represent a general translation, where on the top we can see the ICD10 rule, and at the bottom the translated ICD11 rule. To archive our goal, we are using the mapping table where XXX.X is mapped as KKK.K, and YYY.Y is mapped as JJJ.J. Following we will show the different kind of mapping for both codeDef and subcodeDef, which new rules are still valid, and which need support.

The relation between ICD10 category and ICD11 category can be of 4 types:

- Equivalent, where the category has no changes between ICD10 and ICD11, refigured in the first image of fig5. The green and the orange circle are equal.
- Subclass, where multiple categories of ICD10 are grouped to form a bigger category of ICD11. In this case the classification of ICD11 is less specific compared to the classification of ICD10 regard the mapped category. In fig5 we can see 3 green circle (3 ICD10 categories) that are grouper to form an orange circle (single ICD11 category).
- Superclass, where a single category of ICD10 was split to form multiple categories of ICD11. In this case the classification of ICD11 is more specific compared to the classification of ICD10 regard the mapped category. In the third image of fig5 we can see it refigured with 3 orange circle that form the green circle.
- Intersects, the structure of some categories of ICD10 intersects with some categories of ICD11, in this case the structure of the classification changes.

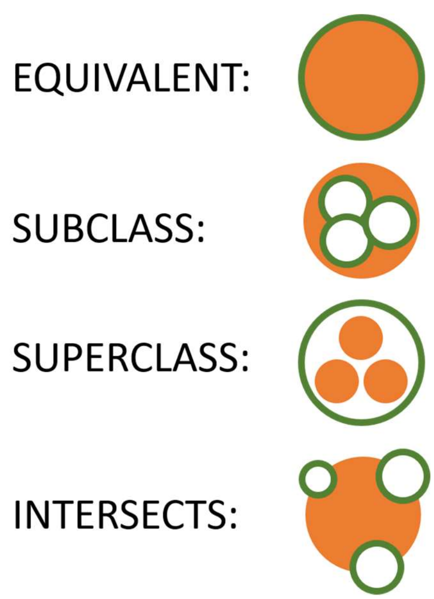


*Figure 5: Relation between ICD10 and ICD11 mapping*

Some examples related to fig5:

- Equivalent: B81.0 (Anisakiasis) ≡ 1F61 (Anisakiasis)
- Subclass:
    - A21.1 (Oculoglandular tularaemia)
    - A21.2 (Pulmonary tularaemia)
    - A21.3 (Gastrointestinal tularaemia)

      ⊑
    - 1B94 (Tularaemia)
- Superclass:
    - A18.8 (Tuberculosis of other specified organs)

      ⊒
    - 1B12.3 (Tuberculosis of endocrine glands)
    - 1B12.7 (Tuberculosis of the digestive system)
    - 1B12 (Tuberculosis of other systems and organs)

Before going deep in the analysis and show how we applied the mapping relation on the fig 4, we need to make some logical reasoning of the meaning of the "due to" consequences. A proper interpretation of the "due to" rule is needed to archive the correct results for the translation.

The rules were created for statistical purpose and only part of the rules are clinically proved and derived from the WHO classification. The interpretation of XXX.X "due to" YYY.Y is: there is a possibility that XXX.X can be due to YYY.Y (YYY.Y is an acceptable cause of XXX.X). With this interpretation is important to consider the "possibility", in fact if we consider fig7 where YYY.Y is mapped to a broader category JJJ.J and XXX.X is equivalent to KKK.K, we can affirm that also KKK.K "due to" JJJ.J since there is at least a case where this stands and we know that YYY.Y is contained in JJJ.J where YYY.Y is an acceptable cause of KKK.K.

A practical example could be:

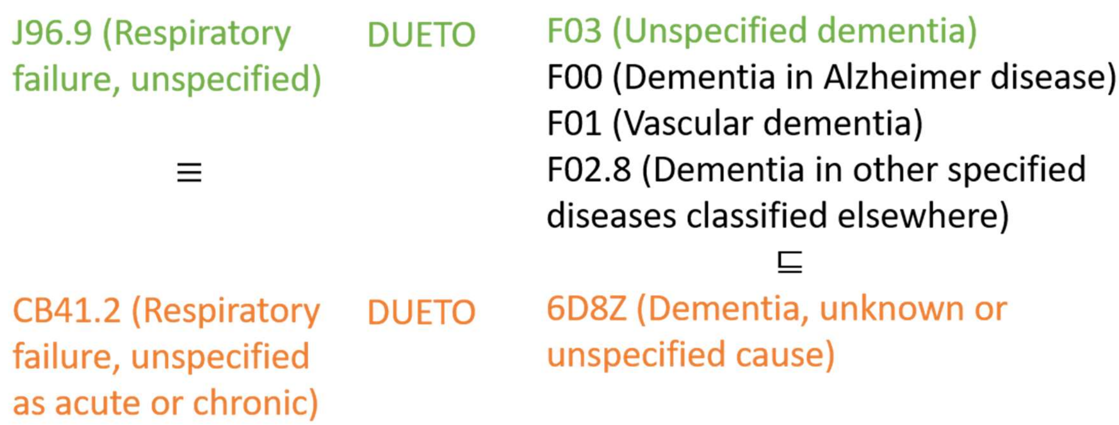


*Figure 6: Example of case presented in fig7.*

In this example we can notice that there is no rule J96.9 "due to" F00, F01 or F02.8, but F03, F00, F01 and F02.8 are grouped to form 6D8Z. From a logical point of view the new rule CB41.2 "due to" 6D8Z is acceptable since there is at least a case where 6D8Z is an acceptable cause of CB41.2, that comes from F03.

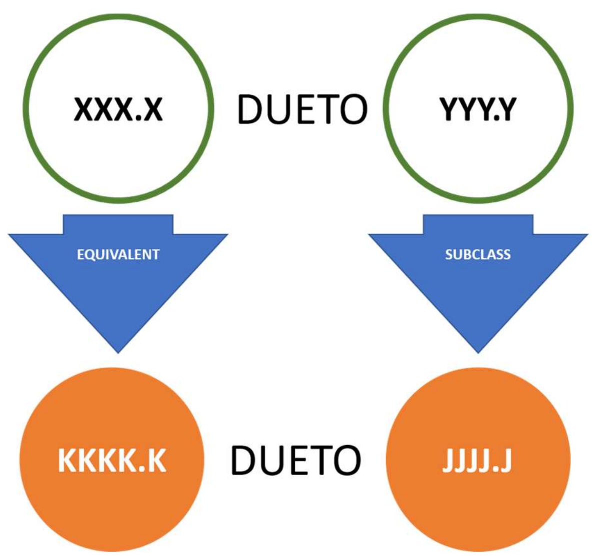


*Figure 7: Broader mapping for the subcodeDef.*

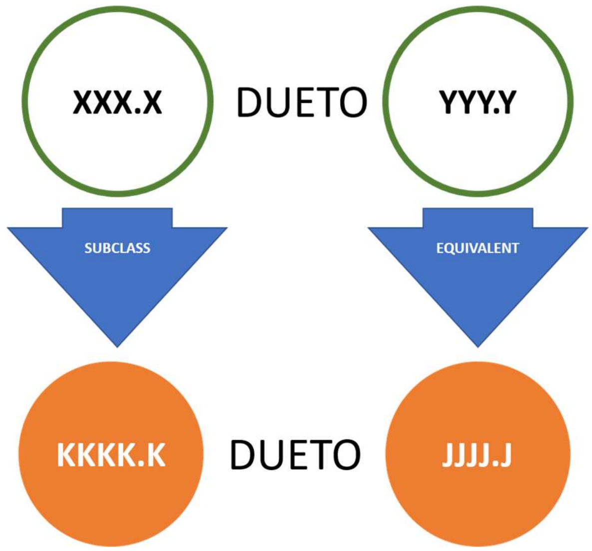


*Figure 8: Broader mapping for the codeDef.*

With the same interpretation if we consider a broader category for the codeDef as fig8 the new rule KKK.K due to JJJ.J is acceptable since there is at least a case where JJJ.J is an acceptable cause of KKK.K, which is the XXX.X.

With the description before we shown the cases of mapping with the relation of subclass for both codeDef and subcodeDef, where do not create any problem and we can generally accept the new rules. Now we will evaluate the cases of superclass which are the opposite of the subclass.

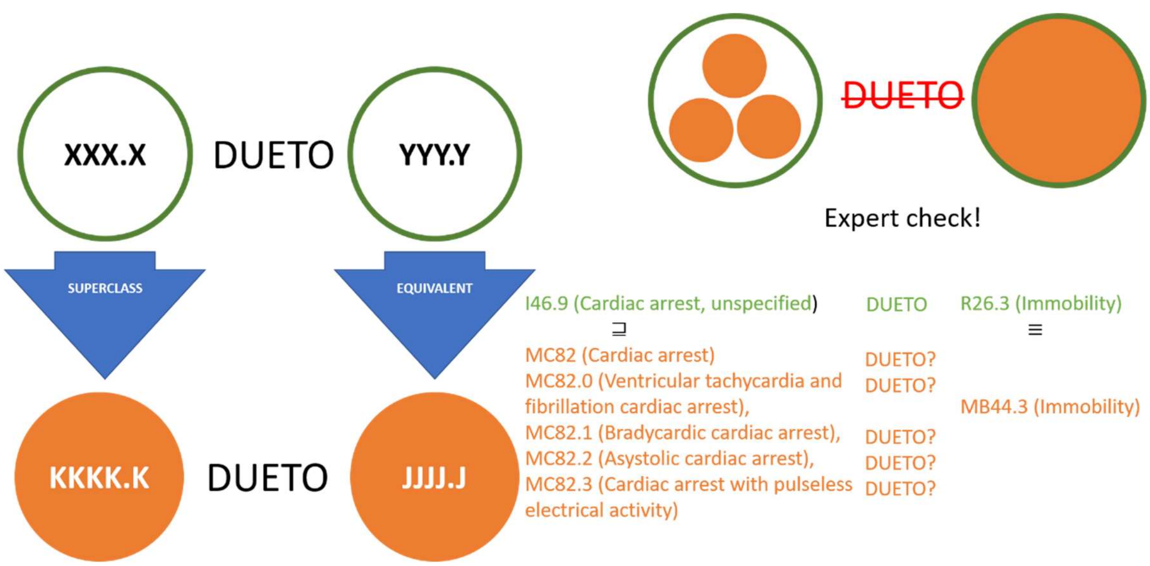


*Figure 9: Illustrate case with codeDef mapped as superclass, and an example associated.*

In this case we have XXX.X that is mapped to KKK.K as superclass, then we know that XXX.X was split to multiple category KKK.1,..,KKK.N. Since this split, we cannot affirm that JJJ.J is an acceptable cause of KKK.K with k category of range 1-N. We know for sure that JJJ.J is an acceptable cause of at least one category of the range KKK.1 – KKK.N, but we cannot affirm which. For this reason, KKK.K "due to" JJJ.J need expert check. The expert should decide which codes of the range can be accepted.

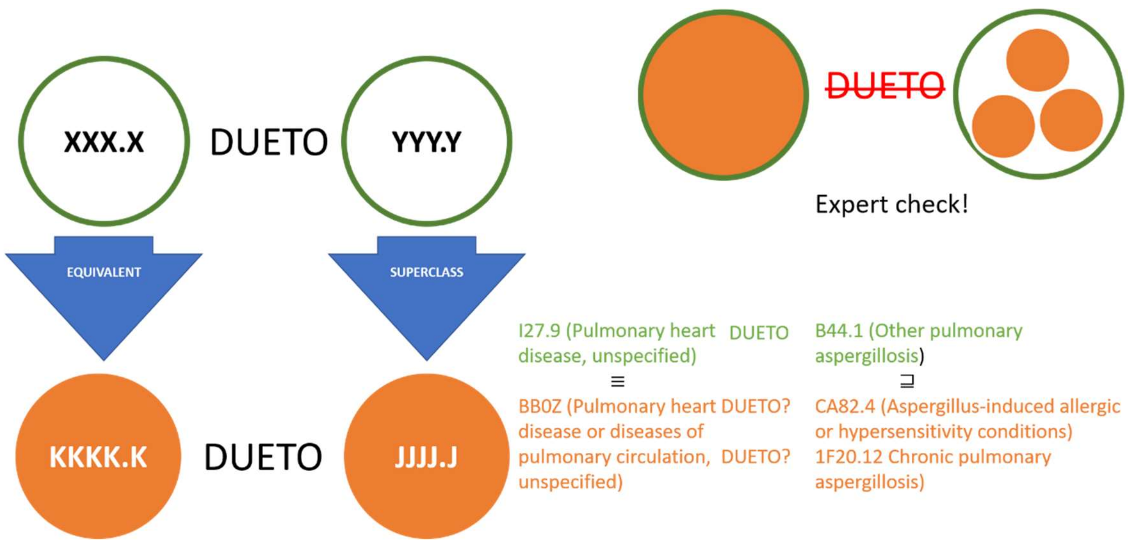


*Figure 10: Superclass of subcodeDef, with example.*

The same problem also occurs for the subcodeDef. If we consider fig10, we know that YYY.Y was split to multiple categories JJJ.1,..,JJJ.N with J in range 1/N, so we cannot accept the rule KKK.K "due to" JJJ.J since we cannot know which are the category of the range that can be acceptable cause of KKK.K, we just know that there is at least one of them, but which? For this reason, the experts need to validate the new rules.

The last case is the intersects, where need manual support since the Classification axis changed (fig11).

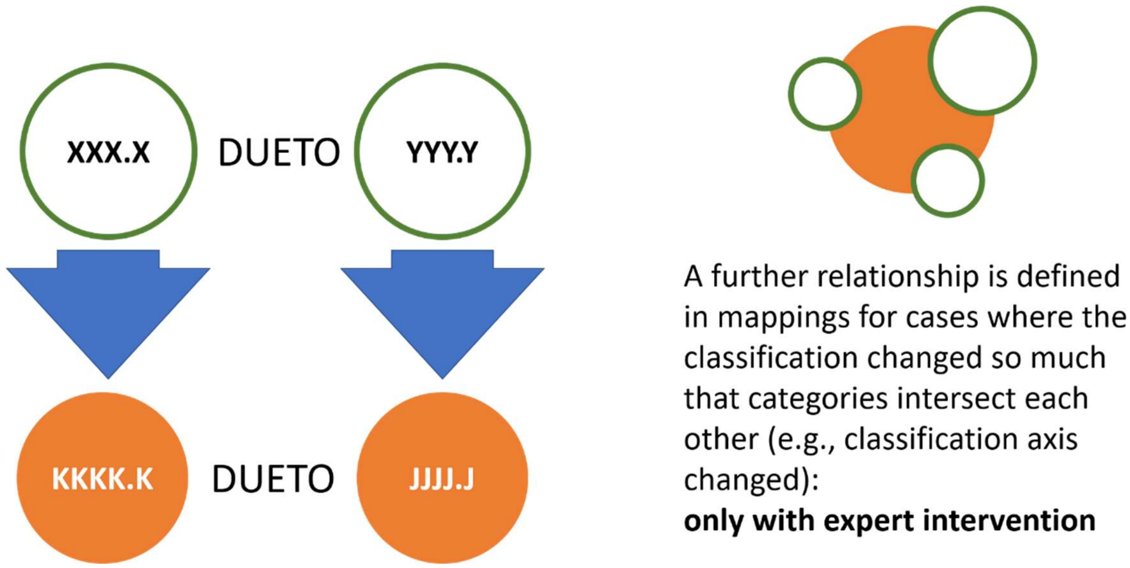


*Figure 11: Intersects for codeDef or subcodeDef.*

## IMPLEMENTATION

In the previous section we analyzed the possible implication of the mapping relation for the translation of the "due to" rule-type. The solution we described can be used for the translation of single rules, but in this chapter, we will see that it is possible to improve the results considering multiple rules in the decision making. The decision tables are organized as pairs of codes in a specific relationship, but for specific use the codeDef can be associated with the same relation to a list of subcodeDef where adjacent categories can be grouped to obtain range of categories.

Example:

A01.3 "due to" B20.0
A01.3 "due to" B20.1 to A01.3 "due to" B200-B24
…
A01.3 "due to" B24

In the WHO Classification the codes are organized within a hierarchy, where the root of the Classification is the Classification itself. On the first level then we have the Chapters, blocks and categories. Some of the categories are called terminal, those categories are the most specific categories of the classification. The decision tables are based on this kind of categories. Since the mapping table contain mapping for all levels of the hierarchy (where possible, where the structure change, there is no mapping) we could improve and add detail for the translation of the rules using higher categories, blocks or even chapters where the subcodeDef are grouped to form big blocks.

Grouping the subcodeDef under the same codeDef is important also to facilitate the translation of the rules, in fact the codeDef need to be translated once and not for each pair. In the same way once we translate and validate a range on the subcodeDef side we can reuse the results for the translation of other rules with the same range of categories. Using the hierarchy as translation is very important also for the maintenance of the Decision Tables which is one of the objectives of this project.

## Algorithm for codeDef

On codeDef, we generally evaluate single category independently, in fact there is only one case where we need to evaluate other categories associated to refine the result. Taken a category we will translate it using the mapping table and annotate it when needed.

For the relation of equivalence, we have the associated translated ICD11 category and no annotation.

For the relation of superclass as we saw in the previous chapter is not accepted and we add an annotation to set this rule as manual. From some analysis we think that this could be only partial manual, in fact if the category is split to multiple categories under the same parent category probably, we can just add a new rule for each category and set the same subcodeDef for each of them, and only if the new categories goes in different blocks or chapters we will need a manual check, but we want to have some feedback from the experts before accept this theory.

If we found a relation of subclass logically it stands and we can accept the new rule with the union of all the subcodeDef of the unified categories, but we still want to associate an annotation as a warning where the unified categories have different subcodeDef categories. There is at least one category that is an acceptable cause of one of the unified categories but not for all of them.

With the relation of intersects we add an annotation as manual for the new rule.

## Algorithm for subcodeDef

The implemented algorithm can be divided in different subroutine. All the subroutines are called repeatedly at each level of the hierarchy from the bottom up to the highest category which is the common category of all the terminal categories.

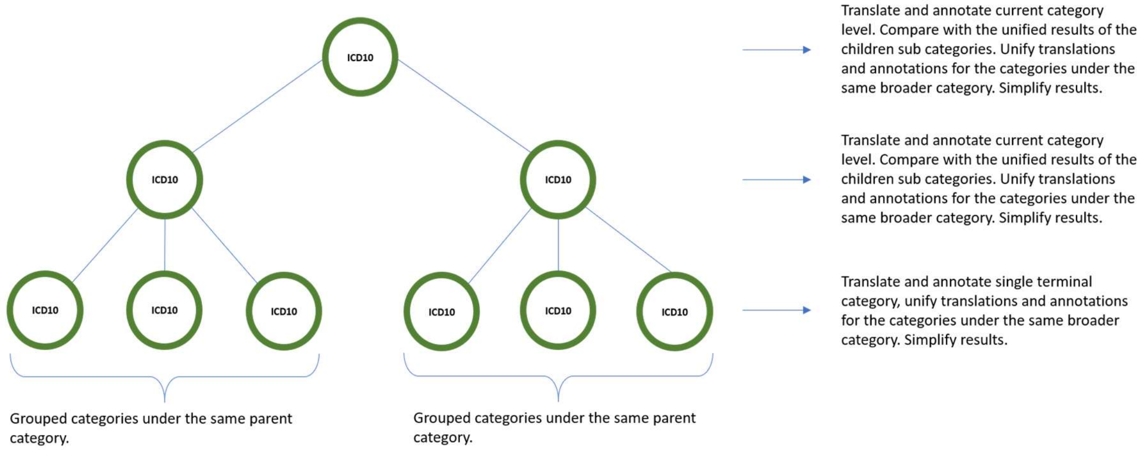


*Figure 12: Possible overview of range hierarchy.*

The first subroutine is the translation and annotation (*sub1*) of single codes started from the terminal codes. The translation comes from the mapping table where a single category of ICD10 is in relationship with one or more ICD11 categories (in some mapping is missing the mapped category of ICD11). From the single mapping we obtain the ICD11 translations rules and from the relation between them we obtain the annotations. Therefor for each single ICD10 category we have associated a list (one or more elements) of ICD11 categories and some annotation, but we also maintain a list of the evaluated ICD10 categories. The annotations we add for the single translations are:

- Equivalent: no annotation
- Subclass: warning, category mapped to broader.
- Superclass: manual, the experts need to choose which categories maintain for the new subcodeDef rule.
- Intersects: manual.

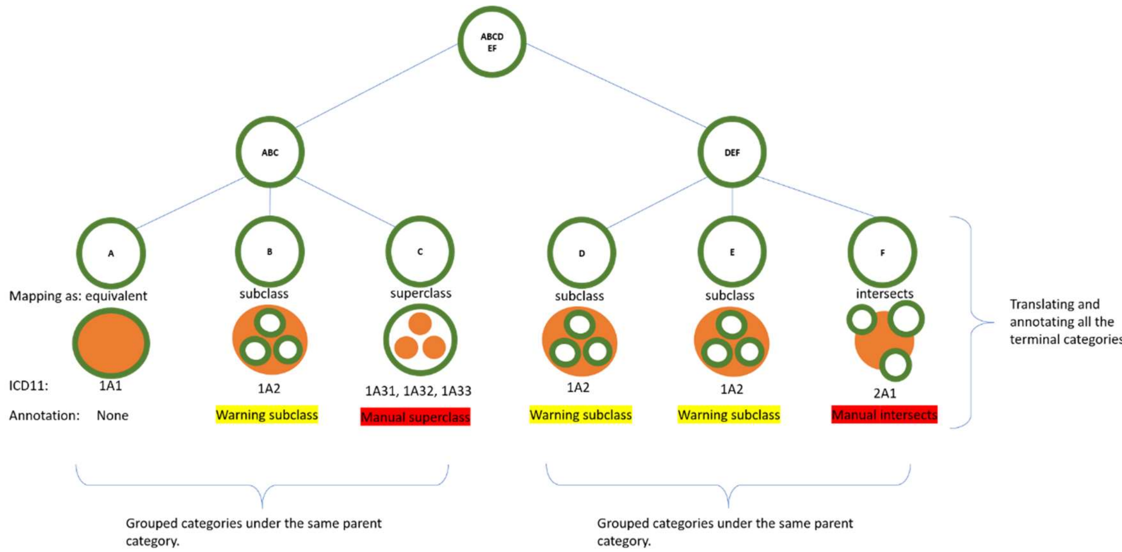


*Figure 13:Translation and annotation of all the terminal categories.*

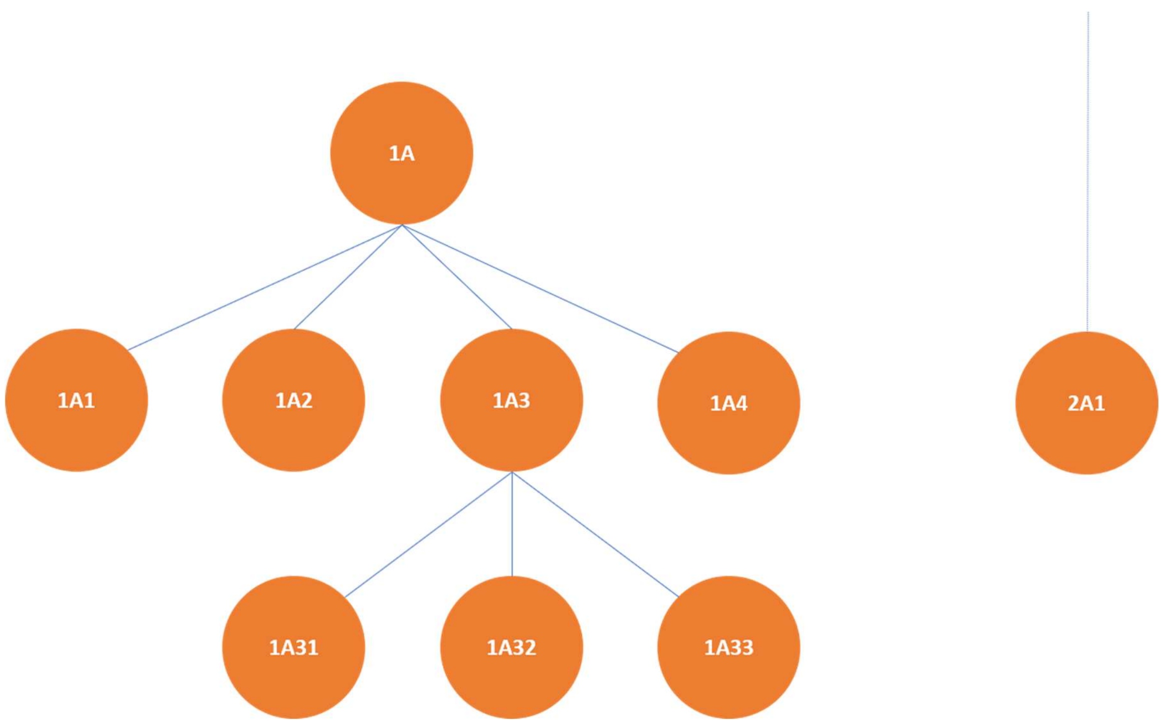


*Figure 14: Hierarchy of the categories in ICD11.*

On the simplify subroutine (*sub2*) we will see that some annotations can be omitted, but some others can be added to provide more support to the experts.

Once the terminal categories are translated, the algorithm unify the results in groups where the categories have the same parent. The results then are ready to be simplified.

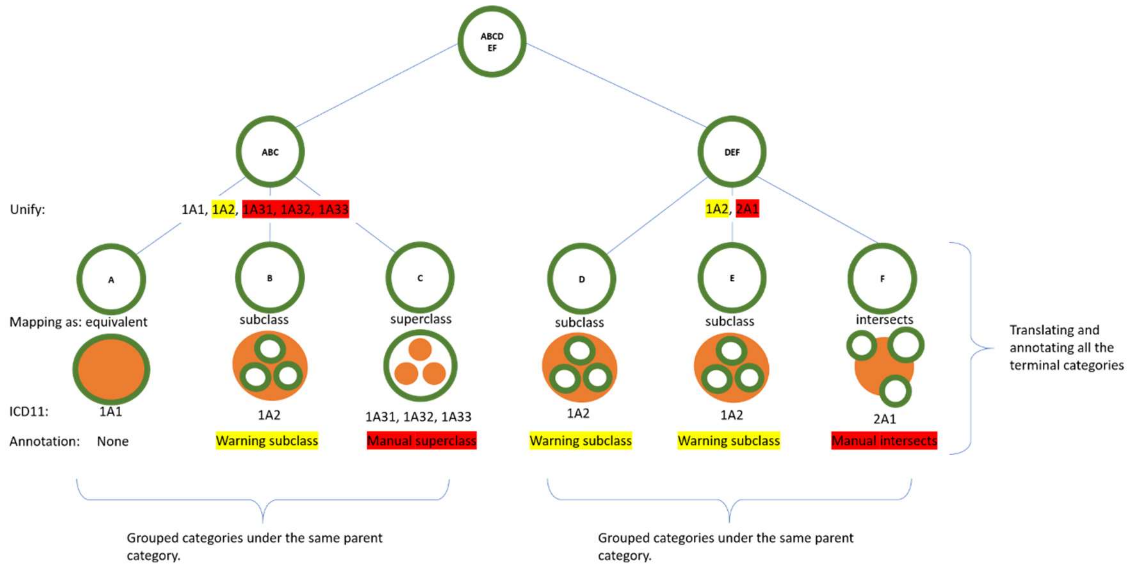


*Figure 15: Unify results under same parent category.*

The simplify algorithm take each annotation and with some computation decide if it can be deleted from the list of annotations.

In the annotation is as subclass we going to check if all the involved ICD10 categories mapped to the broader ICD11 category are in the list of the evaluated. If all the categories are included, we can delete the warning annotation.

For the intersects we need to check if all the category involved for both CD10 and ICD11 are included to delete the annotation. Being all the categories that change structure involved make the manual check.

When evaluate superclass annotation we maintain it. Unlike the other annotations this cannot have system assistance.

With the simplify the terminal categories are fully evaluated, next we start evaluating the parent categories of the terminal categories (in fig 12 the second layer of the hierarchy).

There is only one difference between the layer of the terminal categories and the other layers, the check between the current translation and the sub categories result. The algorithm starts translating and annotating the current layer of categories in the same way as for the single terminal category. From a logical point of view the results should be always equal between parent category and sub categories, but this is it not true. It happens that the children translation is a subset of the parent translation, the parent translation is a subset of the children translation but also that there are differences of both directions. In the case (case 1) where the children translation is a subset of the parent means that in ICD11 was introduced a new category that stay on the same group with the other children categories. In the case (case 2) of parent subset of the children translation a sub category of the broader category was moved under other block/chapter. It could happen that both case 1 and case 2 occur.

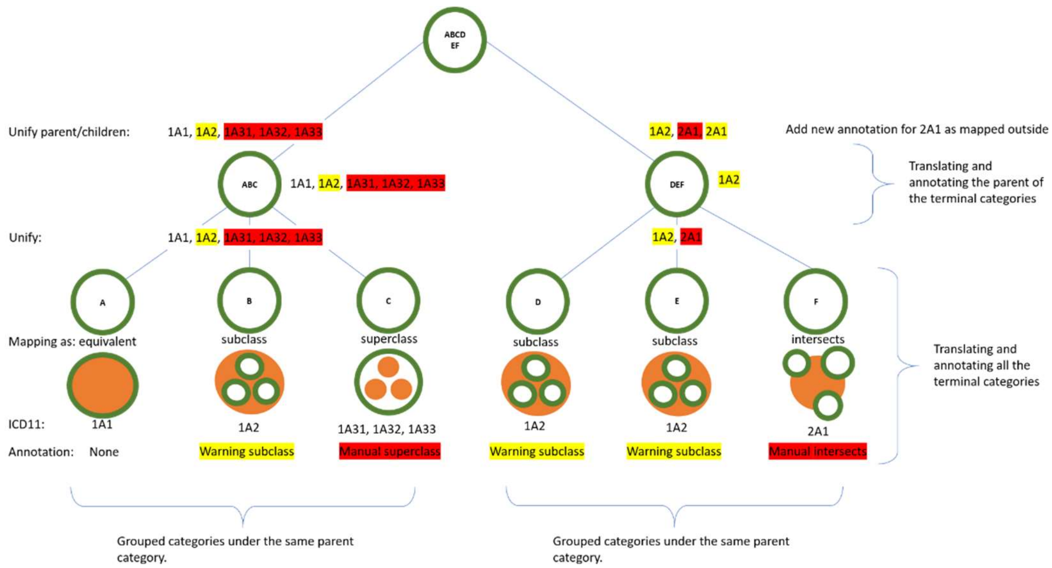


*Figure 16: Translating and annotation the parents of the terminal categories. To be noticed that DEF not containing 2A1.*

For the differences between parent category and subcategories we introduced two annotations that are suggestions to obtain better results. From a logical point of view all the codes should be considered and the translation evaluated as automatable, but we prefer to add a warning annotation for both cases and check what is the expertise interpretation. We will identify the annotation referring case 1 and case 2 for the simplification of the annotation.

After the check between parent/children we will unify the results as for subcategories and then start simplifying the annotation with the same rules we seen before but also adding two new simplify rules for the new annotation we just introduced.

For the first case we can delete the annotation if all the mapping to the new code are included in the ICD10 categories evaluated, for case 2 we can delete the annotation if there are other codes near the annotated code. For example, if a code was moved to another chapter, the annotation remain if there aren't other codes mapped to the same block with that code.

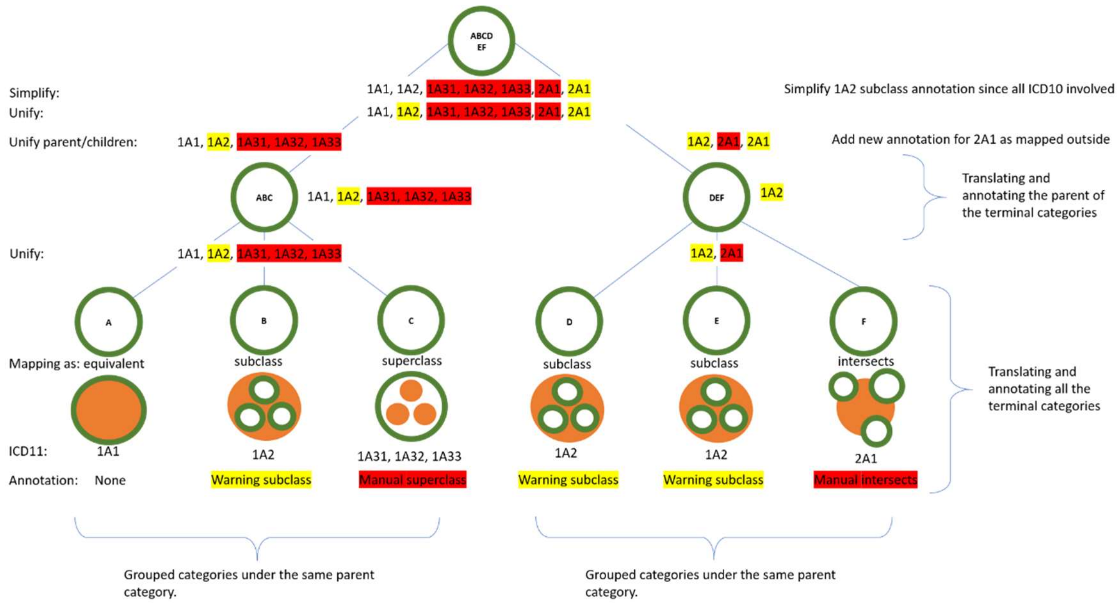


*Figure 17: Unifying and simplifying results.*

Then the algorithm starts evaluating recursively the other layers up to the top layer where we will have the result of the range.

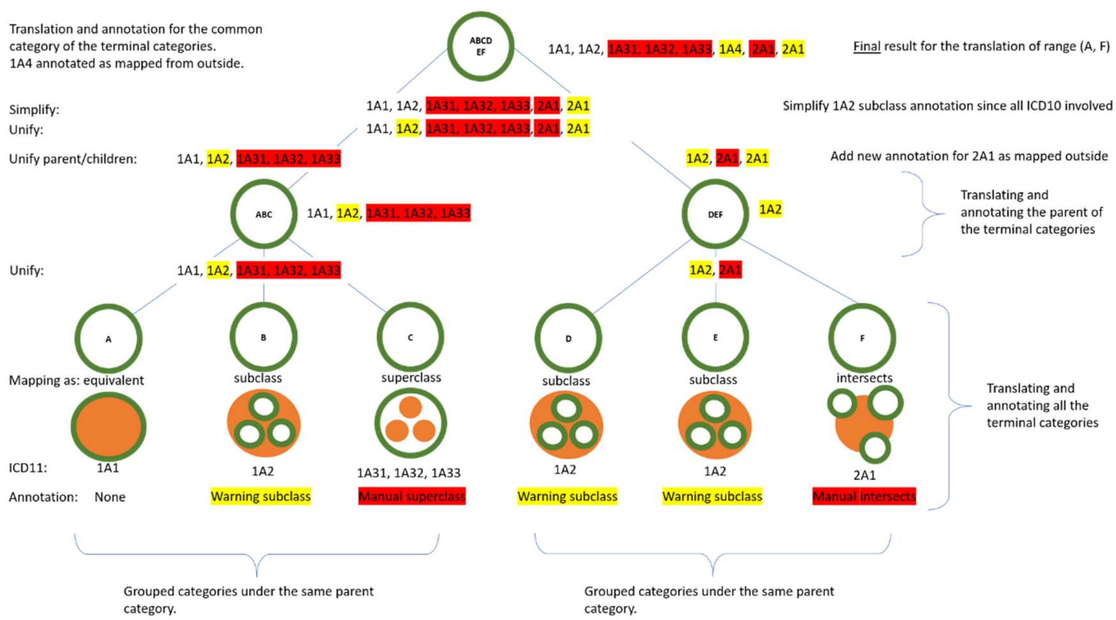


*Figure 18: Result for the translation of the range A-F. We must interpret the various passages from the bottom to the top.*

The algorithm then makes a final step of unifying the results of the different ranges under the same codeDef and simplify the same way we seen before.

## Improvements

From the results we found some incompleteness for the mapping table, there are some categories of ICD11 that have no mapping from ICD10. Those codes could be suggested to the experts if the ranges before and after this code are all covered.