COVID-19 Ontologies and their Applications in Medical Sciences: Reviewing BioPortal

Omid Yousefianzadeh ✉
Ph.D. in Health Information Management, Department of Health Information Technology and Management, Health Technology Assessment and Medical Informatics Research Center, School of Public Health, Shahid Sadoughi University of Medical Sciences, Yazd, Iran. Email: o.yousefianzadeh@gmail.com, ORCID: https://orcid.org/ 0000-0002-9356-6614

Abolfazl Taheri
Ph.D. in Medical Library and Information Science, Health Information Technology Research Center, Isfahan University of Medical Sciences, Isfahan, Iran.

Citation: Yousefianzadeh O, Taheri A. **COVID-19 Ontologies and their Applications in Medical Sciences: Reviewing BioPortal.** Applied Health Information Technology 2020; 1(1): 30-35.

Received: 9-6-2020
Accepted: 9-29-2020

Abstract

The high incidence of coronavirus disease (COVID-19) and the resulting increase in data and information in this area have led medical centers to use different methods to manage them due to the huge amount of information. One of the best ways to avoid confusion in documenting and managing health information is to use new information tools such as ontology. Researchers have used a tool around the world since the late 1990s to support decision-making in various fields. In this regard, the National Center for Biomedical Ontology has established a medical ontology database called BioPortal. In the present research, published ontologies in the field of Covid-19 in this database have been explored.

Keywords: BioPortal, Ontology, COVID-19, Biomedical ontology

On 30 Jan 2020, the WHO declared the Covid-19 outbreak a public health emergency of international concern. In March 2020, they began to characterize it as a pandemic to emphasize the gravity of the situation and urge all countries to detect infection and prevent spread. Unfortunately, the FDA approved no medication, gone through controlled studies, and demonstrated an effect on the virus for this global pandemic. Although there are cures for illnesses and developments made by leaps and bounds in this world, the strongest and most effective weapon that society has against this virus that is affecting not just health but also economics, politics, and social order is the prevention of its spread (1).

Statistics show an increase in the number of patients with Covid-19 disease and increased data and information in this area. Accordingly, if medical centers like to manage this information in their way, they will face an extensive range of management methods, depending on people's perceptions and views of the subject. Besides, information saturation and inefficient information management, combined with existing systems' inefficiencies and their problems such as weak standards, the complexity of concepts, and linguistic meanings, doubled the need to use new technologies to increase integrity and coordination in health information management (2).

In such circumstances, any action and planning to control this disease is a health-management necessity in the world. The basis of

this planning (prevention, screening, timely treatment, and palliative care) is collecting, recording, and analyzing patients' information. Analyzing these data and reporting them to officials, scientific, and research communities by determining the incidence and general trend of the disease and its specific types at the community or specific geographical areas is a special help to managers and policymakers to manage the current situation (3). Undoubtedly, the provision of this infrastructure is possible only by an accurate and integrated recording of patient information based on powerful tools of knowledge representation, such as ontologies; however, the use of ontology in information management systems is the basic structure and one of the most fundamental infrastructures in advanced approaches to information management automation (2).

Ontologies are commonly used in the design of information systems (4) and are useful in providing an effective model of information needs (5). Given the challenges facing information systems and ontology's ability to describe reality, the use of ontology in health information management systems can help define and formalize processes and information. Ontology in any field is considered the heart of knowledge representation systems (6).

Accordingly, part of medical research focuses on reusing knowledge and the design of ontologies. Medical ontologies have been developed to address the demand for reuse and sharing of patient data and the meaning-based criteria for collecting the required statistics. Making an unambiguous connection between complex and detailed medical concepts is an important and vital goal in medical information systems. In these systems, the interaction of several factors is necessary to share the results, and a set of technical and scientific terms with a clear and unambiguous meaning must be used. Like other domain-related ontologies, medical ontologies are a reusable vocabulary of concepts in a domain and the relationships between them. These relationships arise from the activities and theories, and basic principles that govern that domain (7).

However, ontology is a new tool for representing the knowledge of different subject areas. It seems that it can be used by providing a clear and formal explanation of concepts, along with all existing relationships and the possibility of automatic processing and synthesis of concepts. It provided a shared understanding of meaning by different people and thus eliminated some of the shortcomings of medical thesauruses. Therefore, the present study reviewed all Covid-19 ontologies published in the BioPortal database from October 2020.

Ontology

Ontology is defined as a precise and formal description of a conceptualization (8). The main components of ontology include concepts, their properties, and their relationship. For instance, a university's ontology can contain staff, courses, classes, and communications such as information about subclasses, including faculty and staff. An ontology defines the relationship between concepts in web documents. It enables machines to understand and process relevant documents and facilitate information sharing (9).

Ontology in the field of medicine

In biomedicine, ontology is a knowledge engineer and a shared repository of knowledge that extracts new knowledge from existing knowledge. It collects data in a field and shares and reuses it to discover new knowledge (10). Besides, recently, ubiquitous healthcare services are essential. To achieve this goal, information exchange is essential in the medical sciences since much of the available medical information needs an avenue to be shared across disparate computer systems. Ontology-based interoperation has been intended to share knowledge and exchange information across people and services/applications, and it covers

domains related to mobile communications, specifically, addressing people, terminals, services, and networks (11).

The use of ontologies in the medical field is not less than in other fields. Clinical systems, general medical information systems, medical expert systems, hospital systems, decision support systems, knowledge discovery systems, patient medical records systems, and biomedical text databases are among the systems that require controlled biomedical lexical resources (12). Vocabulary management, integration, data exchange, and sharing, as well as knowledge reuse and decision support, are the main reasons for using ontology in medicine (13). In health information management, ontology has been developed as a semantic tool that can display concepts and relationship terms more accurately and comprehensively than thesauri and has been used to plan for disease prevention management and organize medical records (14).

BioPortal

To prevent any reworking in the field of medical ontologies, and given the importance of these types of medical representation tools in medicine, the BioPortal database was designed as an open registration site for biomedical ontologies through web browsers and in the form of web ontology language. The open repository of biomedical ontologies represents one of the most popular portals for both researchers and practitioners in the Linked Data Environment. The BioPortal ontologies contain concepts, relationships, rules, and functions to infer the knowledge from various data resources (15). The search, retrieval, and display of ontologies are possible in the database. This portal's web interface allows the evaluation and gradual evolution of ontology content through features such as adding notes to terms, linking terms, and reviewing ontology based on criteria such as usability, domain coverage, content quality, documentation, and support. The BioPortal also provides the ability to seamlessly search biomedical data sources such as total gene expression through such resource indices. Thus, the BioPortal not only gives access to biomedical ontologies to investors, therapists, and developers but also supports the integration of various biomedical resources (16).

Covid-19 ontologies

Up to 29 October 2020, there were five ontologies for Covid-19 presented in BioPortal, which specialists could use for more information about the disease and organizing its documents.

Coronavirus infectious disease ontology

The Coronavirus Infectious Disease Ontology (CIDO) is a community-driven open-source biomedical ontology in the area of coronavirus infectious disease. It is in Web Ontology Language format and uploaded in October 2020. The CIDO had used 6556 classes and developed to provide standardized human- and computer-interpretable annotation and representation of various coronavirus infectious diseases, including their etiology, transmission, pathogenesis, diagnosis, prevention, and treatment. It is mapped with Influenza Ontology (1501 mapping), LOINC (4202 mapping), Ontology of drug neuropathy events (390 mapping), Ontology of genes and genomes (32 mapping) (17).

Covid-19 ontology

The Covid-19 ontology covers the role of molecular and cellular entities in virus-host-interactions, in the virus life cycle, as well as a broad spectrum of medical and epidemiological concepts linked to Covid-19. The ontology was uploaded in June 2020 in OWL format. It has 2268 classes and is mapped with four other ontologies: Logical Observation Identifiers Names and Codes (1392 mapping), Influenza Ontology (282 mapping), Ontology of drug neuropathy adverse events (94 mapping), and Ontology of Genes and Genomes (239 mapping) (18).

The Covid-19 Infectious Disease Ontology

The Covid-19 Infectious Disease Ontology (IDO-COVID-19) is an extension of the Infectious Disease Ontology (IDO) and the Virus Infectious Disease Ontology (VIDO). The ontology was uploaded in August 2020 in OWL format. It has 486 classes and is mapped with four other ontologies: LOINC (125 mapping), Influenza Ontology (72 mapping), Ontology of drug neuropathy adverse events (26 mapping), and Ontology of Genes and Genomes (34 mapping). IDO Virus follows Open Biological and Biomedical Ontologies Foundry guidelines, employs the Basic Formal Ontology as its starting point, and covers epidemiology, classification, pathogenesis, and treatment of terms used to represent infection by the SARS-CoV-2 virus strain and the associated Covid-19 disease (19).

COVID-19 Surveillance Ontology

The COVID-19 Surveillance Ontology in OWL format has used 52 classes and is mapped with any other ontologies (Table 1). The ontology is an application ontology used to support Covid-19 surveillance in primary care. The ontology facilitates monitoring of Covid-19 cases and related respiratory conditions using data from multiple brands of computerized medical record systems (20).

An Ontology for Collection and Analysis of Covid-19 Data

This COVID-19 Ontology is a data model for publishing Covid-19 data on the web as a Knowledge Graph. The ontology was uploaded in October 2020 in OWL format. It has 90 classes and is mapped with LOINC (97 mapping) (Table 2). The primary focuses of the model are (I) Covid-19 cases: the data for Covid-19 cases (e.g., active, recovered, deceased, migrated) daily across the geo-location (district, state (province), and country), available resources, and requirements. (II) Covid-19 patient data: nationality, symptom, suspected level of Covid-19, treatment facility, Covid-19 clinical facility, patient's travel history, inter-personal relationships between patients, suspected transmission reason, and patient tracking test results (21).

Table 1. Metrics for COVID-19 Surveillance Ontology

Metrics	Number
Classes	52
Individuals	0
Properties	0
Maximum depth	1
Maximum number of children	18
Average number of children	6
Classes with a single child	2
Classes with more than 25 children	0

Table 2. Metrics for an ontology for collection and analysis of Covid-19 data

Metrics	Number
Classes	90
Individuals	271
Properties	123
Maximum depth	4
Maximum number of children	13
The average number of children	3
Classes with a single child	6
Classes with more than 25 children	0
Classes with no definition	34

Conclusion

With the growing knowledge of Covid-19 disease in recent months, the world has attempted to create an effective tool to represent and standardize understanding in this area with acceptable coverage. Accordingly, in this study, ontologies created in English in the field of Covid-19 were studied, and then their characteristics were studied. Therefore, by the end of October 2020, the Coronavirus Infectious Disease Ontology, COVID-19 Ontology, the COVID-19 Infectious Disease Ontology, COVID-19 Surveillance Ontology, an Ontology for collection and analysis of Covid-19 data have been developed to cover this challenge. The purpose of developing them as a semantic tool is to represent, formalize, and standardize the huge amount of heterogeneous textual data related to the field of Covid-19 disease. These ontologies enable researchers to acquire knowledge stored in large biomedical databases and clinical data repositories such as electronic medical records.

Due to the ongoing genetic changes in Covid-19 disease, it is suggested that treatment staff use knowledge management tools, such as ontologies, to familiarize with the results of research in other countries on transmission, prevention, treatment, and other aspects due to time constraints and the importance of updating their knowledge.

Disclaimer Statements

- **Conflicts of Interest:** None
- **Financial support or sponsorship:** None
- **Protection of Human and Animal Subjects:** These subjects were not included in this study.
- **Authors' contributions:** All of the authors have contributed to writing the article. The corresponding author made the final proofreading.

References

1. Guner R, Hasanoglu I, Aktas F. COVID-19: prevention and control measures in community. Turk J Med Sci. 2020; 50:571-77. doi: 10.3906/sag-2004-146.
2. Bavakhani A. Take a look at the link between ontology and knowledge management. Knowledge studies. 2015;1(3):101-15
3. Mosavi M, Ramazani R, Entezarmahdi R, Shamshiri A, Doonelo M, Nadeali F, et al. Guideline: National cancer registry. 2nd ed. Tehran: Ministry of health and medical education, Office of deputy minister for health; 2012.
4. Fonseca F. The double role of ontologies in information science research. J Am Soc Inf Sci Technol.2007;58(6):786-93.
5. Kuziemsky C.E, Lau F. A four stage approach for ontology-based health information system design. Artif Intell Med. 1010; 50(3):133-48.
6. Beale T, Heard S, editors. An ontology-based model of clinical information. Medinfo: Proceedings of the 12th World Congress on Health (Medical) Informatics; Building Sustainable Health Systems; 2007: IOS Press.
7. Asoosheh A, Mehrasa Sh, Khatibi T, Khakshor P. Ontologies, methodologies, tools and development languages. Tehran: Tarbiat Modarres University, Center for publishing Scientific works; 2011.
8. Ding Y. Ontology: The enabler for the semantic web. J Info Sci. 2001;27(6):377-84.
9. Shadegar B, Asareh A, Haratian A. Semantic web: Concepts and techniques. Tehran: Armaghan; 2010.
10. Verma A, Fiasché M, Cuzzola M, Iacopino P,Morabito F.C, Kasabov N. Ontology based personalized modeling for type 2diabetes risk analysis: An integrated approach. NeurIPS; Springer, 2009.
11. Karami M, Rahimi A. Semantic web technologies for sharing clinical information in health care systems. ACTA INFORM MED. 2019;27(1):4-7.
12. Jakus G, Milutinović V, Omerović S, Tomažič S. Concepts, ontologies and knowledge representation. Berlin: Springer; .2013.
13. Valinejadi A, Horri A, Azadeh F, Shams Ardakani MR, Amirhosseini M, Hassanzadeh H. Traditional iranian concepts mapping in meta-thesaurus and schematic network of unified medical system language (umls). J Health Adm. 2010;13(41):53-63.
14. Meraji M. Designing the ontology of the risk factors of cardiovascular diseases in the surveillance system of cardiovascular diseases in Iran [Ph.D Thesis]. Tehran: Iran University of medical sciences; 2013.

15. Chaleplioglou A, Papavlasopoulos S, Poulos M. BioPortal ontologies integration with SNOMED CT, RxNORM & GO Datasets, 2019 International Conference on Control, Artificial Intelligence, Robotics & Optimization (ICCAIRO), Athens, Greece, 2019, pp. 170-175, doi: 10.1109/ ICCAIRO47923.2019.00034.
16. Noy, Natalya F., et al. "BioPortal: ontologies and integrated data resources at the click of a mouse." Nucleic acids research 37. suppl_2 (2009): W170-W173.
17. National center for biomedical ontology. BioPortal [Internet]. Coronavirus infectious disease ontology. 2020. Available from: http:// BioPortal. bioontology.org/ ontologies/ CIDO
18. National center for biomedical ontology. BioPortal [Internet]. COVID-19 ontology. 2020. Available from: https://BioPortal.bioontology.org/ ontologies/COVID-19?p=summary
19. National center for biomedical ontology. BioPortal [Internet]. COVID-19 infectious disease ontology. 2020. Available from: https:// BioPortal. bioontology. org/ ontologies/ IDO-COVID-19? p=summary
20. National center for biomedical ontology. BioPortal [Internet]. COVID-19 Surveillance Ontology. 2020. Available from: https://BioPortal. bioontology. org/ ontologies/ COVID19? p=summary
21. National center for biomedical ontology. BioPortal [Internet]. An ontology for collection and analysis of COVID-19 data. 2020. Available from: https://BioPortal.bioontology.org/ontologies/COD O?p=summary