

Linking Health Terminologies: A Unified Approach to the WHO Family of International Classifications

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Abstract. This paper presents an effort by the World Health Organization (WHO) to integrate the reference classifications of the Family of International Classifications (ICD, ICF, and ICHI) into a unified digital framework. The integration was accomplished via an expanded Content Model and a single Foundation that hosts all entities from these classifications, allowing the traditional use cases of individual classifications to be retained while enhancing their combined use. The harmonized WHO-FIC Content Model and the unified Foundation has streamlined the content management, enhanced the web-based tool functionalities, and provided opportunities for linkage with external terminologies and ontologies. This integration promises reduced maintenance cost, seamless joint application, complete representation of health-related concepts while enabling better interoperability with other informatics infrastructures.

Keywords. WHO FIC, ICD, ICF, ICHI, terminology

1. Introduction

The WHO Family of International Classifications (WHO-FIC) has been a loose federation of classifications and terminologies developed and maintained separately by WHO and a network of collaborating centers and affiliated non-government organizations. It includes three reference classifications: the International Statistical Classification of Diseases and Related Health Problems (ICD); the International

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Classification of Functioning, Disability and Health (ICF); and the emerging International Classification of Health Interventions (ICHI). For the 11th revision of ICD (ICD-11), WHO created a digital framework that includes a formal Content Model that defines the information structure of ICD-11 entities, a Foundation that acts as the repository of all knowledge about ICD entities, different subsets of ICD (called linearizations) that serve different use cases, common platforms for editing, translating, browsing, coding, and proposing changes to the classification, and software APIs for accessing a variety of terminological services [1]. Because of the increasing need for the joint use of these classifications and the possibility of providing a common set of digital tools for them, WHO embarked on a project to develop a terminological system that encompass a tighter integration of these classifications and yet still maintain their separate identities to satisfy their traditional use cases. This fully digitized terminological system promises to reduce maintenance cost, allows seamless joint use of the three classifications, and provides a unified representation of concepts related to health. Finally, it also affords the possibility of computable integration and linkage between the reference classifications and with other terminologies and ontologies.

2. Methods

The WHO strategy to integrate the three reference classifications includes the extension of the ICD Content Model to a WHO-FIC Content Model that puts the information structures of the classifications into a common footing, merging the content of ICD, ICF and ICHI into a single Foundation, and regenerating the classic ICF and ICHI as linearizations of the merged Foundation. Conceptualizations of the WHO-FIC Foundation where the content of the classifications is harmonized and integrated in different ways were developed and a program to investigate areas of overlap and methods for achieving the desired content harmonization is in progress. Finally, updates to the WHO-FIC software platforms allow uniform access, production, maintenance, and use of the three classifications.

3. Results

3.1. *The harmonized WHO-FIC Content Model*

The generalization of the ICD-11 Content Model to a harmonized WHO-FIC Content Model means (a) extending the model to include properties that are specific to ICF and ICHI (e.g., “related impairment” property in ICF), (b) giving ICF and ICHI post-coordination models that prescribe how their codable entities can be defined using stem codes and extension codes, and (c) using the linearization model to generate the ICF and ICHI classifications from subsets of entities in the Foundation [2]. Given that ICHI was developed in parallel to the ICD-11 revision and shared the same conceptual foundation, incorporation of ICHI into a common Content Model was straightforward. The three axes of Target, Action, and Means are modeled as required post-coordination axes for defining Health Interventions in ICHI. To adapt ICF, on the other hand, requires that we reconceptualize ICF coding in terms of the new model.

Unlike ICD, where the classification provides codes that can be used directly to represent disease and disorders, ICF coding requires the combination of an ICF code

(e.g., b1100 “State of consciousness”) with one or more qualifier values (e.g., “1 No problem,” or “4 Severe problem” for the “Extent of impairment” qualifier). Some qualifiers are required for each ICF domain (e.g., “Extent of impairment” for Body Functions) while others are optional (e.g., “Location of impairment” for Body Structures). In the harmonized WHO-FIC Content Model, the post-coordination model provides the mechanism for formalizing these ICF coding rules. We define ICF qualifiers as ICF’s post-coordination axes, some of which are required (i.e., required qualifiers) while others are optional like extension codes in the other classifications.

3.2. *A unified WHO-FIC Foundation and common platforms*

With the modeling of ICF and ICHI entities in the WHO-FIC Content Model and the implementation of the Foundation using the Web Ontology Language (OWL) in Protégé [3], the content of ICF and ICHI were imported into a merged WHO-FIC Foundation. After much curation work, such as the addition of the linearization specification and post-coordination sanctioning rules and the removal of the residuals in the Foundation that can be generated in the linearization process, the 2024/01/21 version of the WHO-FIC Foundation is represented by 100,381 OWL classes, over 135,000 logical axioms, and over 342,000 annotations. From the unified WHO-FIC Foundation, “classic” ICF and ICHI can be generated as linearizations.

With the merging of ICD, ICF, and ICHI content in the unified Foundation in terms of the common WHO-FIC Content Model, all of the digital tooling that WHO had developed for the ICD-11 revision can be adapted for ICF and ICHI. Together with ICD-11, the content of ICF and ICHI can be edited in the iCAT web-based platform [4], browsed together in the Foundation and separately as individual classifications, and further developed using the same translation and proposal platforms.³

Furthermore, the modeling of ICF coding as an application of post-coordination means that the ICD-11 coding tool can be adapted for ICF coding. Figure 1 shows the ICD-11 coding tool being used to code 8B11.5Z&XK8G for “Cerebral ischaemic stroke, unspecified, with laterality of left” and the new adapted ICF coding tool used to code ICF b1100 for “State of consciousness” with the possibility of choosing a qualifier for the extent or magnitude of impairment.

3.4. *Different levels of Foundation “harmonization”*

The merging of ICD, ICF and ICHI content in the same Foundation is only the first step in creating a “harmonized” Foundation. Minimally, concepts of the same semantic types in the three classifications should be re-organized into logically consistent and semantically sound hierarchies. A prime example of such harmonization work is the representation of anatomical concepts that were developed separately in the three classifications: “Anatomy and topography” extension codes for specifying locations of ICD diseases, “Body Structures” in ICF, and anatomical targets of interventions in ICHI. Much work had already been done to align these anatomical concepts [5].

The OWL representation of the classifications’ content in the Foundation allows a level of semantic integration beyond consistent hierarchies. Where appropriate, the concepts can be related to each other using description logic axioms. For example, ICD-11 includes a hierarchy of “Impairment of visual functions” that parallels ICF’s “Seeing

³ <https://icd.who.int/dev11/#/>

functions” hierarchy. Thus, potentially ICD’s “Impairment of colour vision” entity can be defined as, in the OWL Manchester syntax, (`icf: 'Colour vision' and some 'Extent or magnitude of impairment' {qm1, qm2, qm3, qm4}`), where qm1 to qm4 are individuals specifying degrees of impairment from mild to total.

8B11.5Z Cerebral ischaemic stroke, unspecified

Code: 8B11.5Z,XX8G

Selected term
Cerebral ischaemic **stroke**, unspecified Foundation URI: <http://id.who.int/icd/entity/1614718959>

Exclusions from above levels [Show all \[7\]](#) ▼

Related categories in maternal chapter
Diseases of the nervous system complicating pregnancy, childbirth or the puerperium / Cerebral ischaemic stroke, unspecified ([J864.3/8B11.5Z](#))

Related categories in perinatal chapter
Neonatal cerebral ischaemia ([KB00](#))

Coding Note
If an additional code is used for anatomy, the artery affected by the stroke should be selected.

Coding Note from above levels [Show all \[1\]](#) ▼

Postcoordination

Laterality **XX8G** Left **X**

Laterality (use additional code, if desired.)
XX8J Bilateral
XX8K Left
XX8L Right
XX70 Unilateral, unspecified

Specific anatomy (use additional code, if desired.)
Search in axis: Specific anatomy
XA13S2 Cerebral artery

b1100 State of consciousness

Code: b1100

Description
Mental functions that when altered produce states such as clouding of consciousness such as clouding of consciousness, stupor or coma.

Related Impairments
clouding
coma
stupor

Exclusions from above levels [Show all \[3\]](#) ▼

All Index Terms [Show all \[2\]](#) ▼

Postcoordination

Extent or magnitude of impairment (use additional code, if desired.)
qm0 NO impairment (none, absent, negligible,...) 0-4 %
qm1 MILD impairment (slight, low,...) 5-24 %
qm2 MODERATE impairment (medium, fair,...) 25-49 %
qm3 SEVERE impairment (high, extreme,...) 50-95 %
qm4 COMPLETE impairment (total,...) 96-100 %
qm8 not applicable
qm9 not specified

Figure 1. ICF coding tool (right) is adapted from ICD-11 coding tool (left). The combination of an ICF code and a qualifier is analogous to the combination of an ICD code and an extension code.

A third level of integration is to create linkages among the classifications. ICD-11 already includes references to generic ICF domains. ICHI interventions’ functional targets include links to corresponding ICF body functions, activities and participations and environmental factors. The addition and maintenance of additional linkages are resource-intensive and thus need to be justified by compelling use cases.

3.5. Linkage to other terminologies and ontologies

The representation of the WHO-FIC reference classifications as a single Foundation allows additional linkages and integration with other terminologies and ontologies. Past work had mapped, for example, ICF to International Classification of Nursing Practice [6] and procedure coding systems to ICHI [7]. A current project is integrating disease and related concepts in the WHO-FIC Foundation with the Mondo Disease Ontology [8].

4. Discussion

The formulation of ICF in the common WHO-FIC Content Model created an impetus to enhance features of ICF. Foremost among them is the effort to create index terms for ICF codes. Multiple efforts are underway to use machine learning and natural language processing to suggest candidate index terms and to define rules for their possible inclusion in future versions of ICF.

The formulation of the combinations of ICF codes and qualifiers as post-coordination allows us to adapt the ICD-11 coding tool for ICF coding. However, ICF has additional

coding rules, such as the use of environmental factors to provide context for ICF coding. Such multi-faceted coding practices remain to be implemented.

As much as possible the digitization of the WHO-FIC classifications has adhered to standards in semantic web technologies (e.g., the use of OWL and SKOS Simple Knowledge Organization System), terminology mapping (e.g., the use of Simple Standard for Sharing Ontological Mappings (SSSOM) [9] in anatomy mapping), and service architecture (e.g., the use of REST API to provide software services). The adoption of such standards enhances the interoperability and ease of adoption of the artifacts and services of the WHO-FIC informatics infrastructure.

In contrast to other federated ontology libraries such as the OBO Foundry [10], the control that WHO has over the three reference classifications allows them to be tightly integrated into a common Foundation with a shared WHO-FIC Content Model. Lessons learned from other libraries and integration efforts, such as Mondo provenance tracking, however, are applicable when we consider linking and integrating the Foundation with other terminologies and ontologies.

5. Conclusions

The integration of ICD, ICF, and ICHI into a unified Foundation using a common WHO-FIC Content Model allows them to share much of the tooling and web-based platforms that WHO had developed for ICD-11. While much work remains to harmonize the classification entities in the Foundation and to link them with external terminologies and ontologies, WHO has made the integration of the three WHO-FIC reference classifications a key strategic initiative.

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