Observational Research in Dentistry: A Scoping Review

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Background

Evidence-based practice is intended to combine the best available research, clinical experience of the provider, and preferences of the patient to deliver the best care possible (1). Traditionally, dental research has been conducted as either randomized controlled trials or prospective cohort studies. While these provide evidence to support clinical decisions, they are often costly, conducted outside of real-world environments, and may not adequately reflect the realities of patients or interventions because they are not easily generalizable.

Observational research offers an alternative method of studying patient characterizations, population health estimates, and patient level predictions (2). Observational research has several advantages over traditional research methods: notably, lower cost, better generalization, and timeliness (3). The ever-growing amount of patient level data from electronic health records (EHRs), clinical registries, insurance claims, and other data sources provides the opportunity to conduct large scale observational research studies, but disparate datasets from the many healthcare institutions lack common data standards.

Common Data Models (CDM) are uniform sets of meta data that share an agreed upon standardized vocabulary. CDMs standardize data across many disparate datasets and care settings and to allow efficient analytics across organizations (2). Several common data models have been developed. One example is the Observational Medical Outcomes Partnership Common Data Model (OMOP-CDM). Many common data models, like OMOP-CDM, have been adopted by open-source communities that develop analytic tools and governance for the data models that enable observational research to be widely available to medical researchers and clinicians.

Dentistry is moving toward adoption of a learning health system. A learning health system is “designed to generate and apply the best evidence for the collaborative healthcare choices of each patient and provider; to drive the process of discovery as a natural outgrowth of patient care; and to ensure innovation, quality, safety, and value in healthcare.” (4) Patient-level data, such as data from the EHR, can be analyzed to produce real-world evidence that may inform clinical practice (2). Moreover, it is crucial that, sooner rather than later, the dental profession considers implementing a CDM to enhance observational research and improve their ability to provide evidence-based care for patients.

Methods

A scoping review is underway following the PRISMA-ScR protocol (5) to determine the current state of observational research using patient-level data in dentistry. The following research aims were formulated: 1. Describe observational research implementations and challenges in dentistry, and 2. Describe characteristics of successful implementations of observational research in healthcare.

The search strategy was developed with the guidance of a Johns Hopkins University informationist. Additional articles were discovered through interviews with subject matter experts in dental informatics. Searches are being conducted in PubMed and Scopus to address the two research questions. Citations are loaded to Covidence and are screened and reviewed by the authors.

Inclusion criteria:

- Use patient-level data from multiple sources (different institutions) or types (e.g., EDR data and insurance claims data) to conduct observational dental research.
- Uses or discusses a common data model or standardized terminology to conduct dental research.
- Discusses the implications, challenges, or attempts to conduct observational research using common data model or standardized terminology in dentistry.
- Discusses or explains implementing a common data model, standardized terminology, or common data model open-source tools in a certain healthcare setting (e.g., a hospital enterprise) or specialty (e.g., mapping use cases from solid organ transplant, anesthesia, polysomnography to a common data model)
- Discusses the implications or challenges of implementing a common data model, standardized terminology, or common data model open-source tools on healthcare in a given setting or specialty.

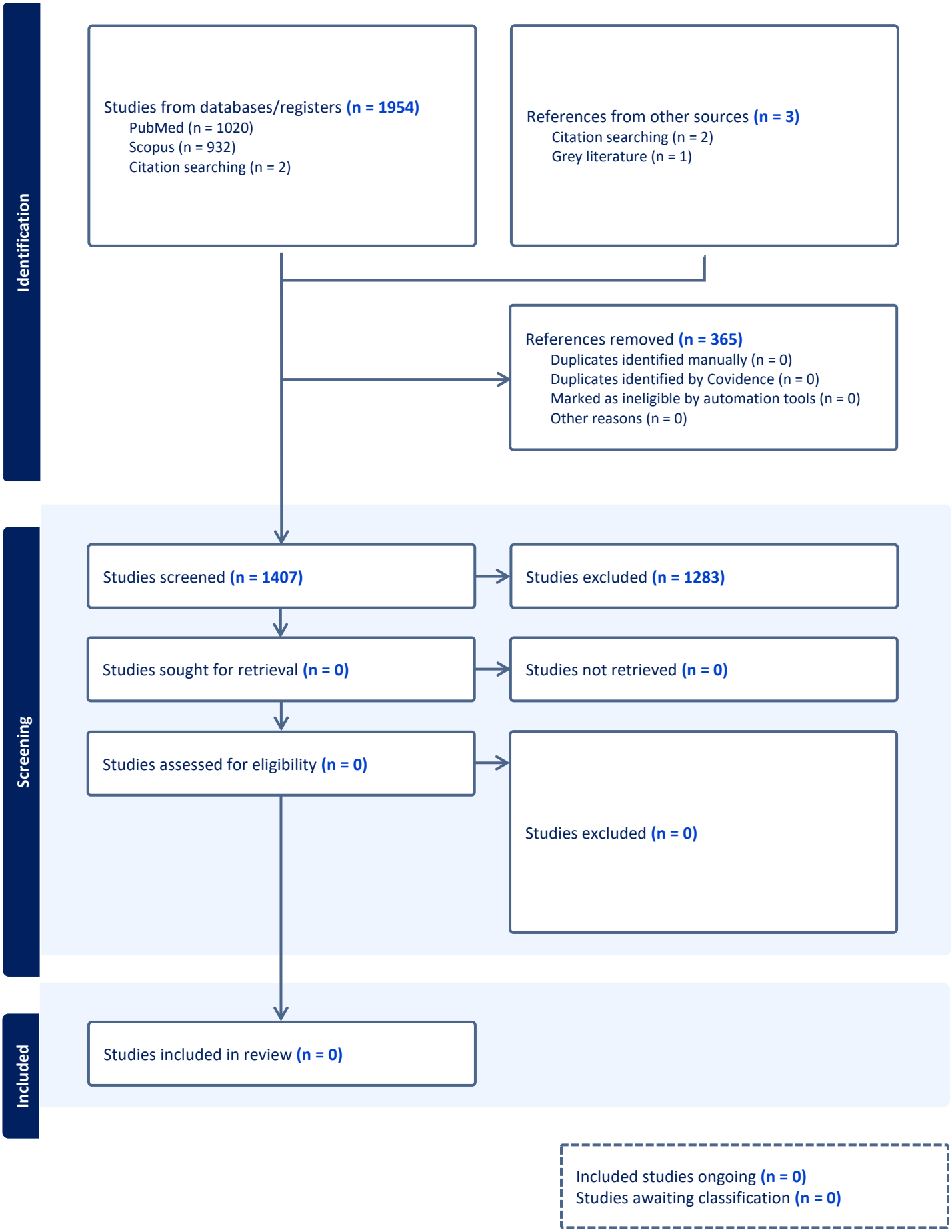
Exclusion criteria:

- Article published before 2010.
- Article is not related to observational research (e.g., a cohort study answering a clinical research question from one site or data source that does not use a common data model or standardized terminology
- Article does not pertain to the process of conducting observational research with health data.
- Letters to the editor, editorials, critical reviews

Results

The scoping review is approximately 50% complete. The current complete work includes the screening of 1407 Aim 1 articles and several rounds of informal review within the workgroup. 1407 studies have been screened so far with 1283 excluded. There are 119 articles that still require screening from Aim 1. A total of 124 articles from the Aim 1 search are ready to review. Additional searches in PubMed and Scopus for Aim 2 are ongoing. The search strategies will be reviewed and refined based on the experiences and results from Aim 1. A formal review of the Aim 1 articles is currently underway. Covidence has proven to be an effective tool for screening and review. Two additional articles were included based on interviews with subject matter experts and the articles also appeared in the PubMed search (6, 7). An additional gray literature article was included based on an interview from another subject matter expert (8).

Current Prisma Diagram (as of Oct 5, 2023)



Discussion

The scoping review is expected to demonstrate the current state of observational research in dentistry, offer examples of its historic uses in dentistry, and provide strategies to facilitate implementation and adoption of observational research in the dental profession.

The current findings based on the articles currently under review highlight the nascent but promising nature of observational research in dentistry. The main findings from the reviewed literature are that observational research in dentistry is less developed because dentistry lacks a widely utilized standardized terminology and that dental records are often incomplete or missing data, which leads to quality issues when conducting observational research with patient level dental data (9).

Dentistry does not have a widely adopted standardized terminology (10). Though there are existing standardized terminologies, including the American National Standards Institute (ANSI) accepted SNODENT, few institutions utilize a standardized terminology in production. Additionally, "SNODENT had quality issues, mainly due to confusion between terms and concept codes (for example, unclear relationships between terms and concepts, polysemic concepts, subsumption problems, etc.)"(9).

The Oral Health and Disease Ontology (OHD) was developed to address some of the deficiencies of SNODENT. The OHD uses a single identifier for each class, making its terms more clearly defined. The Oral Health and Disease Ontology is still being developed, but is not routinely updated, though shows promise as a standard dental diagnostic terminology (6, 11).

The most commonly used terminology for dentistry is the CDT, which is used in nearly all United States dental billing (8). The CDT includes both diagnostic and treatment codes that dental providers use to record what services were provided at a care visit. In the unpublished study by Huser, CDT codes were successfully mapped to SNODENT codes as part of a larger study to map Medicaid data to the OMOP-CDM. The researcher in the study estimated that 90% of billed events could be mapped with the thirty most frequently used codes, suggesting that mapping even a small portion of dental terminology could yield high value in observational research.

Researchers from Indiana University conducted an observational research study using electronic dental record (EDR) data from ninety-nine private dental practices (7, 12). The study used structured field data to perform a survival analysis of posterior composite restorations and root canal treated teeth. The researchers discovered that while much of the structured field data was overwhelmingly complete and utilized similar coding, many important diagnostic and treatment elements were contained in unstructured data that could not be analyzed in the study. The researchers found that documentation for diagnoses and findings were highly variable across dental practices, pointing to a lack of standardization. An overall finding of this scoping review was that both schema and instance level errors were found routinely in EDR data (13).

In 2022, researchers in Korea successfully completed the first known study of dental data utilizing the OMOP-CDM. The goal of the study was "to compare the incidence of periodontitis by menopausal status and to investigate the possible effect of HRT on periodontitis in postmenopausal women using a CDM at a single institution." (14) The study included over 29,000 patients from a single Korean hospital. The authors were successfully able to demonstrate a higher incidence of periodontal disease among postmenopausal patients compared to non-menopausal patients. The authors specifically cited

insufficient relevant CDM data coverage and detailed clinical information for periodontal disease as key limitations of the study.

Conclusion

Dentistry has nascent but growing capabilities to conduct observational research. This scoping review highlights key challenges and successes to conduct observational research on oral health topics. Ultimately, this scoping review will present the current landscape of observational research in dentistry and provide key insights on areas where researchers should focus to improve dentistry's capabilities to conduct observational research.

References

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Appendix 1: Searches Used

Pub Med

("Evidence Gaps"[Mesh] OR "evidence gap"[tiab] OR "evidence gaps"[tiab] OR "Comparative-effectiveness research"[tiab] OR "Comparative effectiveness research"[tiab] OR "patient data"[tiab] OR "Vocabulary, Controlled"[Mesh] OR "common data model*"[tiab] OR "ohdsi*" [tiab] OR "omop*" [tiab] OR "observational health data sciences and informatics*" [tiab] OR ("observational health data sciences"[tiab] AND informatics* [tiab]) OR "observational medical outcomes partnership*" [tiab] OR "omop-cdm"[tiab] OR "pcornet"[tiab] OR "patient-centered outcomes research institute"[tiab] OR "patient centered outcomes research institute"[tiab] OR "pcori"[tiab] OR "sentinel"[tiab] OR "cdisc"[tiab] OR "clinical data interchange standards consortium"[tiab] OR "clinical data exchange"[tiab] OR “electronic dental record”[tiab] OR (“data mapping” [tiab] OR “data-mapping” [tiab]) OR ("Health Care systems Research Network"[tiab] AND "Virtual Data Warehouse"[tiab]))
AND
("Dentistry"[Mesh] OR "Dentists"[Mesh] OR "Dental Informatics"[Mesh] OR dentistry[tiab] OR dentist[tiab] OR dentists[tiab] OR dental[tiab] OR "Mouth Diseases"[Mesh] OR periodont*[tiab] OR tooth[tiab] OR teeth[tiab] OR "Oral health"[Mesh] OR "oral health"[tiab] OR "Dental Facilities"[Mesh] OR prosthodont*[tiab] OR orthodont*[tiab] OR endodont*[tiab] OR "oral surgery"[tiab] OR maxillofacial[tiab] OR "orofacial pain"[tiab] OR pedodont*[tiab] OR gerodontology* OR [tiab] OR "temporomandibular"[tiab] OR dentition[tiab])
AND
(2010:2023[pdat])
NOT
(“sentinel node”[tiab] OR “case study”[tiab] OR “case studies”[tiab] OR “rna”[tiab] OR “lncRNA”[tiab] OR “miRNA”[tiab] OR “mRNA”[tiab] OR “ceRNA”[tiab])

Conducted 23 March 2023

Aim1 Supplemental PubMed search
((“observational research”[tiab] OR “research design*” [tiab] OR “study design*” [tiab] OR “electronic health record*”[tiab] OR “ehr” [tiab] OR “ehrs” [tiab] OR “electronic medical record*”[tiab] OR “emr” [tiab] OR “emrs” [tiab] OR “electronic dental record*”[tiab] OR “edr”[tiab] OR “edrs”[tiab] OR “common data model*”[tiab] OR “ontolog*”[tiab] OR “medical record*”[tiab]) **AND** (“Electronic Health Records”[Mesh] OR “Vocabulary, Controlled”[Mesh] OR “Knowledge Bases”[Mesh] OR “Big Data”[Mesh] OR “Community Networks”[Mesh] OR “Data Mining”[Mesh] OR “Data Warehousing”[Mesh] OR “Observational Studies as Topic”[Mesh] OR “Computer Simulation”[Mesh] OR “Databases, Factual”[Mesh] OR “Medical Informatics”[Mesh] OR “Models, Theoretical”[Mesh] OR “Semantics”[Mesh] OR “Feasibility Studies”[Mesh] OR “Reproducibility of Results”[Mesh] OR “Data Analysis”[Mesh] OR “Medical Records”[Mesh] OR “Computer Communication Networks”[Mesh] OR “Cohort Studies”[Mesh])) **AND (**(“dentist*”[tiab] OR “dental”[tiab] OR “dental informatics”[tiab]) **AND** ("Dentistry"[Mesh] OR “Dentists”[Mesh] OR “Dental Informatics”[Mesh])) **NOT** (“Epidemiologic Studies”[Mesh]) **AND** (“2010/01/01”[dp]:”3000”[dp])
Conducted 4 Oct 2023 (214 results)

Scopus

Aim 1: Describe observational research implementations and challenges in dentistry
TITLE-ABS-KEY("evidence gap*" OR "Comparative-effectiveness research" OR "Comparative effectiveness research" OR "patient data" OR "Vocabulary, Controlled" OR "common data model*" OR "ohdsi*" OR "omop*" OR "observational health data sciences and informatics*" OR ("observational

health data sciences" AND informatics*) OR "observational medical outcomes partnership*" OR "omop-cdm" OR "pcornet" OR "patient-centered outcomes research institute" OR "patient centered outcomes research institute" OR "pcori" OR "sentinel" OR "cdisc" OR "clinical data interchange standards consortium" OR "clinical data exchange" OR "electronic dental record" OR ("data mapping" OR "data-mapping") OR ("Health Care systems Research Network" AND "Virtual Data Warehouse"))
AND
(TITLE-ABS-KEY("Dentistry" OR "Dentists" OR "Dental Informatics" OR dentistry OR dentist OR dentists OR dental OR "Mouth Diseases" OR periodont* OR tooth OR teeth OR "Oral health" OR "oral health" OR "Dental Facilities" OR “prosthodont*” OR “orthodont*” OR “endodont*” OR "oral surgery" OR maxillofacial OR "orofacial pain" OR “pedodont*” OR “gerodontology*” OR "temporomandibular" OR dentition))
AND
(PUBYEAR > 2009 AND PUBYEAR < 2024)
NOT
(TITLE-ABS-KEY("sentinel node" OR "case study" OR "case studies" OR "rna" OR "lncRNA" OR "miRNA" OR "mRNA" OR "ceRNA" OR **“sentinel lymph node” OR “oral squamous cell”))**

Conducted 25 Jul 2023

Additional sources of articles (Interviews):

Duncan, W. (2022). *Interview with William Duncan Regarding the Oral Health and Disease Ontology* [Interview].

Duncan, W. D., Thyvalikakath, T., Haendel, M., Torniai, C., Hernandez, P., Song, M., Acharya, A., Caplan, D. J., Schleyer, T., & Ruttenberg, A. (2020). Structuring, reuse and analysis of electronic dental data using the Oral Health and Disease Ontology. *J Biomed Semantics*, *11*(1), 8. https://doi.org/10.1186/s13326-020-00222-0

AND

Thyvalikakath, T. (2022). *Interview with Thankum Thyvalikakath Regarding EDR Data Use in Research* [Interview].

Thyvalikakath, T. P., Duncan, W. D., Siddiqui, Z., LaPradd, M., Eckert, G., Schleyer, T., Rindal, D. B., Jurkovich, M., Shea, T., & Gilbert, G. H. (2020). Leveraging Electronic Dental Record Data for Clinical Research in the National Dental PBRN Practices. *Appl Clin Inform*, *11*(2), 305-314. https://doi.org/10.1055/s-0040-1709506

AND

Huser, V. (2022). *Interview with Thankum Thyvalikakath Regarding Mapping SNOMED CT for dental research* [Interview via email].

Huser, V. (2021). *Using SNOMED CT procedural concepts for dental research: US Medicaid use case*.