**Methods as an organizing structure for science: professional biomedical literature as an example**

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This paper argues that methods can be seen as a meso-level organizing structure in science. Domains of study can be defined in terms of the questions or problems they take as a starting point, the assumptions they take for granted, or the methods that they use.

This paper argues, more specifically, that in the biomedical literature methods can be seen as an organizing structure that bridge between individual papers reporting research, and idealized notions of how research in biomedicine is done. To do this, the paper analyzes three methodology-focused Knowledge Organization Systems (KOSs) used for organizing and retrieving clinical medical research literature. One KOS is primarily used to design clinical research, and the other two are primarily used to appraise it. The examples are drawn from epidemiology, evidence-based medicine, and knowledge/evidence base construction; are at different levels of consensus and adoption; and are all inform information retrieval of research literature in clinical medicine. The three KOSs are a classification of clinical research study designs, an evidence pyramid providing a hierarchy of those and other designs, and the evidence type representations in the Drug-drug Interaction and Drug-drug Interaction Evidence Ontology (DIDEO). These classifications serve different purposes: canonicalizing the types of clinical research expected, comparing the evidentiary value of different types of clinical research studies, and establishing the relevant designs for a particular application.

Our first KOS, a classification of clinical research study designs, is ubiquitous. In describing the design of clinical research, epidemiology textbooks classify studies as either observational or experimental and as either prospective or retrospective. Specific study designs are widely agreed upon: case reports and case series, case-control studies, cohort studies, and randomized controlled trials. They frequently appear in research paper titles and are the subject of reporting guidelines such as STROBE (Vandenbroucke et al. 2007) and CONSORT (Begg et al. 1996). Each design has a Medical Subject Heading (MeSH) which can be used for retrieval.

Our second KOS, an evidence pyramid, classifies these and other study designs into hierarchical “levels of evidence” with the “best” study designs at the top of the pyramid. There is not just a single consensus pyramid; for instance, in previous work, Schneider & Jackson (2018) have commented that secondary literature is seen sometimes, but not always, atop the pyramid. This secondary literature such as systematic reviews and clinical practice guidelines synthesizes the clinical research to identify gaps and inform clinical decision-making. The evidence pyramid functions as a KOS when used for quality appraisal and in guiding secondary studies, which retrieval focuses on the pyramid’s top (e.g., systematic reviews, randomized controlled trials) and to a lesser extent on its middle tier (cohort studies, and case-control studies). We draw evidence from medical librarians’ information retrieval priorities (e.g., the 38 randomized controlled trial filters compared by McKibbon et al. 2009). We also describe how retrieval focusing on the top of the evidence pyramid is being tested as a way to achieve high-precision high-recall information retrieval for systematic reviews in our ongoing research in a collaborative, National Library of Medicine-funded project on facilitating systematic reviews.

Our third KOS classifies the study designs relevant to establishing drug-drug interactions in an knowledge/evidence base called the Drug Interaction Knowledge Base (DIKB) (Boyce et al. 2009). Inclusion criteria for the DIKB first took the form of an evidence taxonomy (Boyce 2015) of relevant study designs. This was subsequently formalized as the evidence type representation within an ontology, DIDEO (Brochhausen et al. 2016). These study designs, which are substantially more granular than those of the first and second KOS, are currently manually assessed and annotated. To enable large-scale information retrieval, in ongoing work we are testing hierarchical classification as a way to automatically identify these study designs (Hoang et al. 2019).

1. BACKGROUND ON KO
   * 1. Multiple systems for biomedicine support knowledge organization and information retrieval. Beyond the biomedical literature (on which we will focus), Knowledge Organizing (KO) systems have also addressed records of patient diagnosis and treatment (Stanfill et al. 2010) and continue to be a building block in clinical research informatics (Kahn and Weng 2012). KO systems are used to organize basic research in biology and chemistry (CITE) for instance chemical structure (CITE), and pre-clinical biomedical literature (CITE) with topics such as genetics (CITE). Fields such as health care administration (Taylor, Gebremichael, and Wagner 2007), implementation science (CITE), and public health (CITE) integrate complementary knowledge, for instance about policymaking and group or organizational behavior, along with biomedical knowledge. Biomedical knowledge is also relevant to citizens, as health consumers (patients, patient advocates, wellness, etc.) (Miller, Tyler, and Backus 2004).
     2. KO on the biomedical literature is vast.   
        Examples include:
        + 1. MeSH

Underlies MEDLINE

Translated into multiple languages

Use in literature based discovery: Ranking indirect connections in literature-based discovery: The role of medical subject headings

* + - * 1. Narrow domain ontologies

Enabling Biomedical NLP (e.g. MetaMap + UMLS)

Enabling reasoning

Supporting reproducibility (NIF work)

* + - * 1. Development of structured abstracts, enhancing the text generally available in indexing and retrieval systems

Historical information - starting from citations/bibliographies to these:

R.B. Haynes et al., More informative abstracts revisited, Annals of Internal Medicine 113(1) (1990) 69–76.

P. Froom and J. Froom, Deficiencies in structured medical abstracts, Journal of Clinical Epidemiology 46(7) (1993) 591–594.

* + 1. Topic-based information retrieval in the biomedical literature has been studied from different usage perspectives, especially taking account of the interests of clinicians, patients, and their intermediaries.
       - 1. (paper) Comparison of full-text searching to metadata searching for genes in two biomedical literature cohorts
         2. (paper) Consumer language, patient language, and thesauri: a review of the literature
         3. (paper) Evaluating the impact of MeSH (Medical Subject Headings) terms on different types of search
    2. Various search strategies, notably citation retrieval, have been tested on biomedical literature
       - 1. (paper) Descriptor and citation retrieval in the Medical Behavioral Sciences literature: Retrieval overlaps and novelty distribution
         2. (paper) Chris Belter - Citation analysis as a literature search method for systematic reviews.
         3. (paper) Chris Belter - A relevance ranking method for citation-based search results
         4. Pao, M.L.: Term and citation retrieval: A field study. Information Processing and Management 29(1) (1993) 95-112
         5. (paper) Topic Diffusion Analysis of a Weighted Citation Network in Biomedical Literature
    3. Methodology in the more general KO literature
       - 1. (paper) The Blind Men and the Elephant: Towards an Organization of Epistemic Contexts

1. BACKGROUND ON METHODS In Information Science
   * + - 1. Citation of methods as concepts Small, Henry G. 1978. “Cited Documents as Concept Symbols.” *Social Studies of Science* 8 (3): 327–40. <https://doi.org/10.1177/030631277800800305>.
         2. Small, Henry, Kevin W. Boyack, and Richard Klavans. 2019. “Citations and Certainty: A New Interpretation of Citation Counts.” *Scientometrics* 118 (3): 1079–92. <https://doi.org/10.1007/s11192-019-03016-z>.
         3. Small, Henry. 2018. “Characterizing Highly Cited Method and Non-Method Papers Using Citation Contexts: The Role of Uncertainty.” *Journal of Informetrics* 12 (2): 461–80. <https://doi.org/10.1016/j.joi.2018.03.007>.
         4. “Of the 100 most cited articles in Pubmed Central only about four are discoveries and the remaining 96 either methods, reviews or data compilations.” Small, Henry, Hung Tseng, and Mike Patek. 2017. “Discovering Discoveries: Identifying Biomedical Discoveries Using Citation Contexts.” *Journal of Informetrics* 11 (1): 46–62. <https://doi.org/10.1016/j.joi.2016.11.001>.
2. BACKGROUND ON KO & METHODS combined
   * + 1. (paper) Comparative effectiveness research designs: an analysis of terms and coverage in Medical Subject Headings (MeSH) and Emtree
       2. (paper) Studying the potential impact of automated document classification on scheduling a systematic review update
       3. My previous work on methodologies have com (CITE work with Sally Jackson on RCT, CITE work with Sally Jackson on Cochrane Reviews)

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Hoang, Linh, Richard D Boyce, Mathias Brochhausen, Joseph Utecht, and Jodi Schneider. 2019. “A Proposal for Determining the Evidence Types of Biomedical Documents Using a Drug-Drug Interaction Ontology and Machine Learning.” In *Proceedings of the AAAI 2019 Spring Symposium on Combining Machine Learning with Knowledge Engineering (AAAI-MAKE 2019)*, 2350:1–2. CEUR-WS. http://ceur-ws.org/Vol-2350/xposter3.pdf.

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