A survey of OMOP CDM-compatible visualization tools & what the community may do to support tool development and adoption

Natthawut Adulyanukosol†‡, David Gotz†
† University of North Carolina at Chapel Hill, North Carolina, USA
‡ Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok, Thailand

Background

Data visualization generates a visual representation of data that enables data exploration and data analytics to gain new information or insights as well as explains such insights to the intended audience. In the healthcare settings, there are over 50 visualization tools published in peer-reviewed journals, as reviewed in existing papers.[1, 2] One main obstacle of adopting these tools in new environments or institutions is the vast differences in data source models. The standardization of data models, such as OMOP CDM and HL7 FHIR, considerably eases the adoption of visualization and analytics tools. This survey aims to characterize OMOP CDM-compatible visualization tools and identify opportunities for new visualization tools with OMOP CDM support.

Methods

We systematically reviewed the literature with the following eligibility criteria: (1) the visualization tool or system was created to use OMOP CDM as its main data source, (2) written in English, and (3) original peer-reviewed work. Search terms or were grouped into two categories: (1) visualization, which consisted of three terms: *information visualization*, *visual analytics*, and *dashboard*, (2) data model, which consisted of two terms: *OMOP CDM* and *OHDSI*. Within each group, the keywords were combined using "OR" logic. Then, two keyword groups were combined using "AND" logic. Searches were conducted in PubMed and Scopus in May 2022.

Results

Our searches yielded 80 articles (PubMed n = 10 and Scopus n = 70). We removed 6 duplicates. The 74 remaining records were assessed for eligibility with 7 records retained for further classification. The included articles cited 3 relevant publications that were not already included, and one additional article was added manually. Thus, there are 11 records for qualitative analysis. The screening process is summarized as a PRISMA flow diagram[3] in **Figure 1**.

The included publications are summarized in **Table 1**. The tools were grouped by their sources (standard OHDSI tools or non-OHDSI tools) and the applicable scope of usage of the tools. A broad scope is recognized by the generalizability of a given tool to all or most datasets in OMOP CDM, while a tool with a limited scope supports only some datasets or scenarios, namely certain fields of medicine. Detailed summaries of the tools are reported in **Table 2**.

Most of the reviewed tools provide open-source libraries that are generalizable to other research and connectable to databases with data in the OMOP CDM format. These 3 features (open-source, generalizability, and database connection) are crucial for tool adoption by other users. Conversely, lacking any of the 3 features limits the applicability of the tools to other use cases.

Only two included publications report evaluation studies of the visualization tools.

Our searches were limited to articles that specifically mentioned visualization work. It is probable that there are other visualization methods compatible with OMOP CDM that leverage visualization libraries in R or Python, for example.

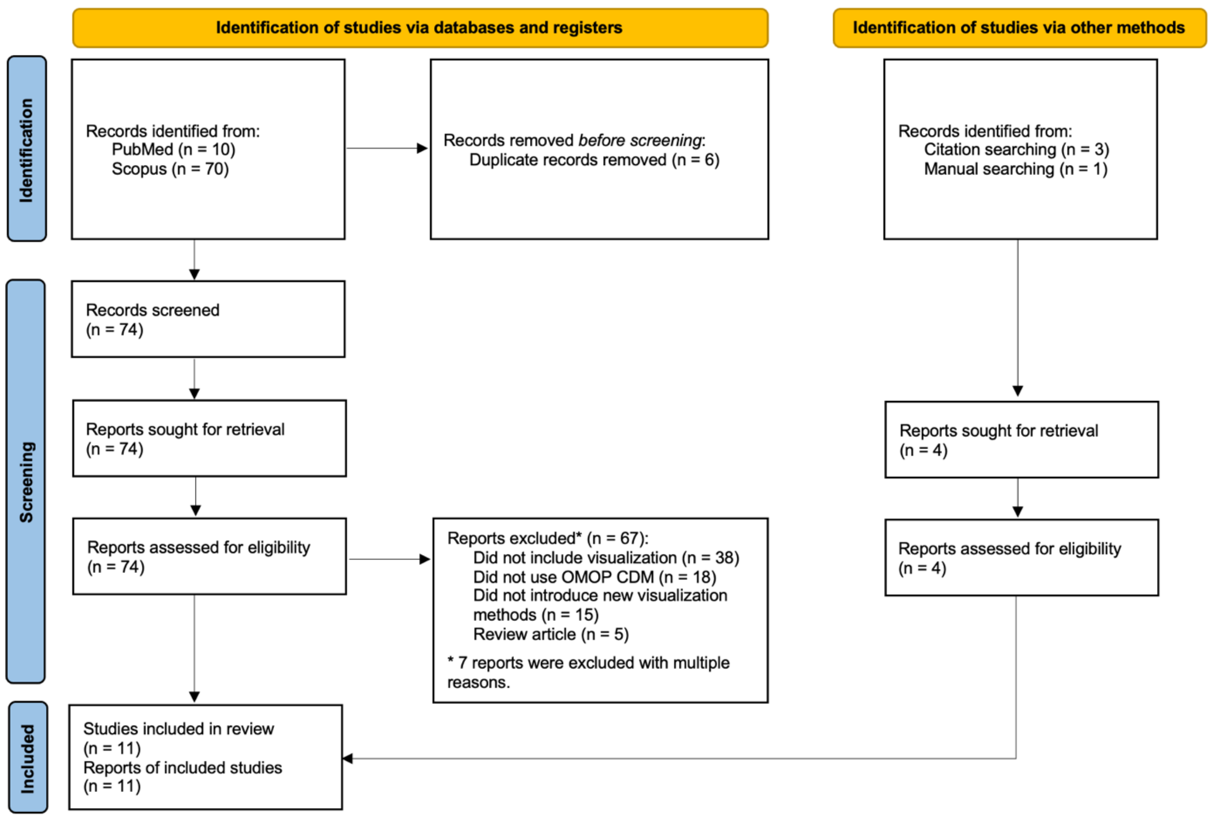

Figure 1: PRISMA flow diagram.

Table 1: Statistical summary of all included publications. (n = 11)

		n	%
Source	PubMed [a]	5	45
	Scopus	2	18
	Citation network	3	27
	Manual	1	9
Publication year	2022	1	9
	2021	5	45
	2020	2	18
	2019	1	9
	2016	2	18
Study location	North America	7	64
	Europe	4	36
Target audience	Academicians	10	91
	Healthcare providers	2	18
Data source in OMOP CDM	Database connections	10	91
	Static files	1	9
	Undefined	1	9
Visualization type	Data analysis too	5	45
	Data quality tool	3	27
	Data query tool	2	18
	Dashboard	2	18
Programming language	R	7	64
	Java	3	27
	JavaScript	3	27
	Python	2	18
Evaluation of visualization	Structured interview	1	9
	User feedback	1	9
	Not reported	9	82

[a] Publications indexed in both PubMed and Scopus count as PubMed in the source.

Table 2: Classification of all included publications. (in chronological order)

	Publication year	Summary	Target audience	Data source in OMOP CDM	Visualization type	Programming language
OHDSI tools with a broad scope of usage (n = 4)						
Huser *et al.* 4	2016	OHDSI Achilles with evaluation by structured interviews	Academicians	Database connections	Data quality tool	R
Hripcsak *et al.* 5	2016	Sunburst plot that is later integrated in OHDSI Atlas	Academicians	Database connections	Data analysis tool	JavaScript
Dixon *et al.* 6	2020	Extensions to OHDSI Atlas	Academicians	Database connections	Data quality tool	Java; JavaScript
Blacketer *et al.* 7	2021	OHDSI Data Quality Dashboard	Academicians	Database connections	Data quality tool	R
Non-OHDSI tools with a broad scope of usage (n = 4)						
Glicksberg *et al.* 8	2019	PatientExploreR visualizing patient timeline	Academicians	Database connections	Data analysis tool; Data query tool	R
Callahan *et al.* 9	2021	Advanced Cohort Engine (ACE), a scalable time-aware data query application	Academicians	Database connections; Static files	Data query tool	Java; Python; R
Boudis *et al.* 10	2021	Sankey diagram visualizing clinical pathways	Academicians	Database connections	Data analysis tool	R; JavaScript
Kunnapuu *et al.* 11	2022	Trajectories detecting disease comorbidity trajectories	Academicians	Database connections	Data analysis tool	R
Non-OHDSI tools with a limited scope of usage (n = 3)						
Felmeister *et al.* 12	2020	Visualization for pediatric brain cancer research with evaluation by user feedback	Academicians	Database connections	Data analysis tool	Python
Lamer *et al.* 13	2021	Anesthesia dashboard	Academicians; Healthcare providers	Database connections	Dashboard	R
Zoch *et al. 14*	2021	Dashboard of rare disease patients	Healthcare providers	Undefined	Dashboard	Java

Conclusion

We observed a considerable growth in the number of publications describing new tools in the last 2 years (2021 and 2022), which coincides with the increase in the number of publications from the OHDSI community in the recent years. Further visualization tools leveraging OMOP CDM could be introduced to address other visual analytics scenarios, such as machine learning-incorporated visualization and longitudinal exploratory analyses, that will benefit observational research. Finally, we offer suggestions for the community to support further tool development and adoption:

1. curate existing OMOP CDM-compatiable visualization tools in addition to the current list on OHDSI Software Tools webpage (https://www.ohdsi.org/software-tools) or as an additional page on the OHDSI Community Dashboard (http://dash.ohdsi.org),
2. support new tool development and the refitting of existing tools to support OMOP CDM by preparing additional guidelines and best practices that promote open-source, generalizability, and database connection features, and
3. encourage more visualization evaluation studies and publications of the tools.

References/Citations

1. Wu DTY, Chen AT, Manning JD, Levy-Fix G, Backonja U, Borland D, et al. Evaluating visual analytics for health informatics applications: a systematic review from the American Medical Informatics Association Visual Analytics Working Group Task Force on Evaluation. J Am Med Inform Assoc. 2019;26(4):314-23.
2. Wang Q, Laramee RS. EHR STAR: The State-Of-the-Art in Interactive EHR Visualization. Comput Graphics Forum. 2021;41(1):69-105.
3. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 2021;372:n71.
4. Huser V, DeFalco FJ, Schuemie M, Ryan PB, Shang N, Velez M, et al. Multisite Evaluation of a Data Quality Tool for Patient-Level Clinical Data Sets. EGEMS (Wash DC). 2016;4(1):1239.
5. Hripcsak G, Ryan PB, Duke JD, Shah NH, Park RW, Huser V, et al. Characterizing treatment pathways at scale using the OHDSI network. Proc Natl Acad Sci U S A. 2016;113(27):7329-36.
6. Dixon BE, Wen C, French T, Williams JL, Duke JD, Grannis SJ. Extending an open-source tool to measure data quality: case report on Observational Health Data Science and Informatics (OHDSI). BMJ Health Care Inform. 2020;27(1).
7. Blacketer C, Defalco FJ, Ryan PB, Rijnbeek PR. Increasing trust in real-world evidence through evaluation of observational data quality. J Am Med Inform Assoc. 2021;28(10):2251-7.
8. Glicksberg BS, Oskotsky B, Thangaraj PM, Giangreco N, Badgeley MA, Johnson KW, et al. PatientExploreR: an extensible application for dynamic visualization of patient clinical history from electronic health records in the OMOP common data model. Bioinformatics. 2019;35(21):4515-8.
9. Callahan A, Polony V, Posada JD, Banda JM, Gombar S, Shah NH. ACE: the Advanced Cohort Engine for searching longitudinal patient records. J Am Med Inform Assoc. 2021;28(7):1468-79.
10. Boudis F, Clement G, Bruandet A, Lamer A. Automated Generation of Individual and Population Clinical Pathways with the OMOP Common Data Model. Stud Health Technol Inform. 2021;281:218-22.
11. Kunnapuu K, Ioannou S, Ligi K, Kolde R, Laur S, Vilo J, et al. Trajectories: a framework for detecting temporal clinical event sequences from health data standardized to the Observational Medical Outcomes Partnership (OMOP) Common Data Model. JAMIA Open. 2022;5(1):ooac021.
12. Felmeister AS, Waanders AJ, Mason JL, Stevens J, Bailey LC, Ganesan S, et al., editors. A Framework for Analysis, Ontological Evaluation, and Visualization in Preparation to Predictive Analytics in Pediatric Brain Tumor Research2020: Institute of Electrical and Electronics Engineers Inc.

13. Lamer A, Abou-Arab O, Bourgeois A, Parrot A, Popoff B, Beuscart JB, et al. Transforming Anesthesia Data Into the Observational Medical Outcomes Partnership Common Data Model: Development and Usability Study. J Med Internet Res. 2021;23(10):e29259.
14. Zoch M, Gierschner C, Peng Y, Gruhl M, Leutner LA, Sedlmayr M, et al. Adaption of the OMOP CDM for Rare Diseases. Stud Health Technol Inform. 2021;281:138-42.