



HAL
open science

Organization of medical knowledge: documentation techniques applied to a macro-domain underpinned by sociopolitical issues

Marcin Trzmielewski, Claudio Gnoli

► To cite this version:

Marcin Trzmielewski, Claudio Gnoli. Organization of medical knowledge: documentation techniques applied to a macro-domain underpinned by sociopolitical issues. ISTE. Information Practices and Knowledge in Health, 5, Wiley, pp.167-206, 2022, Health Engineering And Society Series Health Information Set, 10.1002/9781119902058.ch8 . hal-03610336

HAL Id: hal-03610336

<https://hal.science/hal-03610336>

Submitted on 16 Mar 2022

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Organization of medical knowledge: documentation techniques applied to a macro-domain underpinned by socio- political issues

8.1. Introduction

The objective of this contribution is to evaluate the dynamics and systems of medical knowledge organization developed by information and documentation specialists and to explain the specific trends and developments in this field since the 1960s. Knowledge organization is a field of research that brings together researchers from disciplines such as information and documentation science, linguistics, philosophy, and computer science [GNO 20, ZAC 10]. After clarifying the key concepts and the methodology of the study, we will proceed with a literature review, combined with the analysis of a corpus of knowledge organization systems in medicine. An assessment, highlighting the current directions and explaining the positioning of the discipline, will conclude the reflection.

8.2. Documentation and Library and Information Sciences and the organization of knowledge

Documentation and Library and Information Sciences form an interdisciplinary field of research bringing together librarianship and information science, which lies between the humanities and social sciences (HSS) and computer science [HJØ 18]. Furthermore, the current trend is to use the terms Library and Information Science

1. Chapter written by Marcin TRZMIELEWSKI and Claudio GNOLI (p. 167-206).

and Information Science as synonyms [HJØ 18]. The reflections on the theoretical and practical notions developed by specialists in this field, i.e. teachers-researchers and professionals of information-documentation (librarians, documentalists, cataloguers, taxonomists, etc.) are concentrated around "access to knowledge and culture" and "recorded knowledge" [MET 06, p. 43]. One of the fundamental concepts and one of the principal missions of the sciences of information and documentation is to study and envisage *documentary mediation*. As Gérard Régimbeau points out, "documentary mediation is a mediation of knowledge" [RÉG 11, p. 108]. It manifests itself in the interactions between the information professional and the user of an information system and "requires the implementation of a communication system adapted to the user" [*Ibid.*, p. 108-109]. The challenge of this process is to "allow the user to find the information he needs" so that he "builds his own knowledge in order to constitute himself a knowledge-base" [*Ibid.*, p. 106-109]. The interactions between the producer of the information, the mediator and the user are implemented within the *documentary devices*, which are "instrumental components" within the information systems [MET 06, p. 54], responsible for the diffusion of the knowledge between these actors, with the aim of the appropriation of the information by the user as content allowing to act [COU 11]. The devices have three dimensions: technical, socio-organizational and socio-economic, which are inseparable and interdependent [MET 06]. To enable access, consultation and management of information in information systems, and to implement mediation within documentary devices, professionals, users and computer programs resort to *knowledge organization* [COU 11, GNO 20, HJØ 16, RÉG 11]. The two main aspects of this activity are: knowledge organization processes (cataloging, indexing, social tagging, shelf arrangement, ...) and knowledge organization systems (bibliographic description rules and formats, taxonomies, folksonomies, classifications, thesauri, semantic networks, ontologies, ...) [HJØ 16, MAZ 18]. Knowledge organization systems (KOS) are schemas that organize concepts (represented by terms that come from common word usage) and the relationships between these concepts to reflect all human knowledge or knowledge related to a knowledge domain [GNO 16, p. 403]. By *knowledge domain* we mean "a group with an ontological base that reveals an underlying teleology, a set of common hypotheses, epistemological consensus on methodological approaches, and social semantics" [SMI 12, p. 114]. Medical specialties, such as allergology or pediatrics, can be considered as such domains. The International Classification of Diseases (ICD) and the Medical Subject Headings (MeSH) are examples of medical knowledge organization systems (MKOS), which list and organize concepts within medical domains.

8.3. Methodology

The research for original, peer-reviewed articles and conference proceedings was conducted on March 25, 2020 and constitutes our corpus. We first manually searched the archive of the journal *Knowledge Organization* (1974-2019) and the conference proceedings *Advances in Knowledge Organization* (1990-2018), published by the International Society for Knowledge Organization (ISKO). Due to a modest number of relevant articles found in the archive (34 selected works), we extended the search by consulting the *Knowledge organization literature database*. The search engine in the database is available on the official ISKO website². The database contains a bibliography related to knowledge organization from journals on information science, linguistics and computer science. To query the database, we used the terms "health" and "medicine". The queries provided 135 results. After removing duplicates and results not relevant to our approach, we retained 25 works. To complete and vary our sample, we went to LISTA (Library, Information Science & Technology Abstracts), a database of abstracts of publications in information science and technology, edited by EBSCO. The query terms used in the "title" field were composed of the adjectives "health" and "medical", combined with the names of different types of KOS [MAZ 18]: "(TI health OR TI medical) AND (TI vocabulary* OR TI gazetter+ OR TI dictionnar* OR TI glossar* OR TI terminolog* OR TI nomenclature* OR TI taxonom* OR TI classification+ OR TI subject headings OR TI thesaur* OR TI folksonom* OR TI conceptual scheme+ OR TI ontolog* OR TI semantic network+ OR TI knowledge graph+ OR TI knowledge organization)". We filtered the results by peer-reviewed scientific journal articles and we obtained 122 publications. After selecting the relevant works and eliminating the duplicates, we retained 10 articles. To complete our sample, we also integrated 2 articles obtained during our literature search in a generalist search engine. The final corpus amounts to 71 publications (see Appendix).

We analyzed, evaluated and synthesized the content of the documents in the corpus, using two reading grids, established as a result of the first exploratory readings: the first one is dedicated to theoretical approaches and evaluations, and the second one focuses on the design work of MKOSs. The progressive reading of the corpus according to a hermeneutic approach allowed us to organize the data, information and knowledge into categories and to connect them to each other in order to discover facts, regularities, relationships and phenomena. We identified the MKOSs discussed in the literature and collected information about them. The analysis of the MKOSs, with the help of the second grid, made it possible to

2. ISKO, "KO literature," available at: <https://www.isko.org/lit.html>, June 26, 2020.

illustrate certain statements with concrete examples. Consultation of some additional resources completed the report.

8.4. Presentation of the corpus of publications between 1960 and 2019

Among the 71 articles published in information and documentation sciences between 1968 and 2018, we observed 11 publications published between the years 1960 and 1999 and 60 between 2000 and 2019. The significant increase in publications from 2000 onwards can be explained by the development of the medical Internet and the large-scale computerization of the health sector, which took place at that time [CAM 14, GON 07, p. 14-55; THO 04] and attracted the attention of scholars in the discipline.

8.4.1. Specialists working on the organization of knowledge in medicine

Among the authors of our corpus, 70% are researchers while 30% come from the professional sector. First, we identified information and documentation specialists. As far as scientists are concerned, they are affiliated with schools, faculties, colleges, as well as centers, departments and programs, within universities specialized in Archivistics, Library & Information Science, Information Science, Librarianship and Documentation (*Biblioteconomía y Documentación*), Information and Documentation, Information Management, Communication & Arts, Communication Studies, Information and Media Studies and Information and Communication Sciences (*Sciences de l'Information et de la Communication*). On the professional side, they are often librarians, documentalists and catalogers. They work in national health libraries or in specialized libraries and resource centers, which are aimed at the general public, the academic community (higher health institutes, universities) or hospital professionals. We also found articles published by employees working in private companies providing documentation services. Secondly, we identified co-authors who participated in projects conducted by information and documentation specialists. These are researchers attached to schools, centers and departments of informatics within universities, or affiliated with faculties of medicine and research institutes in epidemiology and public health. We have also identified computer scientists and physicians who work in university hospitals and health care centers.

The majority of authors (58%) come from countries in the Americas: the United States leads, followed by Canada, Brazil, Mexico, and Puerto Rico. The minority (27%) come from European countries, in particular from Western Europe (France,

Spain, United Kingdom, Italy, Germany, Switzerland) and Northern Europe (Sweden, Finland, Norway, Denmark). They are followed by specialists from Asian countries (India, Japan, Singapore, Israel, China, South Korea) (14%) and Australia (1%). No work from an African country has been identified.

8.4.2. *The socio-documentary fields studied*

The research first focuses on techniques and MKOSs for organizing resources in traditional documentary organizations: national and public libraries, general university libraries, health libraries, and documentation centers [Texts 11, 13, 16, 37, 46, 65].

Following the computerization of library catalogs and the constitution of medical bibliographies in the 1970s [NAT 19], and then the development of the Web from the second half of the 1990s [GON 07], specialists in the field have been interested in the evaluation and design of MKOSs and indexing methods in these environments [Texts 3, 4, 6, 10, 19, 20, 21, 22, 23, 25, 35, 36, 41, 42, 52, 53, 55, 62, 65, 66].

After the computerization of health systems in Western countries, at the turn of the 1990s and 2000s [CAM 14, GON 07, p. 14-55; THO 04], the attention of researchers has been focused on health care institutions. These are reflections on indexing practices and on the representation of documents recording activity (notably patient records) and information resources (scientific articles) as well as the design of ontologies for the development of knowledge bases, essential for the practices of health professionals [Texts 2, 5, 8, 15, 17, 31, 48, 49, 60].

The widespread availability of health information on the medical Internet at the turn of the 2000s and 2010s [ROM 08] has contributed to the extension of the field of investigation to the webosphere. Nowadays, scholars study the methods of organizing medical knowledge and the info-communicative activities of users on websites and social media [1, 7, 9, 24, 18, 24, 28, 29, 30, 32, 34, 35, 43, 44, 47, 51, 56, 61, 69, 70].

Recently, information and documentation sciences have been involved in public health and medical knowledge engineering research, trying to extract knowledge from massively accessible information on the Internet (big data). These are studies that apply the techniques of literature-based knowledge discovery, sentiment analysis and information visualization (dataviz) in the processing of data from social media, the online press or bibliographic databases [Texts 33, 39, 59, 61].

8.5. Medical knowledge organization systems

Medical knowledge organization systems (MKOS) are schemes consisting of concepts and relationships between concepts, representing knowledge about different domains of medicine and related fields. In MKOSs, concepts correspond to terms that are derived from specialized vocabulary (e.g., "Seasonal allergic rhinitis") and/or lay terminology (e.g., "Hay fever"). Furthermore, as evidenced by the analysis of the MKOSs in our corpus, diseases are often classified by reference to human body systems, e.g., cardiovascular, gastrointestinal, respiratory, or immune system. Information and documentation sciences are mainly involved in the organization of knowledge in Western medicine. However, as complementary and alternative medicine is gaining popularity among the general public, it is also coming to be considered. Examples are Ayurveda, Siddha medicine, traditional Chinese medicine, aromatherapy and herbal medicine [Texts 30, 31, 64, 67, 68].

8.5.1. Typology and uses

Taking into consideration the level of specialization of the topics covered by the MKOSs and the purpose of the devices for which they are implemented (general or specific audience), we can distinguish between general and specialized systems. General MKOSs aim to index all human knowledge and devote part of their schemas to concepts representing medical knowledge. They are used more in services and devices of a multidisciplinary nature, intended for a large, often non-specialized public. Specialized MKOSs emerged at a time when the rapid growth in the volume of medical knowledge, the constant evolution of medicine and the emergence of new specialties, at the turn of the 20th century, required the development of specialized tools, sufficiently detailed to satisfy the informational needs of users of scientific and technical information [Texts 46, 50, 54]. Specialized systems are dedicated mainly to phenomena in medical fields, but also include associated disciplines. They are mobilized in organizations, in systems and in documentation services specialized in medicine and health, aimed mainly at professionals of the sector, but also the general public. Their typology has not changed since the 1960s [Text 46] - they are either very general specialized systems that include all fields of medical sciences, such as the National Library of Medicine (NLM) Classification and the Medical Subject Headings (MeSH), or MKOSs dedicated to limited domains such as the Thesaurus of Psychological Index Terms and the Colon Cancer Treatment Ontology. Domain MKOSs often focus on medical specialties, for example: obstetrics and neonatology [Text 2], pharmacy [Text 37], neurosurgery [Text 49], nursing [Text 23], but also on specific pathologies: brain tumors [Text 17], colon cancer [Text 33, 45], infectious and parasitic diseases [Text

52], AIDS [Text 27]. The designers also focused on important public health issues, such as health insurance [Text 11, 60], health and aging [Text 55] or nutrition [Text 71].

The analysis of our corpus highlights the use of different types of MKOSs, including: general classifications, medical classifications, medical nomenclatures, subject headings, medical thesauri, semantic networks, medical ontologies, medical glossaries, dictionaries and terminology directories, categorization schemes, medical taxonomies, folksonomies, and consumer health vocabularies.

General classifications can be divided into enumerative classifications (Dewey Decimal Classification, Universal Decimal Classification, Library of Congress Classification) and faceted classifications (Bliss Bibliographic Classification, Colon Classification). They have been developed since the 19th century to classify medical and health collections in public libraries, in general university libraries and also, but more rarely, in university health libraries which are part of the larger university library system [Texts 11, 16, 37, 65].

As noted in Texts 13, 16, 37, and 65, medical bibliographic classifications are used in health libraries, located in medical schools or hospitals (NLM Classification), and in health sections created in public libraries (Plantree Classification), for the classification of openly accessible materials. It is interesting to note that between the 1950s and 1970s, there was a wide variety of medical classifications in health libraries (Cunningham Classification, Boston Classification, Barnard Classification, Army Medical Library Classification, ...) [Text 46] whereas nowadays, the NLM Classification and general classifications significantly dominate the sector [Text 65]. Other medical classifications (International Classification of Diseases – ICD, Diagnostic and Statistical Manual of Mental Disorders – DSM, Classification commune des actes médicaux³) and nomenclatures (SNOMED-CT, RxNorm) are mobilized to index the resources contained in electronic patient records [Texts 2, 15, 48]. For example, the ICD is used for coding morbidity to generate epidemiological statistics on a global scale, while the Classification commune des actes médicaux is used in France for medico-economic purposes, in particular for the coding of medical and technical procedures performed by health professionals. Furthermore, medical classifications and nomenclatures are considered terminological standards that ensure semantic interoperability between health data repositories. They therefore become components of the shared medical

³ Common Classification of Medical Procedures

record, which allows patients to share their data with healthcare professionals⁴ [ODE 16, Text 15].

Subject headings (Library of Congress Subject Headings, RAMEAU, Répertoire de vedettes-matière de l'Université de Laval), developed between the end of the 19th and the second half of the 20th century, are used by documentation professionals to describe and index the content of documents in the catalogs of public, general university and health libraries [Texts 10, 41, 65].

Medical thesauri (MeSH, Emtree, Thesaurus of Psychological Index Terms), semantic networks (UMLS), and more recently, ontologies (OntoDip), are developed and used by information professionals and computer programs to describe and index the content of documents in online library catalogs, bibliographic databases (e.g., MEDLINE/PubMed), and strategic information systems [Texts 3, 4, 6, 10, 20, 23, 25, 32, 37, 51, 52, 53, 65, 66]. Moreover, ontologies, which allow the "conceptual modeling of a domain and the definition of a shared vocabulary" as well as the "simulation of human reasoning" [WAL 18, p. 163], act as knowledge bases, and are used for semantic information retrieval and for knowledge extraction from electronic patient records and scientific literature [Texts 17, 31, 33, 39, 49]. As evidenced by work in computer science, ontologies are also being mobilized for medical imaging management and retrieval [MAR 11]. Information and documentation specialists also design glossaries, dictionaries (lexicons) and directories of medical terminologies [Texts 3, 44]. These are schemes, often organized alphabetically, that list specialized or lay vocabularies used in a medical field, which can be used as terminology resources in language processing systems based on a linguistic approach or for the creation of ontologies.

Finally, some MKOSs (categorization schemes, taxonomies, consumer health vocabularies, ontologies) are used for the organization and retrieval of specialized and general public information on the Web. A categorization scheme is used on the National Center for Complementary and Integrative Health website.⁵ The faceted taxonomy Health Topics, which organizes topics related to common diseases and conditions, mediates content on MedlinePlus [Text 51]. Folksonomies are tags, keywords, and hashtags created by social media users through the process of social tagging [Texts 1, 18, 34, 35]. Consumer Health Vocabularies (CHVs) are schemas used to represent lay terminology, taking the structure of different MKOSs (from a terminology repository, classification, thesaurus, or ontology), and are used for

4. WHO, "Classifications," available at: <https://www.who.int/classifications/icd/en/>, 2020.

5. National Institutes of Health, "National Center for Complementary and Integrative Health," available at: <https://www.nccih.nih.gov/>, 2020.

example in search engines for consumer services [Texts 9, 44, 56]. As highlighted by work in computer science and biostatistics, CHVs are also used in text mining tools when automatically processing corpora of data from social media [NZA 15].

8.5.2. The sources of the description

MKOSs aim primarily to represent the content of documents by expressing their subject through a concept, represented by a term, sometimes accompanied by alphanumeric symbols (notations) or graphics (images). The subject may concern a discipline to which the document refers: *L9F:4* "Gynecology" (Colon Classification), or a phenomenon discussed in the document, for example a disease: *EA80* "Atopic Eczema" (ICD-11) or a treatment: *QW 900* "Desensitization, Immunologic" (NLM Classification). We can therefore consider them as *content models* of documents [ZAC 10, p. 148]. Moreover, with some specialized systems, it is possible to model *extra-documentary situations* [*Ibid.*, p. 148]. In the MeSH, edited by the NLM, we find for example the descriptor "Publication Characteristics" [*V*] which means the form of documents can be described, in particular the "Publication Formats" (e.g., "Journal Article", "Conference Proceedings", "Academic Dissertation"), "Study Characteristics" (e.g., "Clinical Study", "Meta-Analysis", "Multicenter Study") and "Publications Components" (e.g., "Comment", "Advertisement", "Published Erratum"). Classifying and sorting publications in medicine according to these criteria is important for the practice of evidence-based medicine, where the type of publication and study methodology conditions the level of evidence of the work [HAS 13, HJØ 16]. Furthermore, in Siddha Ontology, modeled by Hemalata Iyer and K. S. Raghavan, we find concepts related to institutions, domain experts, and types of collections and documents: reference books, journals, articles, and manuscripts in the domain [Text 31]. Moreover, in MKOS, users can be grouped into sociological categories according to the type of information or collection that may satisfy their info-communication needs and practices. For example, the categorization scheme that is used on the National Center for Complementary and Integrative Health's website contains the categories "Be an informed consumer" and "For Health Care Professionals" that address the specific types of users to whom the service is dedicated.

8.5.3. The design of new MKOSs

Our corpus includes 22 original articles on the design of MKOSs. The most frequently developed systems are ontologies (10 works) [Texts 2, 9, 17, 31, 33, 45, 49, 52, 60, 71] in the context of researchers' work, then thesauri (7 works) [6, 10, 23, 25, 27, 55, 67] and finally classifications (3 works) [11, 40, 50], generally developed

and updated by documentation professionals. We also note the design of a conceptual framework of complementary and alternative medicine to establish bridges between the tradition of Western medicine and the tradition of Eastern medicine [Text 68]. In addition, one work proposes the development of a repertoire of lay medical terminology [Text 44].

8.5.3.1. *The designers*

As the texts in our corpus attest, researchers in information and documentation sciences most often develop conceptual models [Texts 2, 9, 17, 31, 33, 49, 50, 60, 67, 71], but also formalized systems [2, 17]. The development of organizational systems ready to be implemented in information systems (for example in an integrated library management system or in a shelf signposting system in library) is rather the prerogative of information professionals [Texts 6, 10, 13, 23, 25, 55].

Some MKOSs are developed outside the information and documentation community. The ICD, for example, is revised and maintained by the World Health Organization in collaboration with medical experts in various fields. SNOMED-CT is developed by a non-profit organization, SNOMED International, which brings together specialists in information and communication technologies, information architecture and medicine. Moreover, as shown by the programs of scientific events around artificial intelligence and knowledge engineering organized in France and internationally, notably the *Journées francophones d'Ingénierie des Connaissances*⁶ (*Atelier IA et Santé*), the *Plateforme de l'Intelligence Artificielle*⁷ (*Journée Santé & IA*) and the Congress on Medical and Health Informatics [OHN 19], laboratories, learned societies and consortia of informatics and artificial intelligence seem to be settling in the field of medical knowledge organization. By observing the different sources of funding of these events (governments, territorial communities, learned societies, universities, research organizations, scientific consortia, private companies and ICT giants), listed on the websites and mentioned in the works published in the proceedings, it seems that computer science and artificial intelligence have found a lucrative field of application, in which both private and public actors are interested, since the economic and societal stakes are very high. This funding allows them to conduct and present research on ontologies, terminologies and associated services. They rely on the exploitation of large corpora of texts and resort to automatic natural language processing (NLP) techniques, on the assumption that these corpora "provide the stable, consensual and shared elements of a domain" [AUS 12, p. 252].

6 . IC 2016, "Programme – 6 juin : IA et Santé 2016," available at: <https://ic2016.sciencesconf.org/resource/page/id/27.html>, 2016.

7 . PFIA 2020, "Journée Santé et IA," available at: <http://pfia2020.fr/journeesthematiques/sante-et-ia/>, 2020.

Probably, with the same issue of research funding, in the last decade we can note a significant growth of interest in medical ontologies in the field of information and documentation. This trend is interesting since ontologies, although already conceptualized in computer science by Gruber in 1993 [GRU 93], are not even mentioned in the *Dictionnaire encyclopédique de l'information et de la documentation*, published in France 1997 by Serge Cacaly [CAC 97]. As the publications in our corpus show, information and documentation specialists are now very much involved in the development and research of medical ontologies [Texts 2, 9, 17, 31, 33, 45, 49, 52, 60, 71]. In addition, Texts 2, 9, 52 and 60 confirm the funding of ontology projects led by information scientists, ministries of education, public health organizations, scientific development agencies and scientific associations.

8.5.3.2. Design methods

The elaboration of MKOSs consists in identifying different elements relevant to a domain: concepts, terms, situations, objectives and issues, through the analysis of different textual corpora. For this purpose, different types of documents are used: books, abstracts, scientific or general public articles, clinical documents, social media messages, websites of learned societies, query logs, descriptors of indexed documents, existing MKOSs and survey data [Texts 2, 9, 10, 13, 17, 23, 25, 27, 31, 33, 40, 44, 45, 49, 50, 55, 56, 60, 67, 68]. Recently, authors have also used the method of crowdsourcing including non-experts [Text 71]. Furthermore, as pointed out in Texts 49 and 56, there are ethical issues that need to be addressed when designing MKOSs, especially when extracting terms from the contents of computerized patient records and social media, which include personal data. After the collection of relevant elements for a given domain, the concepts and terms expressing them are then normalized and organized by professionals or by a machine into systems of semantic relations.

Information and documentation scholars' methods of designing MKOSs can be attributed to five different epistemological perspectives: pragmatism, historicism and hermeneutics, socioconstructivism, rationalism, and empiricism [GNO 20, p. 39-40; HJØ 03, p. 107; HUB 98, WEI 16].

8.5.3.2.1. The pragmatic method

The analysis of the objectives, values and applicative orientations of a community, which guide the production and use of genres of discourse in a field (hospital reports, scientific articles, messages on social media, etc.), is the first method, attached to pragmatism [GNO 20, p. 39]. It consists of the study of the uses of health information, seen as social, communicational and cultural practices [Text

58]. Most often, this involves using the categories of information searches, identified through studies of users' information behavior [Text 57]. For example, Hemalata Iyer conducts interviews with practitioners and educators of Siddha medicine to identify the principles, professional and informational practices, communication patterns and knowledge structures developed, and then transposes this information into a domain ontology model [Text 31].

8.5.3.2.2. The historicist and hermeneutic method

The second method is part of the historicist or hermeneutic perspective. It involves studying the context and development of knowledge and the social and scientific division of labor and categorizing concepts from a cultural point of view [GNO 20, p. 39; HJØ 03, p. 107]. The Universal Decimal Classification, the Bliss Bibliographic Classification, and the NLM Classification are thus conceived and revised by librarians and documentalists in Europe and America, who organize medical knowledge from the perspective of Western medicine. As a result, the fields of complementary and alternative medicine, which often belong to Eastern traditions, are poorly represented [Texts 30, 64]. It also seems that the MKOSs constructed in Eastern cultures are also influenced by Western medicine. The Colon Classification for example, which is revised in India, is not sufficiently developed to cover collections on Indian Ayurveda medicine [Text 30].

8.5.3.2.3. The socioconstructivist method

The third method, belonging to socioconstructivism, consists in the modeling of classification schemes that reflect knowledge influenced by social constructions, developed through mutual actions between individuals and their environment [HUB 98, WEI 16]. These constructs, which derive from individual experiences and social perspectives (formed for example by social ideologies or political interests), are said to stimulate the representation of a reality, which can sometimes be disconnected from scientific reasoning [HUB 98, p. 195-196]. In the field of HIV/AIDS, for example, diseases and associated phenomena coexist together in such a reality, because the categorization, marginalization and stigmatization of populations affected by HIV (gays, African-Americans, drug users, ...) or of their sexual behaviors (considered in some discourses as deviant or immoral) are influenced by social stimuli [*Ibid.*, p. 195-201]. According to a socioconstructivist approach, MKOSs must reflect the complexity of realities marked by the coexistence of social constructions alongside historical and cultural factors. To develop a vocabulary-mediator of dialogue in the HIV/AIDS community, as an attempt to accommodate such complexity, Jeffrey F. Huber and Mary L. Gillaspay look at the different models of communication and knowledge production (both traditional and non-traditional) as well as the different vernaculars developed by different actors (clinicians,

researchers, patients, etc.). Given the multidisciplinary, interdisciplinary and transdisciplinary nature of the field, Huber and Gillaspay base their vocabulary on the different domains: "[...] Epidemiology and Transmission; Education and Prevention; [...] Treatments, Therapies, and Medical Management of HIV Disease; Psychosocial and Religious Issues, Case Management; Legal, Ethical, Economic, and Political Aspects; [...] Fine Arts; Belles Lettres and Non-Fiction" to which they attribute relevant concepts [Text 27, p. 297]. They also use the common facets: "Age Ranges, Sexual Orientation, Gender, Stages of Infection, Ethnic Groups, Geographic Names, At-Risk Populations, Religious Faiths, Signs and Symptoms, and Special Populations", endowed with a syntactic role that allows them to be associated with the main categories, and to complete them, if necessary [HUB 98, p. 203]. It is interesting to observe that, although the work is based on a socioconstructivist perspective, the designers finally resort to faceted analysis, which makes it possible to see that their method is also part of a rationalist approach, another method of classification which will be presented below.

8.5.3.2.4. The rationalist method

The fourth method is to create logical divisions that are considered universal [GNO 20, p. 39; HJØ 03, p. 107]. This method of organizing concepts is often based on the theory of facet analysis. It is considered by Birger Hjørland, to be an expression of rationalism [HJØ 14], even if other authors, such as Joseph T. Tennis [TEN 08], also see components of pragmatism in it, because the fundamental categories used to organize knowledge (explained later) prove useful for the classification process, and classifications that rely on these categories save time for the reader. Moreover, even if one can criticize the confusion between pragmatism and practicality of this method (practicalism), it seems to us that it is above all the facet analysis based on the contents exchanged and used in a domain (scientific articles, books, patient files...) for a concrete application, which allows us to see that it has pragmatist influences. The principles of this approach are based on a general theory of classification conceived by the Indian librarian Shiyali Ramamrita Ranganathan, and these principles were introduced in Europe in the 1950s by the Classification Research Group [VIC 60]. Based on a review of a sample of literature in a specialized field, concepts and terms are grouped into facets, which generally fulfill different semantic and syntactic roles. In faceted classifications, for example, concepts are assigned to facets of medicine. As Vanda Broughton points out, in class *H* "Physical anthropology, human biology, health sciences" in the second edition of the Bliss Bibliographic Classification, terms are assigned to the different categories:

- (Thing) Human beings;
- (Kind) Women, children, old people, etc.;

- (Part) Head, legs, muscles, bones, heart, brain, lungs, etc.;
- (Process) Respiration, digestion, reproduction, disease, etc.;
- (Operation) Surgery, drug therapy, physiotherapy, etc.;
- (Agent) Doctors, nurses, equipment, buildings, etc. [BRO 15, p. 308].

Thus, the terms in each category constitute a facet of a subject. In this way, in Bliss, all the terms of the category "Part" become, for example, the facet of the class *HDP* "Anatomy" or *HPT* "PARTS, ORGANS, SYSTEMS OF THE BODY", while the terms of the category "Operation" become the facet of the class *HNP* "Treatment, therapy" [*Ibid*]. In the same approach, K. S. Raghavan and C. Sajana propose facets of the domain, grouped in three major facets (which refer to Ranganathan's categories) to develop an ontology of neurosurgery dedicated to health professionals: "Personality (Patients, Body Organs, Health Care personnel, Institutions, Hospital Managers), Matter-Property (Diseases, Symptoms, After effects), Energy (Diagnosis, Treatment)" [Text 49, p. 210]. Since the ontology's mission is to ensure rapid access to clinical documents, Raghavan and Sajana develop these categories and associate concepts with them based on the patient records produced and used by professionals in their professional practices. The mobilization of information contents, used by the actors in their daily practice, to design an MKO, allows us to see that this approach does indeed have pragmatic aspirations.

8.5.3.2.5. The empirical method

The fifth method, which is empirical, is manifested by statistical generalizations, based on the "similarity" of informational objects that share a large number of properties in common [GNO 20, p. 39; HJØ 03, p. 107]. As evidenced in Texts 2, 9, 44, the empirical method often consists of analyzing very large text corpora via NLP techniques to establish semantic relationships between ontology terms, or via machine learning techniques to establish links between terms and terminology definitions. An exemplary study of this approach is the work of Yunseon Choi, which focuses on building an ontology dedicated to healthcare consumers. She identifies a non-expert vocabulary via a latent semantic analysis of social tags, assigned by users of Del.icio.us (a social bookmarking site) to index and share documents [Text 9]. It is interesting to observe that even if the neutrality of the statistical technique emanates from empiricism, the consideration of lay terminology in order for the ontology to best satisfy the needs of users, related to the search for relevant information resources, is in our view a pragmatist influence. On the other hand, the development of an ontology representing a non-expert view of the domain,

based on a lay language built by an online community to index documents, also reflects socioconstructivist aspirations.

Authors rarely state the theoretical frameworks on which their work is based. One explanation lies in the recent nature of the epistemological foundation of MKOSs, developed with the formalization of the field of knowledge organization [GNO 20, HJØ 18].

8.5.3.3. Test, validation and evaluation methods

The knowledge organizations, proposed by information and documentation specialists, are tested, validated and evaluated in a qualitative and quantitative way. In the qualitative method, which is most often practiced, the aim is to evaluate the usefulness and efficiency of the MKOSs at representing the terms of the targeted domains or verifying their efficiency and their potential at integrating the information systems to which they are dedicated [Texts 2, 9, 17, 31, 49, 50]. The designers validate the designed MKOSs by conducting semi-structured interviews with individuals representing the categories of future or potential users: health care consumers [Text 9] or domain specialists [Text 2]. They are asked, for example, to indicate in a document the information they would like to have in a specific situation and the examiners verify to see if these elements are correctly represented in the system being evaluated. MKOSs are also validated through text analysis, performed by experts, information professionals or by machines [Texts 2, 50]. To validate the OntoNeo ontology, Mauricio Barcellos Almeida and Fernanda Farinelli use NLP techniques to automatically extract obstetrics and neonatology terminology from clinical records, which allows them to verify whether the most frequent terms, obtained from the extraction are present in the ontology [Text 2]. In other works, designers submit queries to test the efficiency and potential functionality of information systems, based on MKOSs [Texts 17, 31, 49]. For example, the authors of the Siddha medicine domain ontology perform semantic information retrieval in the knowledge base based on this ontology [Text 31]. The designers of the ontology of the neurosurgery domain, on which a decision support system based on the semantic indexing of patient records is relied on, ask this system specific queries, such as: "identify & retrieve records of patients: age => 40 with astrocytoma" [Text 49, p. 214]. Quantitative evaluation aims to measure the number of documents retrieved via a query to the information system. At the end of this operation, the recall and precision rates are calculated [Text 60]. In addition, to evaluate the accuracy of the statements in the nutrition ontology, the recruited subjects evaluate the accuracy rate of the relations established by the designers [Text 71].

8.5.3.4. New challenges for the design of MKOSs

General and specialized classifications, in which knowledge is organized by discipline, are now confronted with the challenge of interdisciplinary knowledge. However, some interdisciplinary concepts from the medical sciences may appear in several classes within these classifications, since they are studied by several disciplines. In the NLM Classification, for example, the concept of "tumor" is found in different disciplines: pathology, ophthalmology, gynecology, nursing, etc. Such a classification method leads to the dispersion of resources, which is illustrated in the location of documents (on interdisciplinary topics) in several spaces of a library's classification scheme. As a result, there is a risk of scattering materials on different shelves of a library, and in this way, users may lose some of the resources that may be of interest to them. The somewhat dated (1996), but very timely study by Lynn Silipigni Connaway and MaryEllen C. Sievert, masterfully illustrates this problem: because of the interdisciplinary nature of the concept of "health insurance", resources on this topic, catalogued in bibliographic databases, are dispersed in 13 different classes of the NLM Classification and the Dewey Decimal Classification as well as in 23 classes of the Library of Congress Classification [Text 11]. We will see later that such inconsistency in classifications can create constraints for knowledge representation in Semantic Web standards.

Now, knowledge organization specialists recommend moving KOSs to online applications in order to optimize indexing and information retrieval in this environment [BIN 20]. Such a goal leads to representing the traditional organization of concepts in the syntax of Semantic Web technologies. While medical ontologies are natively created following these standards, MKOSs, whose origins date back to the 19th century and the beginnings of digital transformation, must undergo the conversion to Networked Knowledge Organization Systems (NKOS). Following these recommendations, the Library of Congress and the NLM respectively published the Library of Congress Subject Headings and the MeSH in SKOS (Simple Knowledge Organization System) format, which is a standard and a set of specifications developed to support the use of MKOSs within the Semantic Web [Text 6, W3C 09]. However, in our opinion, basing general and specialized medical classifications on disciplines can become a considerable technical constraint for the conversion of these classifications to NKOS. Yet, for publishing classifications in SKOS format, the World Wide Web Consortium (W3C) recommends identifying MKOS concepts by URIs (Uniform Resource Identifiers), which allows concepts to be identified by a unique address for their description and linking, using Resource Description Framework (RDF) or RDF Schema (RDFS) languages, based on the "subject - predicate - object" triplet model [W3C 09]. This specification seems difficult to achieve with disciplinary classifications where some interdisciplinary concepts may appear several times in a schema, and each time from a different

perspective. A group of researchers from different countries, working on the Integrative Levels Classification (ILC), a faceted interdisciplinary classification, proposes an alternative approach: instead of integrating interdisciplinary concepts into different disciplinary classes, they would represent them through phenomena, which are basic units of knowledge, independent of any discipline [GNO 16]. The latest work by this team, on the conversion of ILC into SKOS format, underlines that the phenomenon-based classification approach is quite suitable for the representation of classifications in Semantic Web standards [BIN 20].

Other texts present reflections on the design and evaluation of MKOSs and bibliographic data exchange formats to improve knowledge discovery techniques based on scientific literature [Texts 33, 39, 59]. They are a continuation of the work initiated by Don R. Swanson on the establishment of new relations between the knowledge contained in articles published in biomedical fields through treatments involving the use of semantic technologies. This idea can be related to the philosophy of the Web of data (linked data), which is a metadata infrastructure developed for the interoperability of repositories in order to "group the information in a useful way, as in a gigantic database where everything is written in a structured language" with the aim of developing different services of research, consultation, exchange, annotation and indexing of contents [WAL 18, p. 159]. In order to describe the knowledge about the documentary resources and the relations between these resources, it is necessary to use the languages of the Semantic Web that we have just mentioned (RDF, RDFS) and to build triplestores, which can be queried with the SPARQL language [*Ibid.*, W3C 09].

Finally, the designers of MKOSs are currently led to organize information in a new type of medical devices, notably in "healthcare interface organizations" [Text 5]. As French examples of such devices, we can mention the Personal Health Records, the Territorial Support Platform or telemedicine tools. The aim of their development is to associate the public and private sectors, including patients and their families, so that they become spaces for cooperation around shared knowledge. As Christian Bourret points out in Text 5, such systems need new thinking on the organization and representation of knowledge, adapted to the informational needs and skills as well as to the cognitive capacities of communities of scholars, experts, professionals and laymen, in the spirit of building a collective intelligence based on the knowledge of all their members.

8.6. New challenges for indexing and information retrieval

Part of our corpus of works focuses on the new challenges for indexing and retrieving medical and health information in the context of the social Web, the medical Internet and bibliographic databases.

The first category of publications deals with social indexing practices [Texts 1, 9, 18, 28, 32, 34, 35], "allowing non-specialist users to index documentary resources" on Web 2.0 [WAL 18, p. 161]. In the netnographic approach, specialists collect and analyze data with qualitative (observation, interview, facet analysis, comparison, equivalence, NLT) and quantitative (descriptive statistics, infometric and similarity measures) techniques. The results of these works highlight the subjective nature of social indexing, performed by different categories of users on online services. The study by Hemalata Iyer and Lucy Bungo shows, for example, that less than 1% of the tags concerning complementary and alternative medicine, posted by users of a social cataloging web application, correspond to terms of the UMLS semantic network [Text 28]. The data collected by Margaret E. I. Kipp on CiteULike, a web-based bibliographic cataloging application, compared with those collected on PubMed, highlight that there are significant differences in the criteria for indexing biomedical literature between biomedical researchers and professional catalogers [Text 34]. Marit Kristine Ådland and Marianne Lykke emphasize that users and editors of a cancer website disagree on both the purpose of tags and what characterizes a good tag [Text 1].

Many MKOSs have been designed for information professionals in order to simplify access to information. However, the above-mentioned work points out that the medical terminology used by users and their indexing criteria may differ from the terminologies and criteria used by professionals. For example, Pertti Vakkari evaluates the extent to which the vocabulary used by users of digital question-and-answer services on the Web, concerning health, nutrition and social services, is covered by general and specialized systems developed by information professionals. The results vary between 15% and 65% of terminological convergence, which shows a semantic divide between professional MKOSs and the vocabulary used by non-specialized users on the Web [Text 63]. These results make us think about the knowledge organization tools developed in a top-down approach, which can be incompatible with the users' behaviors and practices, which can have negative consequences on the user's information search process and distance them from the information they need. Solutions to these terminology and indexing discrepancies are most often sought in the construction of terminology resources and consumer health vocabularies [Texts 9, 44, 56] and in taking into account users' preferences for document indexing and information relevance criteria [1, 14, 29, 34, 35]. This

kind of user knowledge can be acquired, for example, through domain analysis, which is a paradigm inspired by a sociological approach to knowledge organization, according to which indexing must be considered with a socio-cultural perspective, i.e., linked to the social practices of individuals in a discourse community [HJØ 16]. Domain analysis thus brings together both hermeneutic and pragmatist approaches [GNO 20].

The second category of work is based on a cognitive approach to knowledge organization [GNO 20] which seeks to take into account the cognitive abilities of the user (located in a culture or community) when searching for information [Texts 24, 29, 47, 51, 56]. In this approach, Dagobert Soergel, Tony Tse and Laura Slaughter are inspired by the work on human cognition carried out in biomedical informatics, which emphasizes that the understanding of pathologies by patients and physicians can be summarized in two distinct models: *illness model*, manifested in patients, and *disease model*, characterizing the perception of physicians [Text 56]. Soergel's team bases their work on this model and develops an interpretive layer, which aims at mediating health information between the perspective of specialists and the perspective of non-experts. The model focuses on the design of a set of tools: an educational ontology (with non-expert definitions and terminologies), a validated biomedical knowledge base, a false-belief explanation base, and a visual display and classification navigation interface. All these tools form an "interpretative layer" allowing the non-expert user to find the document related to his information need and to understand its content. In addition, to improve access to information, some designers seek to represent knowledge in a design appropriate to the cognitive abilities associated with the information culture of particular groups. For example, the work of Lisa M. Given *et al.* and Hemalata Iyer and Mary Guadrón attempts to identify strategies for organizing and visualizing knowledge on health websites for older adults [Texts 24, 29]. Kyong Eun Oh, Soohyung Joo, and Eun-Ja Jeong collect facets that are preferred, easy to use, and useful in order for the general public to access online health information [Text 47].

The third category of studies deals with the phenomenon of crowdsourcing [Text 66]. The study by James W. Woods *et al.* provides instructive feedback on this practice, using the example of the indexing of images of skin lesions from the NLM collection by dermatologists [Text 66]. 9 experts spent an average of 30 minutes describing the images via a form made available to them on the Web. Comparison of the vocabulary used for indexing, with the UMLS terms shows that 300 terms from this MKOS out of the 346 unique terms submitted by the practitioners have an exact equivalence [Text 66]. This example highlights the great potential of participatory production, which could be used for indexing and annotating large corpora of clinical activity documents or health information resources (e.g., heritage

collections). Crowdsourcing could also be an interesting alternative to automatic indexing and annotation techniques.

The fourth category of work shows that vocabulary control and rigid structuring of terminology in MKOSs built in a top-down approach, e.g., medical thesauri, are still useful for scientific information retrieval. Ying-Hsang Liu and Nina Wacholder point out that MeSH terms are indispensable for measuring the accuracy rate for domain experts, even for graduate students in biomedical fields who have not undergone specific training in information retrieval [Text 36]. In addition, Xiangming Mu, Kun Lu, and Hohyon Ryu, who conducted a study of undergraduate and graduate students with no experience in information retrieval, show that a system that allows searching by MeSH term and navigating its schema is more effective in information retrieval than a system that provides a simple search interface [Text 43]. Finally, as evidenced by numerous medical theses and articles, MeSH is currently widely used by both researcher-practitioners and medical students to query PubMed for systematic literature reviews.

8.7. Social, cultural, political and economic issues

In addition to the problems related to indexing and information retrieval, the organization of medical knowledge also raises social, cultural, political and economic issues.

As Texts 12 and 26 in our corpus attest, adding and removing concepts in an MKOS is based on a socio-political evolution of knowledge, and raises sensitive questions and even political tensions, prompted by normative issues. In 1968, the American Psychiatric Association added homosexuality to the Diagnostic and Statistical Manual of Mental Disorders (a classification of mental illness). This appearance provoked protests from homosexual activists. After a long debate, in 1973, the term was removed from the classification [Texts 12, 26]. Moreover, in the ninth version of the International Classification of Diseases (ICD-9), used until the end of the 1980s, the concept of homosexuality (*302.0* "Homosexuality") appeared in the scheme, as the first subdivision of class *302* "Sexual deviations and disorders", and belonged to chapter *300-316* "NEUROTIC DISORDERS, PERSONALITY DISORDERS, AND OTHER NONPSYCHOTIC MENTAL DISORDERS". The concept was accompanied by a usage note for health professionals: "Code homosexuality here, whether or not it is considered a mental disorder". Even if the classification never explicitly stated that homosexuality should be considered a disease, the analysis of generic concepts, allowing the context in the classifications to be revealed [ZAC 10], led to interpretations of the media discourse as discriminatory and erratic [DRI 94]. In the tenth version of the classification,

published in 1990 and replacing ICD-9, the term no longer appears as a reason for sexual contact [DRI 94]. The above examples clearly illustrate the normative stakes of MKOSs, which reflect the power of certain actors to categorize what is normal and what is pathological [WAL 18, p. 158]. The categorization of individuals has a direct link with their representation in a society. So much so that it is understandable that it becomes a tool of revolt for communities that do not identify with certain categorizations proposed by normative bodies.

Moreover, the cultural warrant principle, which calls for the design of MKOSs that are appropriate and useful to the individuals of a culture, may lead to the interests, values, rights and beliefs of others being overlooked, depriving them of the right to access information [BEG 02]. As we have already pointed out in the section on MKOS design methods, the fields of complementary and alternative medicine are poorly represented in the classifications reviewed by Western information professionals [Texts 30, 64]. Information resources on Eastern medicine topics may therefore be less visible in the collections of a library located in Europe. As a result, followers of Siddha medicine who visit this library, for example, are less likely to find the information they need.

Finally, as emphasized by work in the information and communication sciences and in medicine, the design of reference medical classifications also raises economic issues, linked to political decisions taken by governmental bodies and intergovernmental organizations responsible for their revision [TAN 16, WAL 18, p. 158]. The inclusion or exclusion of certain diseases in classifications such as the ICD or the Classification commune des actes médicaux has, for example, repercussions on the marketing of new drugs by the pharmaceutical industry and on the reimbursement of medical acts by national health insurance funds, mutual health insurance companies and insurance companies. As an illustration of such power, we can mention a case reported by specialists in allergology, a recent specialty that is sometimes incorrectly represented in medical classifications. The absence of a specific class for anaphylaxis in ICD-10, due to the confusion of this disease with anaphylactic shock in class *T78.2* "Anaphylactic shock, unspecified" (the terms "anaphylaxis" and "anaphylactic shock" do not represent the same concept), and the downgrading of the concept of anaphylaxis to class *T78* "Adverse reactions, not elsewhere classified," has led to the underreporting of anaphylaxis mortality by health professionals in Brazil when coding death certificates. The lack of epidemiological data in the Brazilian national database has significantly affected decision-making by the government and pharmaceutical companies, and as a consequence the non-marketing of self-injectable epinephrine for the treatment of anaphylaxis [TAN 16].

The above examples make it clear that MKOSs represent and impose a certain worldview at a given moment and in a particular context [DUB 20, p. 12]. They can also direct knowledge, give visibility to a pathology, become instruments of power, revolt and access to information, as well as enable or prevent the circulation of goods in the health economy.

8.8. Discussion

Our analysis leads us to the observation that the theories and techniques for organizing medical knowledge, developed by information and documentation specialists, have been profoundly affected by the digital transformations of the health information field. On the technical side, the constant growth of the volume of knowledge in this field has created, for example, the need for specialized MKOSs. The paradigm of evidence-based medicine has influenced the criteria for indexing medical literature. The development of Web 2.0 has contributed to the emergence of the practice of social indexing and has created the need to adapt knowledge organization tools to this environment. In addition, the Semantic Web and the idea of the Linked Data have guided the representation of MKOS in new computer standards and languages. Finally, massive data have attracted the attention of researchers who try to extract knowledge from them. In parallel to these technical aspects, we observe the development of theoretical reflections. Epistemological and methodological contributions as well as ethnographic and netnographic studies are the manifestation of this new orientation, which seeks to put the user at the heart of the reflection. It seems that this surge is a consequence of the participative and social character of Web 2.0, which has facilitated the obtaining of behavioral data, the analysis of which has led to an awareness of users' needs. First, the importance is given to the non-specialized user. Traditional medical terminologies and indexing techniques are being challenged. They are confronted with the vocabulary, the indexing and navigation preferences as well as the cognitive abilities of the users. Then, other works focus on the specialized user situated in his work context. This is illustrated by MKOS design methods, which take into account different vernacular vocabularies built within medical domains, as well as the needs, behaviors and information communication practices of health professionals. Finally, specialists are interested in the different issues of knowledge organization, a concern that is specific to the HSS.

Despite the constitution of a corpus from only three data sources, the technical and theoretical trends are in line with the global changes affecting the field of knowledge organization [SOS 19, p. 31-43; WAL 18, p. 155-164]. The large-scale design of medical ontologies for online applications and for knowledge organization, management and retrieval processes is a leading example. Designers

are evolving traditional systems to conform to Semantic Web standards. Participatory production is also spreading, little by little, for the construction of MKOSs and for the indexing of documentary resources on medical topics. Moreover, TALN, clustering and information visualization techniques are more and more practiced, which may reflect a rapprochement of the fields of knowledge of engineering and artificial intelligence, given the interdisciplinary nature of information sciences that oscillate between HSS and computer science, but also, quite simply, a step towards the adaptation of knowledge organization techniques to new technological trends and requirements.

Moreover, statistical classification techniques, such as machine learning (ML), are already used to develop predictive models (classification algorithms), for example for cancer diagnosis, without recourse to classical knowledge organization tools [SID 19]. As a consequence, the relevance of MKOS description, classification and document indexing seems to be questioned with respect to ML techniques such as deep learning, artificial neural networks, etc. [SID 19]. On the other hand, Andrew MacFarlane, Sondess Missaoui and Sylwia Frankowska-Takhari point out that knowledge organization tools should not be neglected in this task [MAC 20]. Using the example of multimedia documents, the authors highlight that the implementation of projects involving supervised learning techniques first requires knowledge about the informational needs and practices in the domains of investigation (which can be mediated by KOSs) in order to identify the elements relevant to the parts of the document contents to be "learned" by the machines. Second, the algorithms used in this kind of work require training documents with metadata describing their "general" and "contextual" features (e.g., objects, styles, genres, emotions, locations), which are difficult for the algorithms to detect [MAC 20]. According to the model developed by MacFarlane *et al.* training corpora for machine learning can consist of documents and associated subject metadata (controlled by KOSs), e.g., from image banks. They can then be merged with image corpora, whose features can be extracted using ML techniques, to constitute the indexes needed for automatic classification. The relevance of this model for the classification of information in the medical domain remains to be evaluated.

The positioning of information and documentation sciences with regard to the organization of medical knowledge can be explained by taking into consideration general and specialized MKOs and by analyzing different facets of medical fields. This approach allows for a holistic view of the objects of study. As we have just seen, the dimensions of knowledge that are often investigated are: reality, ontology, epistemology, documents, collections, information needs (connected to informational behaviors and info-communicational practices) and cognitive capacities of individuals. These "steps between the world and classification", which

can be identified in the contents of MKOSs, are highlighted by Claudio Gnoli from an initial scheme elaborated by Brian Vickery [GNO 20]. They can be applied in medical domains as follows:

- α reality (the undifferentiated totality upstream of human understanding),
- β phenomenon, e.g., allergic hypersensitivity,
- γ perspective, e.g., an integrated approach,
- δ document, e.g., an article in a scientific journal that discusses it,
- ϵ collection, e.g., a digital library that contains the item,
- ζ information needs, e.g., a search by medical specialty thesis,
- η people, e.g., an intern in a teaching hospital,
- θ cognition, e.g., his natural abilities to navigate on lists.

The works inspired by a pragmatic approach, analyzed in this study, also underline that some MKOS designers now feel the need to free themselves from a technocentric approach, which gives pride of place to the tools implemented in the health sector [GRO 07], and to build the digital devices and services, in connection with the users' practices. The study of medical domains in a holistic approach, specific to information and documentation sciences, thus seems very favorable. This approach can lead to the proposal of MKOS models for the design of mediation devices, which are then translated into concrete realizations by engineers. We, as researcher in information and communication sciences and professional in information-documentation, encourage specialists in the discipline to set up multidisciplinary projects in digital humanities, in partnership with the health sector, and in cooperation with specialists in computer science.

8.9. Conclusion

The work in information and documentation sciences on the organization of medical knowledge is divided into two axes. The first one invites us to conceive and evaluate the MKOS. It is characterized by analyses of textual corpora, the use of documentary techniques, semantic technologies and by studies of users, their information-communication activities and their cognitive capacities. The second axis includes reflections specific to a science of mentefacts⁸, notably on the theory and epistemology of knowledge organization and on the issues related to classification.

8. By the concept of "mentefacts" we mean the intellectual products of human creativity (culture): theories, MKOSs, books, critical thinking, etc. [GNO 19].

In the first axis, the aim is to develop MKOSs for the design of systems allowing users to manage, access and consult information. In the second axis, the medical discourse occupies a predominant place. Specialists analyze the discourse carried by information resources and MKOSs, and emphasize their role as mediators of political, scientific, social, cultural and economic phenomena.

This study highlights that knowledge organization opens up a broad spectrum of applications in the field of medicine and health. It also helps explain why MKOSs, despite their artificial and often controlled nature, are able to draw society's attention to the sensitivity of population health and are powerful political instruments.

8.10. Bibliography

- [AUS 12] AUSSENAC-GILLES N., CHARLET J., REYNAUD C., “Les enjeux de l’Ingénierie des Connaissances”, in Sèdes F., Ogier J.-M., Marquis P. (eds.), *Information-Interaction-Intelligence : le point sur le I3*, p. 244-266, Editions Cépaduès, Toulouse, 2012.
- [BEG 02] BEGHTOL C., “A proposed ethical warrant for global knowledge representation and organization systems”, *Journal of Documentation*, vol. 58, n° 5, p. 507-532, 2002.
- [BIN 20] BINDING C., GNOLI C., MERLI D., TRZMIELEWSKI M., TUDHOPE D., “Integrative Levels Classification as a networked KOS: a SKOS representation of ILC2”, *Advances in Knowledge Organization, Vol. 17 (2020) – Knowledge organization at the interface – Proceedings of the Seventeenth International ISKO Conference 6-8 July 2020 Aalborg, Denmark*, Ergon, Baden-Baden, 2020. [in press]
- [BRO 15] BROUGHTON V., *Essential Classification – Second Edition*, Facet Publishing, London, 2015.
- [CAC 97] CACALY S. (ED.), *Dictionnaire encyclopédique de l’information et de la documentation*, Editions Nathan, Paris, 1997.
- [CAM 14] CAMPION-AWWAD O., HAYTON A., SMITH L., VUARAN M., *The National Programme for IT in the NHS – A Case History*, University of Cambridge, Cambridge, 2014.
- [COU 11] COUZINET V., “Les dispositifs : question documentaire”, in GARDIÈS C. (ED.), *Approche de l’information documentation : concepts fondateurs*, p. 117-130, Cépaduès, Toulouse, 2011.
- [DRI 94] van DRIMMELLEN-KRABBE J.J., USTUN T.B., THOMPSON D.H., L’HOURS A., ORLEY J., SARTORIUS N., “Homosexuality in the International Classification of Diseases: A Clarification”, *JAMA*, vol. 272, n° 21, p. 1660, 1994.
- [DUB 00] DUBRIDGE G., *Lost Books of Medieval China*, The British Library, London, 2000.
- [GNO 16] GNOLI C., “Classifying Phenomena, Part 1: Dimensions”, *Knowledge Organization*, vol. 43, n° 6, p. 403-415, 2016.

- [GNO 19] GNOLI C., “Levels of information and library and information science as a science of mentefacts”, *Information Research – Proceedings of CoLIS, the Tenth International Conference on Conceptions of Library and Information Science, Ljubljana, Slovenia, June 16-19, 2019*, vol. 24, n° 4, 2019.
- [GNO 20] GNOLI C., *Introduction to knowledge organization*, Facet, London, 2020.
- [GON 07] GONOD BOISSIN F., L’usage de l’information numérique en médecine générale : étude exploratoire en Rhône-Alpes, PhD thesis, Université Claude Bernard Lyon 1, 2007.
- [GRO 07] GROSJEAN S., BONNEVILLE L., “Logiques d’implantation des TIC dans le secteur de la santé”, *Revue française de gestion*, vol. 3, n° 172, p. 145-157, 2007
- [GRU 93] GRUBER T.R., “Towards Principles for the Design of Ontologies Used for Knowledge Sharing”, *International Journal Human-Computer Studies*, vol. 43, p. 907-928, 1993.
- [HAS 13] HAS – HAUTE AUTORITÉ DE SANTÉ, “Niveau de preuve et gradations des recommandations de bonne pratique – Etat des lieux ”, available at: https://www.has-sante.fr/jcms/c_1600564/fr/niveau-de-preuve-et-gradation-des-recommandations-de-bonne-pratique-etat-des-lieux/, 14 juin 2013.
- [HJØ 03] HJØRLAND B., “Fundamentals for Knowledge Organization”, *Knowledge Organization*, vol. 30, n° 2, p. 87-111, 2003.
- [HJØ 14] HJØRLAND B., “Is Facet Analysis Based on Rationalism? A Discussion of Satija (1992), Tennis (2008), Herre (2013), Mazzocchi (2013b), and Dousa & Ibekwe-SanJuan (2014)”, *Knowledge Organization*, vol. 41, n° 5, p. 369-376, 2014.
- [HJØ 16] HJØRLAND B., “Knowledge organization”, *Knowledge Organization*, vol. 43, n° 6, p. 475-484, 2016.
- [HJØ 18] HJØRLAND B., “Library and Information Science (LIS). Part 2”, *Knowledge Organization*, vol. 45, n° 4, p. 319-338, 2018.
- [HUB 98] HUBER J.T., GILLASPY M.L., “Social Constructs and Disease: Implications for a Controlled Vocabulary for HIV / AIDS”, *Library trends*, vol. 47, n° 2, p. 190-208, 1998.
- [MAC 20] MACFARLANE A., MISSAOUI S., FRANKOWSKA-TAKHARI S., “On Machine Learning and Knowledge Organization in Multimedia Information Retrieval”, *Knowledge Organization*, vol. 47, n° 1, p. 45-55, 2020.
- [MAR 11] MARAGOUDAKIS M., MAGLOGIANNIS I., “A medical ontology for intelligent web-based skin lesions image retrieval”, *Health Informatics Journal*, vol. 17, n° 2, p. 140-157, 2011.
- [MAZ 18] MAZZOCCHI F., “Knowledge organization system (KOS)”, *Knowledge Organization*, vol. 45, n° 1, p. 54-78, 2018.
- [MET 06] METZGER J.-P., “L’information-documentation”, in OLIVESI S. (ED.), *Sciences de l’information et de la communication - Objets, savoirs, discipline*, p. 43-62, Presses universitaires de Grenoble, Grenoble, 2006.

- [NAT 19] NATIONAL LIBRARY OF MEDICINE, “A Brief History of NLM”, available at: <https://www.nlm.nih.gov/about/briefhistory.html/>, 20 mars 2019.
- [NZA 15] NZALI M.D.T., BRINGAY S., LAVERGNE C., OPITZ T., AZÉ J., MOLLEVI C., “Construction d’un vocabulaire patient/médecin dédié au cancer du sein à partir des médias sociaux”, *26èmes Journées francophones d’Ingénierie des Connaissances*, Rennes, France, 1-3 juillet 2015, available at: <https://hal.inria.fr/IC-2015/>, 2015.
- [ODE 16] ODEH S., “Du dossier médical personnel au dossier partagé : Vers un dispositif de médiation documentaire”, *Les Cahiers du numérique*, vol. 12, n° 1, p. 31-50, 2016.
- [OHN 19] OHNO-MACHADO L., SÉROUSSI B. (EDS.), *MEDINFO 2019: Health and Wellbeing e-networks for All – Proceedings of the 17th World Congress on Medical and Health Informatics*, IOS Press BV, Amsterdam, 2019.
- [RÉG 11] REGIMBEAU G., “3-Médiation”, in GARDIÈS C. (ED.), *Approche de l’information documentation – Concepts fondateurs*, p. 75-114, Cépaduès, Toulouse, 2011.
- [ROM 08] ROMEYER H., “TIC et santé : entre information médicale et information de santé”, *Tic en santé*, vol. 2, n° 1. Available at: <https://journals.openedition.org/ticetsociete/365>, 2008.
- [SID 19] SIDEY-GIBBONS J., SIDEY-GIBBONS C., “Machine learning in medicine: a practical introduction”, *BMC Medical Research Methodology*, vol. 19, 2019.
- [SMI 12] SMIRAGLIA R., “Epistemology of Domain Analysis”, in SMIRAGLIA R., LEE H. (EDS.), *Cultural Frames of Knowledge*, p. 111-124, Ergon, Würzburg, 2012.
- [SOS 19] SOSIŃSKA-KALATA B., “Organizacja wiedzy w cyfrowym świecie: wpływ rewolucji cyfrowej na ewolucję metod i narzędzi organizacji wiedzy”, *Zagadnienia Informatyki Naukowej*, vol. 57, n° 1, p. 26-46, 2019.
- [TAN 16] TANNO L.K., CALDERON M.A., DEMOLY P., “New Allergic and Hypersensitivity Conditions Section in the International Classification of Diseases-11”, *Allergy Asthma & Immunology Research*, vol. 8, n° 4, p. 383-388, 2016.
- [TEN 08] TENNIS J.T., “Epistemology, theory, and methodology in knowledge organization: toward a classification, metatheory and research framework”, *Knowledge Organization*, vol. 35, n° 2-3, p. 102-112, 2008.
- [THO 04] THOMPSON T.G., BRAILER D.J., *The Decade of Health Information Technology: Delivering Consumer-centric and Information-rich Health Care – Framework for Strategic Action*, U.S. Dept. of Health and Human Services, Office for the National Coordinator for Health Information Technology, Washington, D.C., 2004.
- [WEI 16] WEISS L.C., BRÄSCHER M., VIANNA W.B., “Pragmatism, Constructivism and Knowledge Organization”, in CHAVES GUIMARÃES J.A., OLIVIERA MILANI S., DODEBEI V. (EDS.), *Advances in Knowledge Organization, Vol. 15 (2016) – Knowledge Organization for a Sustainable World: Challenges and Perspectives for Cultural, Scientific, and Technological Sharing in a Connected Society – Proceedings of the Fourteenth International ISKO Conference 27-29 September 2016 Rio de Janeiro, Brazil*, 211-218, Ergon, Würzburg, 2016.

- [W3C 09] W3C, “SKOS: Simple Knowledge Organization System Reference”, available at: <http://www.w3.org/TR/skos-reference/>, 18 August 2009.
- [WAL 18] WALTER J., DOUYÈRE D., BOUILLON J.-L., OLLIVIER-YANIV C. (EDS.), *Dynamiques des recherches en sciences de l’information et de la communication – Conférence permanente des directeurs-trices des unités de recherche en sciences de l’information et de la communication (CPDirSIC)*, 2018. Available at: <https://pastel.archives-ouvertes.fr/CREM-UL/haI-01885229v2>, 27 juin 2019.
- [VIC 60] VICKERY B., *Faceted classification: a guide to the construction and use of special schemes*. ASLIB, London, 1960.
- [ZAC 10] ZACKLAD M., “Evaluation des systèmes d’organisation des connaissances”, *Les cahiers du numérique*, vol. 6, n° 3, p. 133-166, 2010.

8.11. Appendix 1: the corpus of journal articles and conference proceedings

- Text 1 – ÅDLAND M.K., LYKKE M., “Tags on healthcare information websites”, in RIBEIRO F., CERVEIRA M.E. (EDS.), *Advances in Knowledge Organization, Vol. 16 (2018) – Challenges and Opportunities for Knowledge Organization in the Digital Age – Proceedings of the Fifteenth International ISKO Conference 9-11 July 2018 Porto, Portugal*, 684-692, Ergon, Baden-Baden, 2018.
- Text 2 – ALMEIDA BARCELLOS M., FARINELLI F., “Ontologies for the representation of electronic medical records: The obstetric and neonatal ontology”, *Journal of the American Society for Information Science and Technology*, vol. 68, n° 11, 2529-2542, 2017.
- Text 3 – DE ANDRADE J., LOPEZ GINES DE LARA M., “Interoperability and Mapping Between Knowledge Organization Systems: Metathesaurus—Unified Medical Language System of the National Library of Medicine”, *Knowledge Organization*, vol. 43, n° 2, 107-112, 2016.
- Text 4 – BOEHR D., BUSHMAN B., “Preparing for the Future: National Library of Medicine’s® Project to Add MeSH® RDF URIs to its Bibliographic and Authority Records”, *Cataloging & Classification Quarterly*, vol. 56, n° 2-3, 262-272, 2018.
- Text 5 – BOURRET C., “New ways to produce shared knowledge to improve cooperation in overcoming societal challenges in healthcare: the lever of innovative interface organizations in France”, in RIBEIRO F., CERVEIRA M.E. (EDS.), *Advances in Knowledge Organization, Vol. 16 (2018) – Challenges and Opportunities for Knowledge Organization in the Digital Age – Proceedings of the Fifteenth International ISKO Conference 9-11 July 2018 Porto, Portugal*, 871-879, Ergon, Baden-Baden, 2018.
- Text 6 – BUSHMAN B., ANDERSON D., FU G., “Transforming the Medical Subject Headings into Linked Data: Creating the Authorized Version of MeSH in RDF”, *Journal of Library Metadata*, vol. 15, n° 3-4, 157-176, 2015.

- Text 7** – CAMPBELL D.G., “Farradane’s Relational Indexing and its Relationship to Hyperlinking in Alzheimer’s Information”, in NEELAMEGHAN A., RAGHAVAN K.S. (EDS.), *Advances in Knowledge Organization, Vol. 12 (2012) – Categories, Contexts, and Relations in Knowledge Organization – Proceedings of the Twelfth International ISKO Conference 6-9 August 2012 Mysore, India*, 195-200, Ergon-Verlag, Würzburg, 2012.
- Text 8** – CAMPBELL D.G., “The Human Life as Warrant: A Facet Analysis of Protocols for Dealing with Responsive Behaviours in Dementia Patients”, in BABIK W. (ED.), *Advances in Knowledge Organization, vol. 14 (2014) – Knowledge organization in the 21st century: between historical patterns and future prospects – Proceedings of the Thirteenth International ISKO Conference 19-22 May 2013 Kraków, Poland*, 121-128, Ergon-Verlag, Würzburg, 2014.
- Text 9** – CHOI Y., “Supporting better treatments for meeting health consumers' needs: extracting semantics in social data for representing a consumer health ontology”, *Information Research*, vol. 21, n° 4, 2016.
- Text 10** – COGNETTI G., POPPI G., “The problems of indexing in Italian biomedical libraries”, in NEGRINI G., FARNESI T., BENEDIKTSSON D. (EDS.), *Advances in Knowledge Organization, vol. 3 (1991) – Documentary Languages and Databases – Papers from the Rome Conference, Dec. 3-4, 1990*, 245-249, INDEKS Verlag, Frankfurt/Main, 1991.
- Text 11** – CONNOWAY L.S., SIEVERT M.C., “Comparison of Three Classification Systems for Information on Health Insurance”, *Cataloging & Classification Quarterly*, vol. 23, n° 2, 89-104, 1996.
- Text 12** – COOPER R., “Diagnostic and Statistical Manual of Mental Disorders (DSM)”, *Knowledge Organization*, vol. 44, n° 8, p. 668-676, 2017.
- Text 13** – COSGROVE T.L., “Planetree health information services: public access to the health information people want”, *Bulletin of the Medical Library Association*, vol. 82, n° 1, 57-63, 1994.
- Text 14** – CRYSTAL A., GREENBERG J., “Relevance criteria identified by health information users during Web searches”, *Journal of the American Society for Information Science and Technology*, vol. 57, n° 10, 1368-1382, 2006.
- Text 15** – CUENCA G.M., SALVADOR OLIVÁN J.A., “Representación del conocimiento en historia clínica electrónica interoperable: el caso de la Historia Clínica Digital del Sistema Nacional de Salud de España”, *Scire: Representación y organización del conocimiento*, vol. 23, n° 1, 25-38, 2017.
- Text 16** – DALI K., DILEVKO J., “Towards Improved Collections in Medical Humanities: Fiction in Academic Health Libraries”, *The Journal of Academic Librarianship*, vol. 32, n° 3, 259-273, 2006.
- Text 17** – DAS S., ROY S., “Faceted Ontological Model for Brain Tumour Study”, *Knowledge Organization*, vol. 43, n° 1, 3-12, 2016.
- Text 18** – DEFRANCIS SUN B., “Folksonomy and health information access: how can social bookmarking assist seekers of online medical information?”, *Journal of Hospital Librarianship*, vol. 8, n° 1, 119-126, 2008.

- Text 19** – DOUYÈRE M., SOUALMIA L.F., NÉVÉOL A., ROGOZAN A., DAHAMNA B., LEROY J.-P., THIRION B., DARMONI S.J., “Enhancing the MeSH thesaurus to retrieve French online health resources in a quality-controlled gateway”, *Health Information and Libraries Journal*, vol. 21, n° 4, 253-261, 2004.
- Text 20** – EFTHIMIADIS E.N., AFIFI M., “Population groups: indexing, coverage, and retrieval effectiveness of ethnically related health care issues in health sciences databases”, *Bulletin of the Medical Library Association*, vol. 84, n° 3, 386-396, 1996.
- Text 21** – FERRAIOLI L., “An exploratory study of metadata creation in a health care agency”, *Cataloging & Classification Quarterly*, vol. 40, n° 3-4, 75-102, 2005.
- Text 22** – FERNÁNDEZ L.M.M., IZQUIERDO ALONSO M., MAURANDI LÓPEZ A., VALLÉS VALENZUELA J., “Consistency between indexers in the LILAC database (Latin American and Caribbean Health Science Literature)”, *Information Research*, vol. 18, n° 4, 2013.
- Text 23** – FLOR P., JAKOBSSON A., MOGSET I., TAYLOR S., EASEN S.E., “A controlled vocabulary for nursing and allied health in Norway”, *Health Information and Libraries Journal*, vol. 18, n° 1, 10-19, 2001.
- Text 24** – GIVEN L.M., RUECKER S., SIMPSON H., SADLER E.B., RUSKIN A., “Inclusive interface design for seniors: image-browsing for a health information context”, *Journal of the American Society for Information Science and Technology*, vol. 58, n° 11, 1610-1617, 2007.
- Text 25** – HAMADA M., SAKUMA S., MISAWA K., ““Thesaurus for Medical and Health related Terms” and its relation to Medical Subject Headings”, *Journal of Information Processing and Management*, vol. 51, n° 9, 642-652, 2008.
- Text 26** – HUBER J.T., GILLASPY M.L., “An Examination of the Discourse of Homosexuality As Reflected in Medical Vocabularies, Classificatory Structures, and Information Resources”, in BEGHTOL C., HOWARTH L.C., WILLIAMSON N.J. (EDS.), *Advances in Knowledge Organization, vol. 7 (2000) – Dynamism and Stability in Knowledge Organization – Proceedings of the Sixth International ISKO Conference 10-13 July 2000 Toronto, Canada*, 219-223, ERGON Verlag, Würzburg, 2000.
- Text 27** – HUBER J.T., GILLASPY M.L., “Controlled Vocabulary for HIV/AIDS: An Evolving Nosological: Record of a Diseased Body of Knowledge”, in GREEN R. (ED.), *Advances in Knowledge Organization, Vol. 5 (1996) – Knowledge Organization and Change – Proceedings of the Fourth International ISKO Conference 15-18 July 1996 Washington, DC, USA*, 293-301, INDEKS Verlag, Frankfurt/Main, 1996.
- Text 28** – IYER H., BUNGO L., “An examination of semantic relationships between professionally assigned metadata and user-generated tags for popular literature in complementary and alternative medicine”, *Information Research*, vol. 16, n° 3, 2011.
- Text 29** – IYER H., GUADRÓN M., “Older Adults and eHealth Literacy: Challenges to Knowledge Representation”, in BABIK W. (ED.), *Advances in Knowledge Organization, vol. 14 (2014) – Knowledge organization in the 21st century: between historical patterns and future prospects – Proceedings of the Thirteenth International ISKO Conference 19-22 May 2014 Kraków, Poland*, 429-436, Ergon, Würzburg, 2014.

- Text 30** – IYER H., “Alternative System of Medicine, Ayurveda: Challenges to Knowledge Organization and Representation”, in CHAVES GUIMARÃES J.A., OLIVIERA MILANI S., DODEBEI V. (EDS.), *Advances in Knowledge Organization, Vol. 15 (2016) – Knowledge Organization for a Sustainable World: Challenges and Perspectives for Cultural, Scientific, and Technological Sharing in a Connected Society – Proceedings of the Fourteenth International ISKO Conference 27-29 September 2016 Rio de Janeiro, Brazil*, 384-391, Ergon, Würzburg, 2016.
- Text 31** – IYER H., RAGHAVAN K.S., “Medical ontology: Siddha System of Medicine”, in RIBEIRO F., CERVEIRA M.E. (EDS.), *Advances in Knowledge Organization, Vol. 16 (2018) – Challenges and Opportunities for Knowledge Organization in the Digital Age – Proceedings of the Fifteenth International ISKO Conference 9-11 July 2018 Porto, Portugal*, 347-355, Ergon, Baden-Baden, 2018.
- Text 32** – JORENTE M.J.V., “Information Design as knowledge technology in the organization of digital information environments on the Zika Virus and its effects”, in RIBEIRO F., CERVEIRA M.E. (EDS.), *Advances in Knowledge Organization, Vol. 16 (2018) – Challenges and Opportunities for Knowledge Organization in the Digital Age – Proceedings of the Fifteenth International ISKO Conference 9-11 July 2018 Porto, Portugal*, 820-829, Ergon, Baden-Baden, 2018.
- Text 33** – KHOO C.S.G., NA J.-C., WANG V.W., CHAN S., “Developing an Ontology for Encoding Disease Treatment Information in Medical Abstracts”, *DESIDOC Journal of Library & Information Technology*, vol. 31, n° 31, 103-115, 2011.
- Text 34** – KIPP M.E.I., “Tagging of Biomedical Articles on CiteULike: A Comparison of User, Author and Professional Indexing”, *Knowledge Organization*, vol. 38, n° 3, 245-261, 2011.
- Text 35** – LEE D.H., SCHLEYER T., “Social tagging is no substitute for controlled indexing: A comparison of Medical Subject Headings and CiteULike tags assigned to 231,388 papers”, *Journal of the American Society for Information Science and Technology*, vol. 63, n° 9, 1747-1757, 2012.
- Text 36** – LIU Y.-H., WACHOLDER N., “Evaluating the impact of MeSH (Medical Subject Headings) terms on different types of searchers”, *Information Processing & Management*, vol. 53, n° 4, 851-870, 2017.
- Text 37** – LÓPEZ-MERTZ E.M., “The Adequacy of the Structure of the National Library of Medicine Classification Scheme for Organizing Pharmacy Literature”, *Library Resources & Technical Services*, vol. 41, n° 2, 123-135, 1997.
- Text 38** – MARTELETO R.M., DOS SANTOS CARVALHO L., “Health as a Knowledge Domain and Social Field: Dialogues with Birger Hjørland and Pierre Bourdieu”, *Knowledge Organization*, vol. 42, n° 8, 581-590, 2015.
- Text 39** – MARCONDES C.H., DA COSTA L.C., “A Model to Represent and Process Scientific Knowledge in Biomedical Articles with Semantic Web Technologies”, *Knowledge Organization*, vol. 43, n° 2, 86-101 2016.

- Text 40** – MCILWAINE I.C., WILLIAMSON N.J., “Medicine and the UDC: The Process of Restructuring”, in ARSENAULT C., TENNIS J.T. (EDS.), *Advances in Knowledge Organization, Vol. 11 (2008) – Culture and Identity in Knowledge Organization – Proceedings of the Tenth International ISKO Conference 5-8 August 2008 Montréal, Canada*, 50-55, Ergon, Würzburg, 2008.
- Text 41** – MCTAVISH J.R., FORTIER A., “A domain-analytic perspective on sexual health in LCSH and RVM”, in BEGTOL C., SMIRAGLIA R. (EDS.), *Proceedings from North American Symposium on Knowledge Organization*, vol. 3, 83-93, Toronto, Canada, June 16-17, 2011.
- Text 42** – MCTAVISH J.R., NEAL D.R., WATHEN C.N., “Is What You See What You Get? Medical Subject Headings and their Organizing Work in the Violence Against Women Research Literature”, *Knowledge Organization*, vol. 38, n° 5, 381-397, 2011.
- Text 43** – MU X., LU K., RYU H., “Explicitly integrating MeSH thesaurus help into health information retrieval systems: an empirical user study”, *Information Processing & Management*, vol. 50, n° 1, 24-40, 2014.
- Text 44** – MURESAN S., KLAVANS J.L., “Inducing terminologies from text: A case study for the consumer health domain”, *Journal of the American Society for Information Science and Technology*, vol. 64, n° 4, 727-744, 2013.
- Text 45** – NA J.-H., LENG NEOH H., “Effectiveness of UMLS semantic network as a seed ontology for building a medical domain ontology”, *Aslib Proceedings*, vol. 60, n° 1, 32-46, 2008.
- Text 46** – NICOLE-GENTY G., “Les classifications médicales”, *Bulletin des bibliothèques de France*, vol. 13, n° 7, p. 289-313, 1968.
- Text 47** – OH K., JOO S., JEONG E.-J., “Online consumer health information organization: users' perspectives on faceted navigation”, *Knowledge Organization*, vol. 42, n° 3, 176-186, 2015.
- Text 48** – PINTO V., RABELO C., GIRÃO I., “SNOMED-CT as Standard Language for Organization and Representation of the Information in Patient Records”, *Knowledge Organization*, vol. 41, n° 4, 311-318, 2014.
- Text 49** – RAGHAVAN K.S., SAJANA C., “NeurOn. Modeling ontology for neurosurgery”, in GNOLI C., MAZZOCCHI F. (EDS.), *Advances in Knowledge Organization, vol. 12 (2010) – Paradigms and conceptual systems in knowledge organization – Proceedings of the Eleventh International ISKO Conference 23-26 February 2010 Rome, Italy*, 208-215, Ergon, Würzburg, 2010.
- Text 50** – RAJ P., “Depth Colon Classification Schedule for Anaesthesiology”, *International Classification*, vol. 14, n° 2, 77-83, 1987.
- Text 51** – REDALEN A., MILLER N., “Evaluating Website Modifications at the National Library of Medicine through Search Log Analysis”, *D-Lib Magazine*, vol. 6, n° 1, 2000.

- Text 52** – RIBEIRO C.J.S., DA SILVA D.R., “Knowledge Organization in the health field: an ontology project to improve the information retrieval process”, in RIBEIRO F., CERVEIRA M.E. (EDS.), *Advances in Knowledge Organization, Vol. 16 (2018) – Challenges and Opportunities for Knowledge Organization in the Digital Age – Proceedings of the Fifteenth International ISKO Conference 9-11 July 2018 Porto, Portugal*, 330-338, Ergon, Baden-Baden, 2018.
- Text 53** – SCHOPEN M., “Cross File Searching of Biomedical Databases at DIMDI”, in FUGMANN R. (ED.), *Advances in Knowledge Organization, vol. 1 (1990) – Tools for Knowledge Organization and the Human Interface – Proceedings 1st International ISKO-Conference Darmstadt, Germany, 14-17 August 1990*, 231-237, INDEKS Verlag, Frankfurt/Main, 1990.
- Text 54** – SEETHARAMA S., “Compatibility among Medical Classification Systems: A Case Study in the Classification of Cardiovascular Diseases”, *International Classification*, vol. 12, n° 2, 80-86, 1985.
- Text 55** – SMITH J.B., DEACON P., “Precision with ease: refining thesaurus support for quality health information searching on HealthInsite”, *The Australian Library Journal*, vol. 58, n° 1, 47-62, 2009.
- Text 56** – SOERGEL D., TSE T., SLAUGHTER L., “Helping Healthcare Consumers Understand: An “Interpretative Layer” for Finding and Making Sense of Medical Information”, in FIESCHI M., COIERA E., LI Y.-C. (EDS.), *MEDINFO Proceedings of the 11th World Congress on Medical Informatics*, 931-935, IOS Press, Amsterdam, 2004.
- Text 57** – SOLOMON P., “On the Use of Research Categorizations as the Basis for Organizing Knowledge: A Test in the Domain of Information Behavior in Health Care”, in MUSTAFA EL-HADI W., MANIEZ J., POLLITT S.A. (EDS.), *Advances in Knowledge Organization, Vol. 6 (1998) – Structures and Relations in Knowledge Organization – Proceedings of the Fifth International ISKO Conference 25-29 August 1998 Lille, France*, 293-301, Ergon, Würzburg, 1998.
- Text 58** – SUNDIN O., “Towards an Understanding of Symbolic Aspects of Professional Information: An Analysis of the Nursing Knowledge Domain”, *Knowledge Organization*, vol. 30, n° 3/4, 170-181, 2003.
- Text 59** – SWANSON D.R., SMALHEISER N.R., TORVIK V.I., “Ranking indirect connections in literature-based discovery: The role of medical subject headings”, *Journal of the American Society for Information Science and Technology*, vol. 57, n° 11, 1427-1439, 2006.
- Text 60** – TANG X., WEI W., LIU G., ZHU J., “An Inference Model of Medical Insurance Fraud Detection: Based on Ontology and SWRL”, *Knowledge Organization*, vol. 44, n° 2, 84-96, 2017.

- Text 61** – TANTI M., ROUX P., CARRIERI M.P., SPIRE B., “Exploiting the Knowledge Organization of Health 2.0 to Create Strategic Value in Public Health – An Example of Application to the Problem of Drug Consumption Rooms in France”, in CHAVES GUIMARÃES J.A., OLIVIERA MILANI S., DODEBEI V. (EDS.), *Advances in Knowledge Organization, Vol. 15 (2016) – Knowledge Organization for a Sustainable World: Challenges and Perspectives for Cultural, Scientific, and Technological Sharing in a Connected Society – Proceedings of the Fourteenth International ISKO Conference 27-29 September 2016 Rio de Janeiro, Brazil*, 530-537, Ergon, Würzburg, 2016.
- Text 62** – TANTI M., “The French military documentary system to anticipate health risk: content and information classification”, in RIBEIRO F., CERVEIRA M.E. (EDS.), *Advances in Knowledge Organization, Vol. 16 (2018) – Challenges and Opportunities for Knowledge Organization in the Digital Age – Proceedings of the Fifteenth International ISKO Conference 9-11 July 2018 Porto, Portugal*, 940-944, Ergon, Baden-Baden, 2018.
- Text 63** – VAKKARI P., “How specific thesauri and a general thesaurus cover lay persons’ vocabularies concerning health, nutrition and social services”, in GNOLI C., MAZZOCCHI F. (EDS.), *Advances in Knowledge Organization, vol. 12 (2010) – Paradigms and conceptual systems in knowledge organization – Proceedings of the Eleventh International ISKO Conference 23-26 February 2010 Rome, Italy*, 299-307, Ergon, Würzburg, 2010.
- Text 64** – WILLIAMSON N.J., “Complementary and alternative medicine: its place in the reorganized medical sciences in the Universal Decimal Classification”, in MCLWAIN I.C. (EDS.), *Advances in Knowledge Organization, vol. 9 (2004) – Global Organization and the Global Society – Proceedings of the Eighth International ISKO Conference 13-16 July 2004 London, UK*, 257-262, Ergon, Würzburg, 2004.
- Text 65** – WOMACK K.R., “Conformity for Conformity's Sake? The Choice of a Classification System and a Subject Heading System in Academic Health Sciences Libraries”, *Cataloging & Classification Quarterly*, vol. 42, n° 1, 93-115, 2006.
- Text 66** – WOODS J.W., SNEIDERMAN C.A., HAMEED K., ACKERMAN M.J., HATTON C., “Using UMLS Metathesaurus Concepts to Describe Medical Images: Dermatology Vocabulary”, *Computer in Biology and Medicine*, vol. 36, n° 1, 89-100, 2006.
- Text 67** – YITZHAKI M., SHAHAR T., “A draft version of a consolidated thesaurus for the rapidly - growing field of alternative medicine”, *66th IFLA Council and General Conference*, Jerusalem, Israel, 13-18 August 2000.
- Text 68** – ZENG M.L., KRONENBERG F., MOLHOLT P., “Toward a Conceptual Framework for Complementary and Alternative Medicine: Challenges and Issues”, *Knowledge Organization*, vol. 29, n° 1, 27-40, 2001.
- Text 69** – ZHANG J., WOLFRAM D., WANG P., HONG Y., GILLIS R., “Visualization of health-subject analysis based on query term co-occurrences”, *Journal of the American Society for Information Science and Technology*, vol. 59, n° 12, 1933-1947, 2008.
- Text 70** – ZHANG J., WOLFRAM D., “Visual analysis of obesity-related query terms on HealthLink”, *Online Information Review*, vol. 33, n° 1, 43-57, 2009.

Text 71 – ZHITOMIRSKY-GEFFET M., EREZ E.S., JUDIT B.-I., “Toward multiviewpoint ontology construction by collaboration of non-experts and crowdsourcing: The case of the effect of diet on health”, *Journal of the American Society for Information Science and Technology*, vol. 68, n° 3, 681-694, 2017.

8.12. Appendix 2: MKOS corpus

Bliss Bibliographic Classification, 2nd ed. – BLISS CLASSIFICATION ASSOCIATION, “The Bliss Bibliographic Classification : schedules”, available at: <https://www.blissclassification.org.uk/bcsched.shtml/>, 28 December 2016.

Classification Commune des Actes Médicaux – ASSURANCE MALADIE, “Classification Commune des Actes Médicaux”, available at: <https://www.ameli.fr/accueil-de-la-ccam/index.php>, 2020.

Colon Classification – ISKO ITALIA, “Colon Classification - L Medicine”, available at: <http://www.iskoi.org/doc/colon.htm#L/>, November 2006.

Dewey Decimal Classification – OCLC, “Dewey Services – Resources”, available at: <https://www.oclc.org/en/dewey/resources.html>, 2020.

Health Topics – MEDLINEPLUS, “Health Topics”, available at: <https://medlineplus.gov/healthtopics.html/>, 1 February 2017.

International Classification of Diseases-9 – CDC – NATIONAL CENTER FOR HEALTH STATISTICS, “International Classification of Diseases, Ninth Revision (ICD-9)”, available at: <https://www.cdc.gov/nchs/icd/icd9.htm/>, 6 November 2015.

International Classification of Diseases-10 – WHO, “CIM-10 Version: 2008”, available at <https://icd.who.int/browse10/2008/en>, 2008.

International Classification of Diseases-11 – WHO, “ICD-11 for Mortality and Morbidity Statistics (Version 04 / 2019)”, available at: <https://icd.who.int/browse11/l-m/en/>, 2019.

Library of Congress Subject Headings – Library of Congress, “Linked Data Service - Library of Congress Subject Headings”, available at: <http://id.loc.gov/authorities/subjects.html>, 2019.

MeSH bilingue anglais-français – INSERM, “Le MeSH bilingue anglais-français”, available at: <http://mesh.inserm.fr/FrenchMesh/>, 2019.

NLM Classification – NATIONAL LIBRARY OF MEDICINE, “NLM Classification 2020 Winter Edition”, available at: <https://www.nlm.nih.gov/class/index.html/>, 2020.

SNOMED – SNOMED INTERNATIONAL, “Leading healthcare terminology, worldwide”, available at: <http://www.snomed.org/>, 2020.

Universal Decimal Classification – UDC CONSORTIUM, “UDC Summary”, available at: <http://www.udcsummary.info/php/index.php>, 2020.

