Implementing a common data model in ophthalmology: Comparison of general eye examination mapping to standard OMOP concepts across two major EHR systems

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Background

Increasing utilization of various electronic health records (EHRs) has highlighted data standardization as an increasingly important objective in ophthalmology.[1,2] Data standards have wide-ranging benefits in both clinical settings and research, such as promoting efficient access to patient data and enabling interoperability between different EHR datasets.[3-7] One of the challenges associated with data standardization is that EHR implementations differ across institutions, resulting in limited interoperability due to variations in data structures and terminology. In ophthalmology, the specialized physical exam findings pose an additional barrier to data standardization.[8]

The Observational Medical Outcomes Partnership (OMOP) Common Data Model (CDM) was developed to harmonize disparate source data to standard vocabulary concepts. By transforming a dataset into OMOP CDM standard concepts, consistent and unambiguous interpretations of various source data can be obtained. However, previous literature has demonstrated significant coverage gaps by the OMOP CDM in all areas of the general eye examination of the Epic Foundation EHR system, with only one in four data elements having exact representations in the OMOP CDM.[9] In this study, we investigated the concept coverage of the standard "model experience" Cerner Millennium EHR and compared mappings with the Epic Foundation EHR in order to determine shared areas of poorly represented EHR concepts and to identify opportunities for improving representation of clinically relevant ophthalmology source data in the OMOP CDM.

Methods

The mapping methodology has been previously described for the Epic Foundation EHR and was adapted for mapping of Cerner Millennium ophthalmic exam elements.[9] Briefly, source data elements were extracted from the ophthalmology examination PowerForms of the default Cerner Model Experience implementation of the Cerner Millennium EHR (Kansas City, MO). All source data elements were mapped to the semantically closest standard concept in the OMOP CDM using the Automated Terminology Harmonization, Extraction, and Normalization for Analytics (Athena) web application and the USAGI software tool, which suggests possible target concepts using a textual similarity technique. All mappings were then classified by semantic equivalence of the source data element compared to its corresponding standard concept. The designations included *exact* for mappings with no loss or addition of information, *wider* for mappings that lost information when converted into the nearest standard concept, *narrower* if the standard concept included additional information that was not necessarily accurate, or *unmatched* if there was no standard concept in the OMOP CDM that adequately represented the source data element. Epic and Cerner mappings for semantically equivalent fields were compared.

Results

There were *exact* mappings in the OMOP CDM for only 25.9% (110/425) of Cerner and 25.4% (177/698) of Epic source data elements, respectively (Figure 1a). Imprecise (not *exact*) mappings spanned all areas of the general eye examination. Most of the remaining mappings were *wider* with loss of clinical granularity, accounting for 49.4% (210/425) of the default Cerner and 49.9% (348/698) of Epic mappings. For 19.3% (82/425) of Cerner and 21.2% (148/698) of Epic source data elements respectively, no mappings were possible due to a lack of semantically equivalent concepts in the OMOP CDM. The vast majority of data elements were mapped to standard concepts in either the Systematized Nomenclature of Medicine Clinical Terms (SNOMED CT) or Logical Observation Identifiers, Names and Codes (LOINC) vocabularies (Figure 1b).

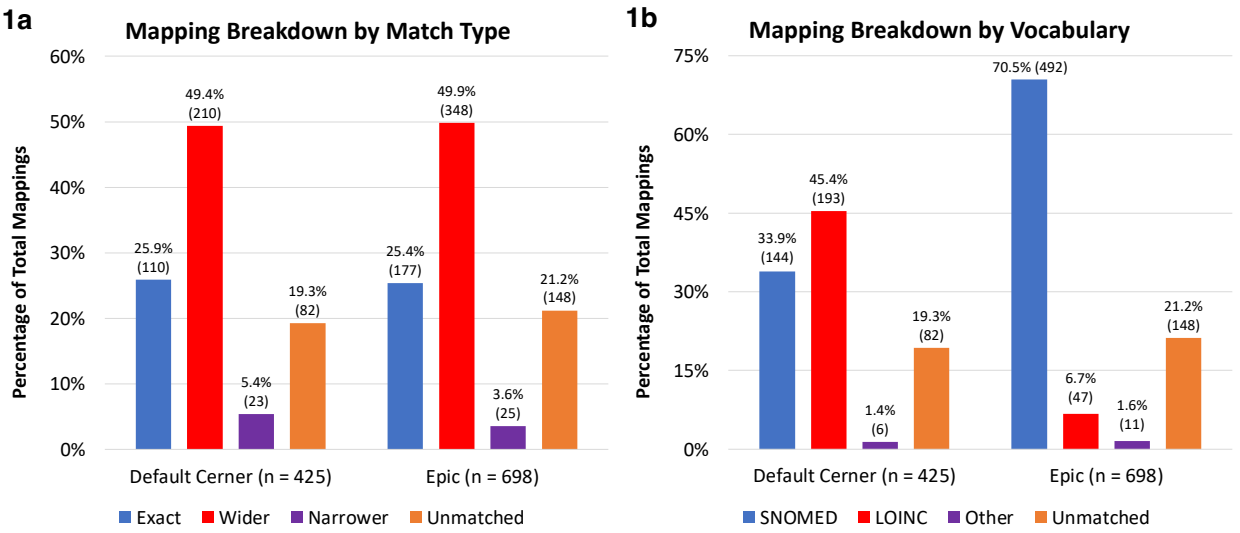

Figure 1. Distribution of mappings for source data elements to OMOP standard concepts by (a) match type and (b) vocabulary of target standard concept

One key discrepancy between Epic and Cerner mappings was the proportion of *wider* mappings that were missing laterality. Laterality was missing in 75.6% of *wider* mappings for the Epic EHR, compared to 38.6% for the Cerner EHR (Figure 2a, b). This discrepancy was due to differences in the vocabularies for target standard concepts. The Epic mapping preferred SNOMED terms, which comprised 90% of data elements excluding unmatched terms, whereas SNOMED terms comprised only 33.9% of Cerner mappings. LOINC mappings were missing laterality in less than 10% of mapped Cerner EHR concepts (Figure 3a, b). This difference is primarily due to whether laterality information was pre-coordinated into the standard concept itself, or left as a post-coordination modifier. Because laterality is an important inclusion criterion in ophthalmology research studies, standardizing whether laterality is pre-coordinated or post-coordinated with OMOP standard concepts is an opportunity for streamlining efficient data access.

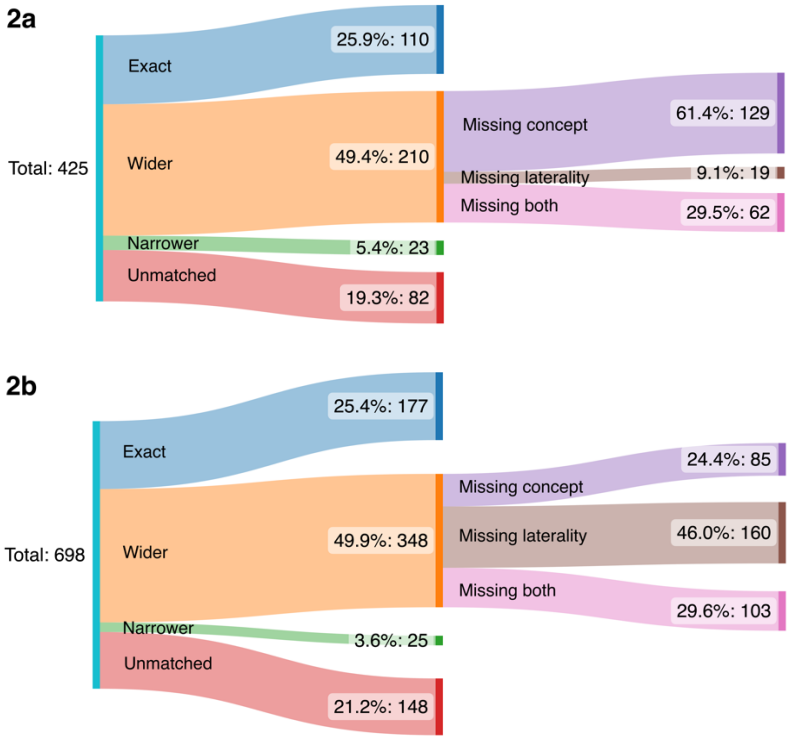

Figure 2. Sankey diagrams depicting match type breakdown for (a) Cerner EHR and (b) Epic EHR general eye exam source data

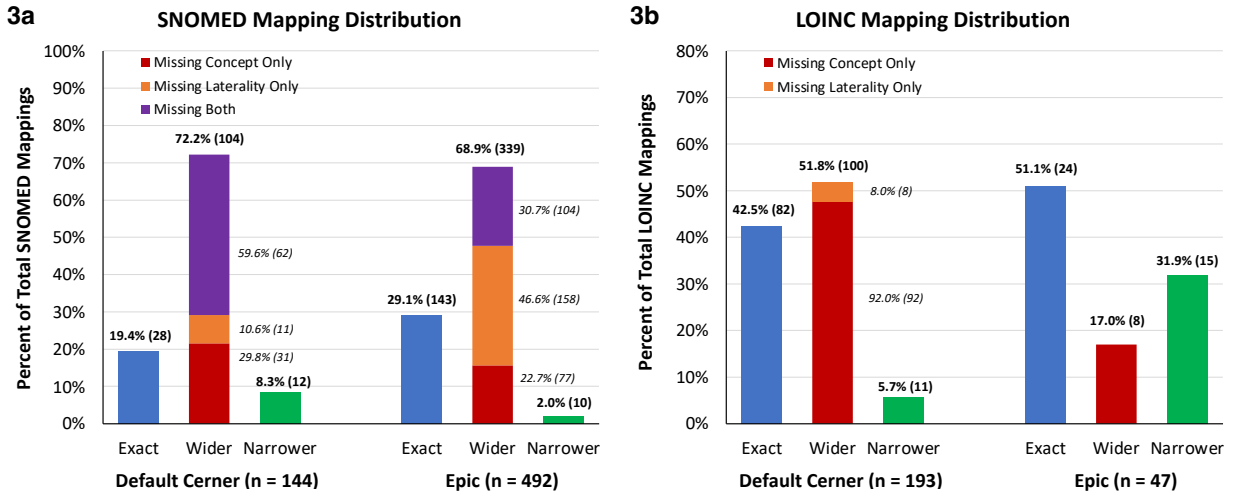

Figure 3. Distribution of match type separated by (a) SNOMED target standard concepts and (b) LOINC target standard concepts

During the mapping process, inconsistencies in how the OMOP CDM handles semantically equivalent standard concepts were also discovered. For instance, the data element *left eye IOP* had semantically equivalent mappings to both SNOMED and LOINC, but the OMOP CDM listed *Intraocular pressure of left eye [SNOMED]* and *Left eye Intraocular pressure [LOINC]* as two distinct concepts in the same domain.

This illustrates the need to harmonize semantically equivalent standard concepts so that a source element would not have ambiguous mappings to duplicated concepts. Another example of an inconsistency in the OMOP CDM is that *LogMAR visual acuity left eye* is classified under the *[observation]* table, but there exists another distinct concept for *Visual acuity log MAR Eye – left* under the *[measurement]* domain. In this situation, improving data standards would involve standardizing the storage location of eye exam data to maintain consistency.

Conclusion

In conclusion, we demonstrate that the OMOP CDM has coverage gaps for all areas of the general eye exam, which may limit the utility of the CDM in clinical practice and research. Suggestions for improving concept coverage and efficiency of data access may involve adding more clinical granularity to standard concepts, standardizing pre-coordination or post-coordination for laterality, ensuring that semantically equivalent concepts have unambiguous mappings, and harmonizing the storage location of eye exam data.

References

1. Baxter SL, Apathy NC, Cross DA, Sinsky C, Hribar MR. Measures of electronic health record use in outpatient settings across vendors. J Am Med Inform Assoc. 2021;28:955-9.
2. Halfpenny W, Baxter SL. Towards effective data sharing in ophthalmology: data standardization and data privacy. Curr Opin Ophthalmol. 2022;33:418-24.
3. Ahmadi N, Peng Y, Wolfien M, Zoch M, Sedlmayr M. OMOP CDM can facilitate data-driven studies for cancer prediction: a systematic review. Int J Mol Sci. 2022;23:11834.
4. Baxter SL, Reed AA, Maa A, Boland MV, Borkar DS, Brown EN, et al. Ocular health and national data standards: a case for including visual acuity in the United States Core Data for Interoperability. Ophthalmol Sci. 2022;2:100210.
5. Quiroz JC, Chard T, Sa Z, Ritchie A, Jorm L, Gallego B. Extract, transform, load framework for the conversion of health databases to OMOP. PLoS One. 2022;17:e0266911.
6. Si Y, Weng C. An OMOP CDM-Based Relational Database of Clinical Research Eligibility Criteria. Stud Health Technol Inform. 2017;245:950-4.
7. Mun Y, You SC, Lee DY, Kim S, Chung YR, Lee K, et al. Real-world incidence of endophthalmitis after intravitreal anti-VEGF injections in Korea: findings from the Common Data Model in ophthalmology. Epidemiol Health. 2021;43:e2021097.
8. Chiang MF, Boland MV, Brewer A, Epley KD, Horton MB, Lim MC, et al. Special requirements for electronic health record systems in ophthalmology. Ophthalmology. 2011;118:1681-7.
9. Cai CX, Halfpenny W, Boland MV, Lehmann HP, Hribar M, Goetz KE, Baxter SL. Advancing toward a common data model in ophthalmology: gap analysis of general eye examination concepts to standard OMOP concepts. Ophthalmology Science, https://doi.org/10.1016/j.xops.2023.100391.