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Research and Applications

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A practical strategy to use the ICD-11 for morbidity coding in the United States without a clinical modification

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ABSTRACT

Objective: The aim of this study was to derive and evaluate a practical strategy of replacing ICD-10-CM codes by ICD-11 for morbidity coding in the United States, without the creation of a Clinical Modification.

Materials and Methods: A stepwise strategy is described, using first the ICD-11 stem codes from the Mortality and Morbidity Statistics (MMS) linearization, followed by exposing Foundation entities, then adding postcoordination (with existing codes and adding new stem codes if necessary), with creating new stem codes as the last resort. The strategy was evaluated by recoding 2 samples of ICD-10-CM codes comprised of frequently used codes and all codes from the digestive diseases chapter.

Results: Among the 1725 ICD-10-CM codes examined, the cumulative coverage at the stem code, Foundation, and postcoordination levels are 35.2%, 46.5% and 89.4% respectively. 7.1% of codes require new extension codes and 3.5% require new stem codes. Among the new extension codes, severity scale values and anatomy are the most common categories. 5.5% of codes are not one-to-one matches (1 ICD-10-CM code matched to 1 ICD-11 stem code or Foundation entity) which could be potentially challenging.

Conclusion: Existing ICD-11 content can achieve full representation of almost 90% of ICD-10-CM codes, provided that postcoordination can be used and the coding guidelines and hierarchical structures of ICD-10-CM and ICD-11 can be harmonized. The various options examined in this study should be carefully considered before embarking on the traditional approach of a full-fledged ICD-11-CM.

Key words: International Classification of Diseases, ICD-11, ICD-10, ICD-10-CM, controlled medical vocabularies, medical terminologies

INTRODUCTION

With its first release in February 2021, the ICD-11 became the official version of the International Classification of Diseases (ICD). According to the World Health Organization (WHO) release announcement, 35 countries are already using the ICD-11 for causes of death, primary care, cancer registration, and reimbursement, among others.[1–4] In the United States, no adoption timeframe has been proposed yet. In September 2021, the National Committee on Vital and Health Statistics issued recommendations to the Secretary of the US Department of Health and Human Services advising on a research agenda to evaluate the use of ICD-11 in the United States.[5] One of the recommendations is "to assess whether ICD-11 can fully support morbidity classification in the United States without development of a US Clinical Modification (CM), and if not, which areas might be targeted in a CM version."

Upgrading to the ICD-11 directly (without a CM version) for morbidity coding avoids the cost to create and maintain a separate ICD-11-CM. Avoiding the delay of creating a CM version also enables the United States to adopt ICD-11 earlier to reap the benefits of ICD-11's up-to-date medical knowledge, structure, and capabilities to embrace sound terminology development principles and support digitization. In addition, future potential divergence of the CM version from the core ICD, as seen in ICD-10-CM, can be avoided. Given the innovative features of ICD-11 (eg, Foundation Component, postcoordination) and the moderate increase in the number of codes over ICD-10, skipping a CM version becomes a distinct possibility.[6] In our previous article, we examined the feasibility of replacing 943 commonly used ICD-10-CM codes by ICD-11 codes.[7] We found that while only 23.5% of the examined codes could be fully represented by ICD-11 stem codes, with the use of postcoordination, an additional 8%–35% could potentially be fully represented. We concluded that migrating from the ICD-10-CM to the ICD-11 is not necessarily more disruptive than from the ICD-9-CM to the ICD-10-CM and that the ICD-11 (without a CM version) should be considered a serious candidate to replace the ICD-10-CM for morbidity coding.

In addition to using postcoordination, the Foundation component is another resource that can be leveraged in ICD-11 to expand its coverage.[6,8–11] The ICD-11 Foundation is a rich knowledge base that holds all necessary information to generate the list of codes (called "linearizations") needed for various purposes. The analogy is that the Foundation is a deep

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sea of terms and meanings, where a subset of the most common or important terms will appear "above the shoreline" in the linearizations. Multiple linearizations for different purposes and settings can be generated from the same Foundation, which are fully compatible and interoperable. The primary linearization of ICD-11 is called the MMS (ICD-11 for MMS).

Based on our previous feasibility analysis, using only the stem codes in MMS is not likely to be sufficient to support the transition from ICD-10-CM to ICD-11. Various options are available to augment the coverage of ICD-11 beyond the MMS. The first option is to create a "U.S. linearization," whereby exposing more entities in the Foundation for coding. The second option is to use postcoordination. In this option, it may also be necessary to expand the existing postcoordination capabilities of ICD-11 by adding extension codes in a "U.S. extension of extension." A third option is to maintain a set of US-specific stem codes which are not based on the Foundation. We can all this "ICD-11-CM lite," as opposed to the full-fledged CM. These 3 options are not mutually exclusive.

Considering the level of effort in development and maintenance, the ease of implementation by users, and the risk of divergence from the core ICD-11, we propose a stepwise, incremental strategy. Among the 3 options, creating a US linearization is the simplest and most economical. While it is true that there will be new US-specific stem codes in a US linearization, since they are derived from the same Foundation, their relations with existing stem codes can be readily determined. For example, a US-specific stem code based on a finer-grained inclusion term of an existing stem code can be computationally identified as a descendant of that stem code. For these reasons, a US linearization is also the least disruptive and has the lowest risk of divergence from the core ICD-11. For these reasons, we believe that a US linearization should be the first option to choose. The second option to use will be postcoordination, including the addition of some US-specific extension codes. While postcoordination is an elegant and efficient method, 1 caveat is that it has never been used in ICD coding and will have additional requirement and impact on tooling, coder education, and coding variability. We consider the creation of US-specific stem codes as the last resort as it is most disruptive and can potentially lead to code divergence and incompatibility between national and international data.

The specific contributions of the present study are (1) description of 3 distinct and complementary options to make ICD-11 backwardly compatible with ICD-10-CM; (2) evaluation of the performance of the incremental strategy to replace ICD-10-CM with ICD-11 through recoding 2 representative samples of ICD-10-CM codes in ICD-11; and (3) analysis of the implications of the findings and future directions. This work differs from our previous investigation[7] in that (1) the sample of ICD-10-CM codes is more extensive with the addition of all digestive disease codes and (2) we allow more exhaustive use of the coding capabilities in ICD-11, which includes: exposing the Foundation entities, allowing all meaningful combinations in postcoordination and addition of new extension codes.

MATERIALS AND METHODS

The following sections describe how we used 2 different approaches to identify representative samples of ICD-10-CM codes and then recoded them in ICD-11.

Two samples of ICD-10-CM codes

We used 2 samples of ICD-10-CM codes in this study. The first sample was the 943 frequently used codes from our previous study, which were derived from Medicare claims data supplemented by additional data from 3 community hospitals.[7,12] This sample covered at least 60% of usage volume from every chapter. We excluded codes that were no longer valid in 2022. This first sample represented a "horizontal sample," analogous to taking the top portion of a cake. In addition, we added a "vertical sample," analogous to taking a slice of a cake, by including all codes from a specific chapter. Vertical sampling adds the perspective of the entirety of a particular domain and includes codes that are less commonly used. The chapter we chose was *Chapter 11 Diseases of the digestive system*. According to our previous study, this chapter had good spread of code usage, that is, usage was not concentrated in a small number of codes, and intermediate coverage (not the highest or lowest) by ICD-11. This study was rated as not human subject research by the Office of Human Research Protection at the National Institutes of Health.

Recoding ICD-10-CM codes in ICD-11

Using the 3 options of aligning ICD-10-CM and ICD-11 in the order specified in our proposed stepwise strategy, we recoded the ICD-10-CM codes in a "waterfall" manner, that is, only the codes that did not achieve exact matching in 1 step would be passed to the next step.

Exact match to stem codes in the ICD-11 MMS

We used the online MMS browser from the ICD-11 maintenance platform (the "orange" browser[13]) because the display of inclusion and index terms was more complete than the MMS browser of the official release (the "blue" browser[14]) and there were links to the ICD-11 Foundation. Inclusion terms are usually common and important alternative terms for a specific category, or borderline terms to distinguish the boundary between categories. Index terms are terms contained in the Alphabetical Index. We looked for exact matching ICD-11 stem code at the lowest (or "leaf") level, following the ICD-11 morbidity coding reference guide.[15] We considered matching in meaning rather than lexical matches and ignored parts of the ICD-10-CM or ICD-11 name that conveyed absence of information, for example, gout *unspecified*, Zoster *without complications*. We allowed the use of multiple ICD-11 stem codes if the combined meaning exactly matched the ICD-10-CM code. For example, *K56.2 Volvulus* was considered an exact match to the combination of 2 ICD-11 codes *DA91.1 Volvulus of small intestine* and *DB30.1 Volvulus of large intestine*. This is different from postcoordination which can also involve multiple stem codes. In postcoordination, the interpretation is always "and," but in this case, the meaning is "or"—only one of the codes is applicable in a particular patient.

Exact match to ICD-11 Foundation entities

Entities in the Foundation layer are mostly displayed in the browser as inclusions or index terms under a stem code. Foundation entities are not given specific codes, but they can be identified by their unique resource identifiers (URIs), which are unique and unchanging. URIs are assigned to all *distinct* entities in the Foundation, whether they appear in a

linearization or not. Some of the inclusion or index terms are considered synonymous with the stem code, and they do not have their own URI. Only those terms that are not synonymous have URIs. In the browser, the nonsynonymous terms can be identified by a clickable double arrow (⇒), which links to a separate page with a distinct URI. Terms that are synonymous with the stem code do not have the double arrow. As an example, in Figure 1, the index terms *Basal cell papilloma* and *Seborrheic wart* are considered synonymous with the stem code *2F21.0 Seborrhoeic keratosis*, while *Acanthotic seborrhoeic keratosis* (*Foundation URI*: http://id.who.int/icd/entity/1100061193) and *Adenoid seborrhoeic keratosis* (*Foundation URI*: http://id.who.int/icd/entity/1952242927) are not synonymous with the stem code. For ICD-10-CM codes that did not have exact-matching stem codes, we looked for an exact match in the nonsynonymous inclusion or index terms and recorded the URI. Similar to stem codes, we allowed the use of multiple Foundation entities if the combined meaning exactly matched the ICD-10-CM code.

Postcoordination

For ICD-10-CM codes that did not have exact matches at the stem code or Foundation level, we would choose the closest matching stem code or Foundation entity, and proceed to use postcoordination if that could achieve exact matching. We followed the general patterns suggested by the browser but did not restrict to the list of codes shown in the tool, which were based on postcoordination sanctioning rules to detect and correct nonmutually exclusive coding arising from a postcoordinated expression being iso-semantic with an existing precoordinated stem code. In our previous study, we found that the postcoordination options shown in the tool were too restrictive (eg, *Tinnitus* could not be postcoordinated with *bilateral*). In this study, we allowed code combinations as long as they were clinically meaningful. We also allowed the use of stem codes, Foundation entities, and extension codes in postcoordination. In some cases, we would propose the addition of brand-new extension codes to improve ICD-11's coverage.

New stem codes

If there was still no exact match after the above 3 steps, the last resort was to create a brand-new stem code to match the meaning of the ICD-10-CM code.

Recoding was done by 2 authors, JX and SM (same as our previous study[7]) who are experts in ICD-10-CM and very knowledgeable in ICD-11. In our previous study,[7] we achieved concordance rate of over 75% in the selection of main codes and the use of postcoordination when they recoded all ICD-10-CM codes separately (dual independent coding). Our concordance rate is comparable to reported concordance rates in ICD coding by professional coders.[16–18] In this study, for expediency, we used a "code and review" approach. Each of the 2 authors recoded half of the ICD-10-CM codes. They then reviewed each other's results, noting disagreements and potential issues, which were discussed until consensus was reached. After the recoding was finalized, a further analysis was done based on the cardinality of the matches. We reviewed all cases of one-to-many (one ICD-10-CM code recoded to more than one ICD-11 stem code or Foundation entity) and many-to-one (more than 1 ICD-10-CM code recoded to 1 ICD-11 stem code or Foundation entity) matches. These cases warrant special attention as they could be potentially challenging when substituting 1 coding system for another.

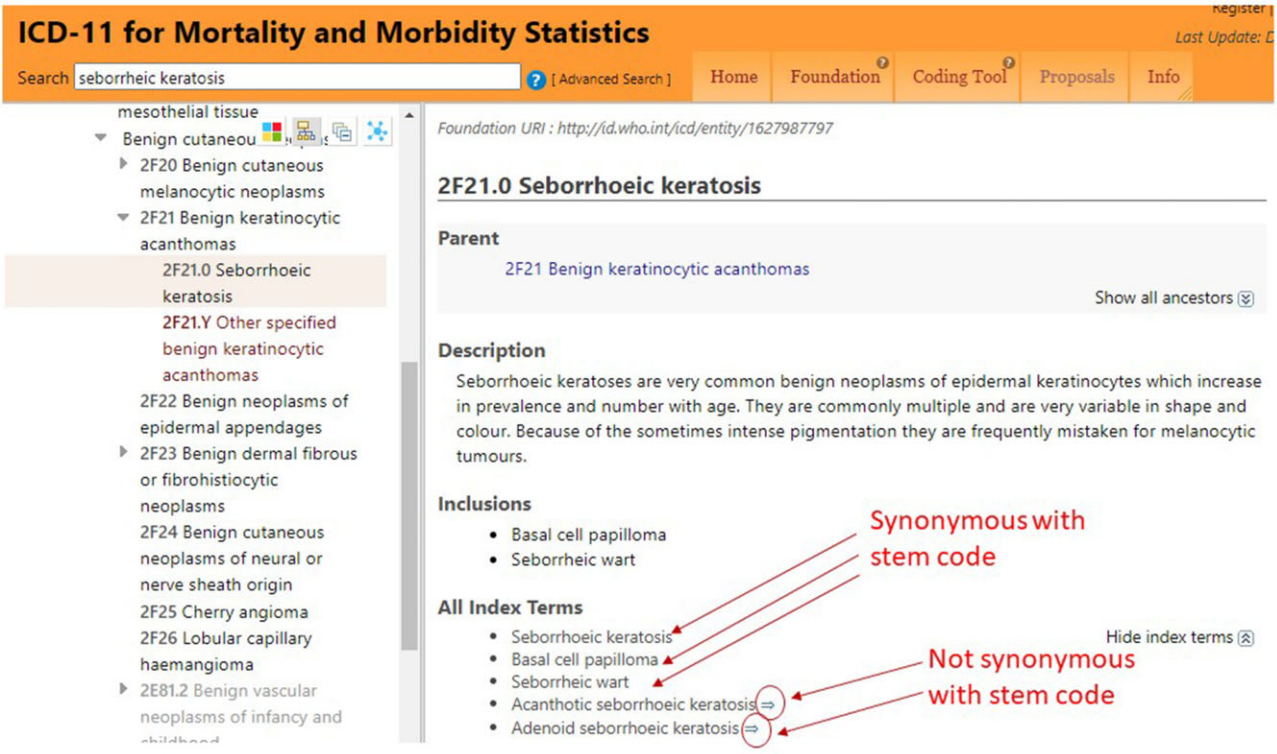

Figure 1. Display of synonymous and nonsynonymous inclusion and index terms in ICD-11.

RESULTS

ICD-10-CM code samples

Of the 943 frequently used codes in our previous study, 9 codes became obsolete in 2022. Among the active codes, 25 codes were digestive disease codes (overlapping the second sample), leaving 909 codes for analysis. There were 817 codes in the digestive disease chapter.

Recoding in ICD-11

Among the digestive disease codes, 1 code was considered unmappable. In ICD-10-CM, *K56.41 Fecal impaction* was a type of intestinal obstruction and had an exclusion term of *constipation* (pointing to *K59.0-*). However, in ICD-11, *fecal impaction* was an index term under *ME05.0 Constipation*. Therefore, *K56.41* was considered unmappable in ICD-11 because of the irreconcilable conflict in coding guideline. The results of the recoding of the mappable codes are summarized in Table 1. The following is a detailed description at each level of recoding.

L1. Stem code

Overall, 35.2% of the ICD-10-CM codes (32% of frequently used codes, 38.7% of digestive disease codes) could be exactly matched to ICD-11 stem codes.

L2. Foundation entity

Exposing Foundation entities for coding resulted in 11.3% (6.4% in frequently used codes, 16.8% in digestive disease codes) increase of exact matches. For example, for the ICD-10-CM code *M54.12 Radiculopathy, cervical region*, the closest match at the stem code level was *8B93.Y Other specified radiculopathy*. *8B93.Y* had an index term *Radiculopathy, cervical region* (*Foundation URI:* http://id.who.int/icd/entity/1182793547), which was an exact match.

L3a. Postcoordination with existing codes

Using postcoordination with existing codes (stem codes, Foundation entities and extension codes) further increased exact match rate by 42.9% overall (53.1% in frequently used codes, 31.5% in digestive disease codes). For example, the ICD-10-CM code K22.11 Ulcer of esophagus with bleeding could be matched exactly by the postcoordination of DA25.Z Oesophageal ulcer, unspecified and ME24.A2 Oesophageal haemorrhage.

L3b. Postcoordination with new extension codes

Some cases were considered suitable for postcoordination, but the necessary extension code was not available. For example, the ICD-10-CM code O09.93 Supervision of high risk pregnancy, unspecified, third trimester could be matched exactly to QA43.Z Supervision of high-risk pregnancy, unspecified if there was an extension code for third trimester. If we added all the necessary extension codes, the exact match rate by postcoordination would increase by 7.1% (6.8% in frequently used codes, 7.4% in digestive disease codes).

We further analyzed the new extension codes needed and classified them according to the categories in the ICD-11 Extension codes chapter (Table 2). The most frequently required extension codes belonged to the category *Severity scale value* (45.6%), followed by *Anatomy and topography* (28%).

L4. New stem codes

In cases where all the above steps still did not result in an exact match, we proposed adding new stem codes. A total of 61 (3.5%) ICD-10-CM codes required new stem codes, which comprised of 15 (1.7%) frequently used codes and 46 (5.6%) digestive disease codes. Some of these codes shared specific patterns. For example, several ICD-10-CM codes were of the pattern *Long term (current) use of x* where x is a medication, for example, *aspirin (Z79.82)*, *anticoagulants (Z79.01)*, and *insulin (Z79.4)*. ICD-11 had codes like *QC48.0 Personal history of long-term use of anticoagulants*, but they were not equivalent to the ICD-10-CM codes. In ICD-10-CM, personal history (no longer current) of drug therapy and long-term (current) drug therapy were coded separately under Z92- and Z79-, respectively. The 2 meanings were lumped together in ICD-11. So, we decided that new stem codes like *Long term (current) use of aspirin* were necessary. Another pattern was *Complications of y*, where y was a procedure, for example, *esophagostomy (K94.39)*, *gastric band procedure (K95.09)*, and *bariatric procedure (K95.89)*. The closest match in ICD-11 was *PK80.3Z Gastrointestinal, abdominal, or abdominal wall procedure associated with injury or harm in therapeutic use, unspecified approach*. New stem codes were needed to capture the additional detail in the ICD-10-CM codes.

Cardinality analysis

Overall, we found 36 cases (2.1%) of one-to-many matches and 59 cases (3.4%) of many-to-one matches. (Table 3) All the one-to-many matches were cases in which a broader ICD-10-CM code was mapped to 2 narrower codes in ICD-11. One-to-many matches could happen with stem codes, Foundation entities or new stem codes. The many-to-one matches could be categorized into 3 types:

Table 1. Recoding ICD-10-CM codes in ICD-11

	Frequently used codes		Digestive disease codes		Combined	
Level of recoding	Count (%)	Cumulative %	Count (%)	Cumulative %	Count (%)	Cumulative %
L1. Stem code	291 (32%)	32.0	316 (38.7%)	38.7	607 (35.2%)	35.2
L2. Foundation entity	58 (6.4%)	38.4	137 (16.8%)	55.5	195 (11.3%)	46.5
L3a. Postcoordination—existing code	483 (53.1%)	91.5	257 (31.5%)	87.0	740 (42.9%)	89.4
L3b. Postcoordination—new extension code	62 (6.8%)	98.3	60 (7.4%)	94.3	122 (7.1%)	96.5
L4. New stem code	15 (1.7%)	100.0	46 (5.6%)	100.0	61 (3.5%)	100.0
Total	909 (100%)		816[a] (100%)		1725 (100%)	

[a] One unmappable code K56.41 Fecal impaction excluded (see text for details)

Table 2. New ICD-11 extension codes required

Extension code category	Example	Frequently used codes	Digestive disease codes	Combined
Anatomy and topography	fifth metatarsal bone	22 (35.5%)	13 (20.6%)	35 (28%)
Health devices, equipment and supplies	urinary catheter	18 (29%)	0 (0%)	18 (14.4%)
Temporality	First trimester	12 (19.4%)	0 (0%)	12 (9.6%)
Severity scale value	loss of teeth class I	7 (11.3%)	50 (79.4%)	57 (45.6%)
Dimensions of injury	Complex tear meniscus	2 (3.2%)	0 (0%)	2 (1.6%)
Dimensions of external causes	prolonged static or awkward postures	1 (1.6%)	0 (0%)	1 (0.8%)
Total		62 (100%)	63 (100%)	125 (100%)

Table 3. One-to-many and many-to-one matches

Match category	Example		Frequently used codes ($N = 909$)	Digestive disease codes ($N = 816$)	Combined ($N = 1725$)
	ICD-10-CM code	ICD-11 code			
One to many					
a. Stem code	K56.2 Volvulus	DA91.1 Volvulus of small intestine DB30.1 Volvulus of large intestine	5 (0.6%)	25 (3.1%)	30 (1.7%)
b. Foundation entity	S22.089A Unspecified fracture of T11-T12 vertebra, initial encounter for closed fracture	Fracture of eleventh thoracic vertebra http://id.who.int/icd/entity/974407071; Fracture of twelfth thoracic vertebra http://id.who.int/icd/entity/329415944	2 (0.2%)	1 (0.1%)	3 (0.2%)
c. New stem code	K55.059 Acute (reversible) ischemia of intestine, part and extent unspecified	Acute reversible ischemia of small intestine; Acute reversible ischemia of large intestine;	0 (0%)	3 (0.4%)	3 (0.2%)
d. Total			7 (0.8%)	29 (3.6%)	36 (2.1%)
Many to one					
a. Residual categories	K12.30 Oral mucositis (ulcerative), unspecified; K12.39 Other oral mucositis (ulcerative)	DA01.11 Oral mucositis	21 (2.6%)	4 (0.4%)	25 (1.4%)
b. ICD-10-CM codes indistinguishable	K50.90 Crohn's disease, unspecified, without complications; K50.919 Crohn's disease, unspecified, with unspecified complications	DD70.Z Crohn disease, unspecified site	13 (1.6%)	4 (0.4%)	17 (1%)
c. ICD-11 synonymy questionable	G47.30 Sleep apnea, unspecified; G47.33 Obstructive sleep apnea (adult) (pediatric)	7A41 Obstructive sleep apnoea	14 (1.7%)	3 (0.3%)	17 (1%)
d. Total			48 (5.9%)	11(1.2%)	59 (3.4%)

Residual categories

One or both ICD-10-CM codes were residual categories ("unspecified" or "not elsewhere classified" codes) which were mapped to the same ICD-11 code. For example, both *K12.30 Oral mucositis (ulcerative), unspecified* and *K12.39 Other oral mucositis (ulcerative)* were recoded to *DA01.11 Oral mucositis*.

ICD-10-CM codes indistinguishable

there was no information to distinguish the 2 ICD-10-CM codes, so they ended up being recoded to the same ICD-11 code. For example, both *K50.90 Crohn's disease, unspecified, without complications*; *K50.919 Crohn's disease, unspecified, with unspecified complications* were recoded to *DD70.Z Crohn disease, unspecified site*.

ICD-11 synonymy questionable

these cases were caused by ICD-11 inclusion or index terms that should be considered as distinct entities but were not. For example, in ICD-11, *sleep apnoea NOS* was listed as an index term of *7A41 Obstructive sleep apnoea*. This caused both *G47.30 Sleep apnea, unspecified* and *G47.33 Obstructive sleep apnea (adult) (pediatric)* to be recoded to *7A41*.

DISCUSSION

Implications of findings

Overall, combining the results of the frequently used codes and digestive disease codes, ICD-11 has exact matches for 35.2% of ICD-10-CM codes that were examined in this study, at the stem code level. Exposing the Foundation entities in a US linearization will increase exact-matching coverage to 46.5%. Using existing postcoordination capabilities will increase the coverage to 89.4%, and adding US-specific extension codes will further increase it to 96.5%. Only 3.5% of codes will require US-specific stem codes. These numbers are higher compared to our previous study. This is largely due to the adoption of a more aggressive recoding approach in this study. This study allows the use of multiple ICD-11 codes (stem codes, Foundation entities, and new stem codes), if the union of the codes represents the full meaning of the ICD-10-CM code. In this study, exact match between residual

categories is possible, but they were all considered inexact matches in our previous study. This study accepts the presence of an inclusion or index term as evidence of exact match, even though their appropriateness is questionable in some cases. We did not include the use of Foundation entities in our previous study. For postcoordination, this study allows the use of code combinations that are clinically meaningful, instead of restricting to the displayed options in the ICD-11 browser, as in our previous study. We also allow the use of Foundation entities for postcoordination in this study, not limiting to stem codes and extension codes. For these reasons, the results in the current study should be interpreted as the upper-bound, or best-case scenario, of transitioning from ICD-10-CM to ICD-11.

However, to realize this best-case scenario, some conditions need to be satisfied. The first condition is the use of postcoordination, which adds a big boost in coverage. Postcoordination has never been used in ICD coding. Most electronic health data and messaging standards do not currently support postcoordination. Implementation of postcoordination will certainly present additional challenges in tooling and user training. The second condition is the alignment and harmonization of the coding guidelines, which includes textual definitions, coding rules, inclusions, exclusions and index terms. Coding guidelines are important safeguards in the accuracy of coding since they depict the meaning and boundaries of codes. In our previous study, we found that in approximately 10% of the recoded cases there were real and potential conflicts in the coding guidelines that could affect the choice of target codes. Careful examination of the coding guidelines is essential to avoid semantic shift when changing from 1 version of ICD to another.[19–21] The most severe coding guideline conflict, such as the ICD-10-CM code *K56.41 Fecal impaction* in this study, can render the code unmappable, despite the apparent lexical matching of terms. Other coding guideline conflicts can lead to inaccurate or suboptimal recoding under some specific circumstances.[7] The third condition is the alignment of the hierarchical structure of the 2 classifications, which is especially important for residual categories. Exact matching between residual categories assumes that they have the same, or at least compatible hierarchical context—ancestors, descendants, and siblings, which together delineate the meaning of the residual categories.

In our study, we used postcoordination only when exposing Foundation entities through a US linearization did not achieve exact match. Based on our findings, it is highly unlikely that a US linearization alone would be sufficient to replace ICD-10-CM. Postcoordination would most certainly be necessary as well.

Horizontal versus vertical sampling

Comparing the horizontal (all frequently used codes) and vertical (the whole digestive diseases chapter) sampling provides additional insights. In our previous study, we included some frequently used digestive disease codes, which had a higher-than-average exact match rate of 64% at the stem code level. In this study, the exact match rate of the whole digestive disease chapter is 38.7% because of inclusion of less commonly used codes, which are generally less well covered. The addition of Foundation entities results in a 16.8% increase in the coverage of digestive disease codes vs 6.4% for the frequently used codes. This could be explained as follows. Conditions that are less prevalent or considered less important usually do not get into a linearization and become stem codes. However, they are likely to be included as inclusion or index terms and become part of the ICD-11 Foundation. Exposing the Foundation entities, therefore, has a bigger impact on the vertical sample (containing less common conditions) than the horizontal sample (with more common conditions). Postcoordination increases the coverage in the frequently used codes to a greater extent than the digestive disease codes. This is probably attributable to the outsized impact of the codes for conditions related to pregnancy and injury or poisoning (making up 45% of all frequently used codes). Many of these codes contain information that can be added by postcoordination, such as duration of pregnancy and episode of care.

Cardinality

Cardinality is another important issue to consider. Ideally, 1 ICD-10-CM code is recoded to 1 and only 1 ICD-11 code. Cases that are not one-to-one maps can cause problems in code translation between the 2 classifications. Between one-to-many and many-to-one maps, one-to-many maps are arguably less problematic. One-to-many matches occur because there are finer grain (more specific) codes in ICD-11 compared to ICD-11, such as 2 separate codes for small or large intestine volvulus instead of 1 code in ICD-10-CM. If ICD-11 is used for primary coding, the more specific codes would roll-up to the general ICD-10-CM code without information loss or distortion. On the other hand, many-to-one matches are more problematic. The original ICD-10-CM code cannot be accurately recovered from the ICD-11 code because there is more than 1 possible ICD-10-CM code. We have identified 3 types of reasons for many-to-one matches. Problems related to residual categories constitute the most frequent reason, which could be resolved with better alignment of the code structure and coding guidelines. The second type of reason relates to some ICD-10-CM codes that can only be distinguished by some unspecified information. To understand the impact of lumping these ICD-10-CM codes together in an ICD-11 code will require a review of how often and under what situation these codes are used in real life. The third type of reason is related to arguably nonsynonymous inclusion and index terms in ICD-11, which is a quality issue that can lead to inaccurate coding. WHO should review these cases as a quality assurance process.

New stem codes

In our proposed strategy, the creation of US-specific stem codes is the last resort. This is because country-specific stem codes can potentially lead to divergence from the core ICD-11 and impair comparability of international statistics. It is encouraging that we only find a small number of cases requiring new stem codes. However, it is still imperative to keep this at a minimum. There are several ways to reduce the number of US-specific stem codes. Firstly, some codes that are identified initially as US specific may turn out to be required by other countries. WHO may then decide to promote them to the core ICD-11. Second, postcoordination can help to reduce the number of new stem codes. For example, instead of creating 3 new stem codes for *Long term (current) use of aspirin*, *Long term (current) use of anticoagulants*, and *Long term (current) use of insulin*, 1 only needs a new code for *Long term (current) use of medication*, and use postcoordination to specify the drug. Third, postcoordination can potentially be extended to include content from the WHO Family of

International Classifications (WHO-FIC), which comprises International Classification of Functioning, Disability and Health (ICF) (ICD) and International Classification of Health Interventions (ICHI).[22] According to WHO's vision, the WHO-FIC classifications will become more integrated and aligned, to be used alongside each other in future. In fact, ICD-11 and ICHI are already sharing extension codes for anatomy and drugs. In our study, there are cases in which new stem codes can be avoided if "extended post-coordination" within WHO-FIC is allowed. For example, the ICD-10-CM code *K94.39 Complications of esophagostomy* can be recoded as *PK80.3Z Gastrointestinal, abdominal, or abdominal wall procedure associated with injury or harm in therapeutic use, unspecified approach* postcoordinated with the ICHI code *KBA.LI.AA Oesophagostomy*.

Limitations and future work

We recognize the following limitations in this study. The sample of frequently used codes was derived from Medicare claims data and hospital data and may not be generalizable to other healthcare settings. We chose all codes from the digestive disease chapter, which may not be representative of other chapters. Recoding was done by 2 authors and the results were not externally validated. However, our previous study showed a satisfactory concordance rate in recoding by the same 2 authors. The judgment of clinically meaningful post-coordination was based on the clinical and terminological knowledge of the 2 authors. This study has focused only on the content perspective of replacing ICD-10-CM by ICD-11. Other factors to be considered, such as implementation challenges (eg, support of postcoordination) and costs, tooling and training requirements, and anticipated benefits will need to be further studied and addressed. We hope that this study will serve as a primer for more research, discussion and debate on this topic. There are certainly more questions to ask and perspectives to consider. In the future, we plan to study the potential advantages of using ICD-11 in morbidity coding.

CONCLUSION

Using a stepwise strategy, starting from stem codes and proceeding to include Foundation entities and postcoordination, the existing content of ICD-11 can fully represent 89.4% of the ICD-10-CM codes examined in our study, assuming that the coding guidelines and hierarchical structure of the 2 classifications are harmonized and aligned. The remainder will require either new stem or extension codes. Given the benefits of avoiding a CM, the 3 options examined in this study, the US linearization, Extension of extension, and ICD-11-CM lite, should be carefully considered before embarking on the traditional approach of a full-fledged ICD-11-CM.

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AUTHOR CONTRIBUTIONS

KWF, DP, and OB conceived and designed the study. JX and SM-L performed the recoding of ICD-10-CM codes and reviewed the coding guidance. KWF performed the data analysis. KWF drafted the manuscript and all authors contributed substantially to its revision.

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CONFLICT OF INTEREST STATEMENT

The authors do not have competing interests. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Library of Medicine, National Institutes of Health, National Center for Health Statistics, or the Centers for Disease Control and Prevention.

DATA AVAILABILITY

The Medicare claims data are available through the CMS Virtual Research Data Center. The results of recoding are available from the corresponding author, KWF, upon reasonable request.

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