International Journal of Information Science and Management
Vol. 23, No. 4, 2025, 147-166
DOI: https://doi.org/10.22034/ijism.2025.2019889.1361 / DOR: https://dor.isc.ac/dor/20.1001.1.20088302.2025.23.4.7.7

Original Research

Presenting a Pattern for Applicability of Semantic Relations in Information Retrieval Using a Grounded Data Approach (Case Study: Libraries of Medical Sciences Universities)

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Received: 22 February 2024
Reviewed: 02 June 2024
Accepted: 24 September 2024

Abstract

This research aims to identify the effective factors in the applicability of semantic relations in medical sciences university libraries and to present the resulting patterns. Its approach is qualitative, grounded theory-based, and grounded in the nature and purpose of this research. To collect data, documentary methods and interviews were conducted with 15 librarians and information specialists working in the libraries of medical sciences universities in the country, who were selected as samples using a purposive non-probability approach. The data were analyzed in three steps: open coding, axial coding, and selective coding, followed by the interpretation of interview statements and the development of a paradigm model. The validity was measured using the responsive method, and two coding types were used to estimate reliability. The analysis of findings showed that applicability of semantic relations in information retrieval has 6 main categories, 23 sub-categories, and 88 concepts that is presented as a paradigm model including causal factors (semantic search, semantic retrieval, semantic ambiguity, cross-linguistic retrieval, rooting ability, conceptual relations between words), contextual factors (user's ability to use semantic relations in information retrieval, user's information needs, applicability of semantic relations, and the user's need for new systems in information retrieval), intervening (the presence of different semantic tools during information retrieval, the presence of complex semantic relations between words, the lack of understanding of natural language by search engines and the presence of ambiguity in the meaning of words), axial (the applicability of semantic relations in information retrieval, the quality processes of the applicability of semantic relations in information retrieval), and strategic (system strategy, security strategy and accountability strategy). Finally, the presented pattern validity was confirmed by authorities. The results show that

the applicability of semantic relations in information retrieval in the libraries of medical sciences universities is primarily driven by the advantages and benefits inherent in this technological approach. Additionally, the applicability of semantic relations in information retrieval can be measured and managed within the studied population based on the obtained dimensions, main categories, and subcategories.

Keywords: Semantic Relations, Information Retrieval, Library, Medical Sciences Universities.

Introduction

Today, information has become a vital tool in the relationships between people and organizations. This tool influences all human activities, from the most basic to the most complex, as a collaborative activity (Shahbazi, Norouzi, & Alipour Hafizi, 2014). The increasing volume of accessible information, on the one hand, and the extensive changes in users' and experts' information, on the other, have presented libraries and information retrieval systems with challenges in storage, organization, searching, and retrieval of information (Farzandipour, Nabovati, Tadayon, & Sedghi Jebelli, 2021). Therefore, libraries and information storage and retrieval systems strive to provide more suitable services to users by employing solutions to address these issues. This is because non-retrieval of stored information, retrieval of unrelated information, and failure to meet users' information needs can lead to system inefficiency (Kaabomeyr, Osareh, & Gazni, 2021). The inefficiency of medical science libraries and their information systems is primarily categorized into three areas: technical inefficiency, inefficiency in desirability, and inefficiency in applicability.

Inefficiency at the technical level is often related to defects in hardware, software, or communication equipment. Thus, the system cannot provide its function. Inefficiency in the system's desirability occurs when it fails to meet the real needs or the needs related to organizational tasks. In fact, it cannot provide the intended function of the organization (Haji Ahmadi, 2014). Inefficiency in applicability occurs when the information storage and retrieval system, such as a library, is not accepted or rejected by users and visitors. In other words, an information storage and retrieval system, such as a library, cannot provide effective and efficient services to users or meet their expectations (Karimi, Babaei, & Hosseini Beheshti, 2019). Therefore, various studies have investigated information retrieval.

The term "information retrieval" was first proposed by Mores in 1951 (Ehsanifar, 2015). Information retrieval refers to the process of processing, storing, retrieving, and disseminating information to meet the user's information needs. Although information retrieval can be a manual and non-electronic process, e.g., using an index to retrieve information from a book, this term is usually used when a set of information is stored electronically, and the process of reading together, asking, and searching is conducted by a computer (Seyeddokht & Mami Roody, 2021). Information retrieval is primarily based on words and their meanings in most information systems (Arastupour & Ahmadinasab, 2015). Showing the relations between words is one of the most important and, at the same time, the most challenging activities performed by experts in the field of information science and epistemology, because considering each of these relations can extend or limit the scope of searching and its results (Safavi, 2019). For example, relations such as semantic inclusion, vocabulary component, vocabulary membership, and vocabulary unit have been considered as defining hierarchical relations between concepts in different classification or organization systems, such as subject headings or thesauri, for many years. Lexical control systems have been successful in controlling vocabulary and these

semantic relations. However, this task in the field of information retrieval has been more challenging, as the activity previously performed by lexical retention specialists should be delegated to the machine. The difficulty of this issue has finally led to challenges for the applicability of semantic relations in information retrieval (Ahmadinasab, 2011). Applicability is a crucial factor in selecting and utilizing information systems. Applicability is defined in different ways and by different people. However, a noteworthy point is that the definition of applicability has evolved, shifting from a general view to a more specific definition with a detailed description of its features (Tan, 2008). Eason (1988) defines applicability as providing functionality in a way that the intended users can acquire skills and functionality in a way that the intended users can reach skills and exploit the system, without any undesirable change or a deviation in their capacities and abilities to fulfill organizational tasks (Tebyani & Bagheri Taleghan, 2024). Applicability is meaningful only in the context of the used environment, and it cannot be measured outside of it. This field encompasses aspects related to the users themselves, their tasks, the equipment used, and the environment (Narmanji, 2017).

If an information system has a proper design for its user interfaces, including semantic relations, the challenges, unwanted events, and the required time to learn how to work with the system will be reduced, and applicability and quality will be increased. Therefore, it is crucial to develop user interfaces that enhance user experience, such as incorporating semantic relations in information systems, which promote end-user participation in product development (Karimi et al., 2019). Since the libraries of medical sciences universities are considered the center of the country's information system in the field of medical information and health information of the country, they have an active effect in forming the health culture of today's society and changing the society towards a better tomorrow (Mohammad Esmaeil & Nasehi Oskoui, 2014). Obviously, addressing the level of applicability of semantic relations in the libraries of medical sciences universities can be vital and valuable in the country's information field, serving as a treasury of products and scientific activities in the country's medical field. Since the libraries of the University of Medical Sciences are considered part of the state higher education system, they are crucial for the provision and dissemination of specialized information to the state medical community. Improving the quality of services at these sensitive scientific centers plays a crucial role in achieving societal goals in the fields of health and public health. Nowadays, we can see a rapid increase in the number of resources and information in the field of medical sciences, which has created new information needs in this field. Consequently, to respond to these information needs, libraries of medical sciences in academic and research centers should reserve the collected resources and documents in a manner that allows their clients to access them as soon as possible. This is where the use of semantic relations in information retrieval becomes more critical. Users can meet their information needs and facilitate the effective and optimal use of the system through semantic relations. Therefore, the applicability of semantic relations in the information storage and retrieval systems of medical science libraries is a fundamental element in interacting with users and improving information services. The applicability of semantic relations plays a key role in aligning medical science libraries with semantic technologies.

A review of domestic and foreign literature reveals semantic relations issues and information retrieval, which many studies refer to as the problem of information retrieval, as well as various approaches to addressing this issue. Few studies have investigated the role of semantic relations in information retrieval. This issue highlights the significant effort and

attention of experts and theorists in providing valuable solutions to enhance the relationship and influence of these two variables, while also emphasizing the importance of discussing semantic relations in information retrieval. Finding of several researchers have studied the semantic relations and information retrieval individually or generally such as Rezaei Dinani, Karbala Aghaei Kamran and Mirzaiyan (2022) who investigated "the effect of semantic tagging in removing the ambiguity of specialized synonyms in terms of false fallout in the retrieval of scientific texts", Ahmadi and Delghandi (2022) investigated the effect of ontology, semantic web and folksonomy in information retrieval, Bagheri, Noruzi, Esfandiyari Moghadam and Zarei (2022) investigated the application of semantic technology in information retrieval in digital library software, Kaabomeyr et al. (2021) investigated applicability of library information storage and retrieval system based on semantic web technologies, Amirhosseini (2021) investigated in a research with title of "the relationship between the level of composition in the structure of concepts entries and the number of semantic relations in the analysis of information retrieval performance in the agricultural ontology of the Food and Agriculture Organization of the United Nations (scientific paper of the Ministry of Science)", Norouzi (2019) investigated context and meaning in information retrieval: with an emphasis on mother tongue, Jafari Pavarsi, Hariri, Alipour Hafezi, Babalhavaeji and Khademi (2020) investigated enhancing semantic information retrieval using tagging and ontology, Kazerani (2016) compared the semantic relations, shape structure and management system of technical-engineering thesauruses, and Soltani and Qili (2008) referred application of the semantic disambiguation technique of words in inter-lingual information retrieval. Moreover, Saravana Kumar & Santhosh (2020) referred to effective information retrieval and characterization minimization methods in semantic web data, Khan and Bhatti referred the impact of semantic web and ontology-based applications for digital libraries, Munir and Sheraz Najam (2017) referred using ontology for effective knowledge modeling and information retrieval, Ritika and Sonal (2016) referred design and development of semantic web-based system for integration and integration of ontology in information retrieval, Thangaraj and Sujatha (2014) referred designing semantic web architecture in information retrieval. Most studies have investigated the issues using the library and review method, and almost all studies have used tagging methods, ontology, and semantic relations technology in information retrieval.

It can be concluded after studying and reviewing the literature that the libraries of medical sciences universities have made significant progress over time and can further enhance their information retrieval standards. However, with these advancements, they require regular reviews to identify areas for improvement. Thus, this research aimed to address the problem of the current study: what are the factors affecting the applicability of semantic relations in information retrieval in libraries, and to provide a model.

Actually, the researcher seeks to identify the axial, causal, intervening, and contextual strategies and consequences in this research to present a pattern for the applicability factors in information retrieval in medical sciences university libraries.

The results of this research are likely to enhance the applicability of semantic relations in library information retrieval services.

Background

The domestic backgrounds of the research were searched using keywords related to semantic relations, synonyms, and information retrieval in domestic databases, such as Irandoc,

Magiran specialized database, and Noormagz specialized database. The closest and most relevant backgrounds are as follows. The external backgrounds of the research were searched using keywords related to applicability factors, information retrieval in search engines, and external databases, including Google, Yahoo, Cisco's specialized database, IoT analytics, McKinsey & Company, Emerald, ScienceDirect, Elsevier, among others. In addition, the types of records were extracted that were the most relevant to the topic of the research, which are also mentioned below.

Bagheri et al. (2022) concluded that digital libraries, in terms of their application of semantic technology in the architecture of information retrieval, are not in good condition and require additional layers beyond their initial design. Moreover, they have not performed well based on the semantic tools and the use of semantic technological components, as well as their implementation levels. Furthermore, they need to be seriously revised by the designers of digital library software due to the importance of this part in information retrieval.

Rezaei Dinani et al. (2022) concluded that tagging specialized co-writing in the full text of the articles of the experimental group has a direct effect on clearing ambiguity. The results of the research showed that the amount of false loss in retrieval results after using the labeled specialized body has been significantly reduced. The body-oriented approach of the information retrieval system will provide a foundation for preventing false data and saving users' time and energy, while also offering a platform for full-text retrieval. The results of this research showed that well-structured educational data play a crucial role in resolving the semantic ambiguity of specialized synonyms. This method is used to disambiguate specialized synonyms in all languages.

Kaabomeyr et al. (2021) conducted a study in two stages. In the first stage, relevant information sources were identified and collected from Persian and Latin databases to assess the use of semantic web technologies in the library system. The results obtained from the first stage of the research included 125 related data sources, comprising articles from journals, conferences, and theses from both abroad and within the country. In the second stage of the research, a meta-analysis of the studies obtained from the first stage was performed using MAXQDA software, based on three indexes: storage, search, and semantic retrieval. The results obtained from the meta-analysis led to the identification of the use of semantic web technologies in the library system and the frequency of their use. The meta-analysis of the studies showed that RDF technologies had 50% applicability in the indexes of semantic storage and search, ontology had 25%, linked data had 20%, SCAS had 4%, and linked data technologies and F.O.A.F had 20% and 2% applicability in the retrieval semantic index, respectively.

Osareh, kaabomeir and Gazni (2021) in their research concluded that the significant relations between the components of Ontology + SCAS + Linked Data technologies with the departments of organization, provision, and OPEC to perform activities such as organization and knowledge management, the link between metadata, link between related resources, information transformation Knowledge book in RDF format, publishing and sharing data, user-friendly interface, vocabulary control, expansion of user queries, significant ranking of search results according to the user's information needs, as well as substantial relations between FOAF technologies + linked data in the OPEC sector confirmed the optimal fit of the structural model. The results of the confirmatory factor analysis demonstrate the desirability and acceptability of the existing variables' structure at the level of indicators and components of the proposed model. The goodness-of-fit value of the proposed model is 0.64, indicating a strong fit of the overall

model. As a result, the integration of semantic web technologies into the library's storage and information retrieval system enables the selection, organization, and semantic retrieval of information, thereby creating a semantic connection and interaction between the user and the library system. It can serve as a model suitable for a library storage and information retrieval system, as it provides a strong fit for the proposed model in this research.

Jafari Pavarsi et al. (2020) conducted research using a content analysis approach. 313 Persian articles on the subject of information retrieval were collected in a database with topic search capabilities for two groups, pre-test and post-test. After tagging 5,700 words using the natural language processing software at Ferdowsi University of Mashhad, the ontology of concepts and their semantic relations was designed and implemented in the Protege environment. The accuracy of the retrieved results was measured in two stages, before and after the test. They reached the following results: The significance level of the Z-test was 0.99, statistically significant. The level showed a considerable difference between the accuracy of the related results retrieved in the two pre-test and post-test groups. Therefore, these tools have acceptable performance.

Saravana Kumar and Santhosh (2020) concluded that the internet contains structured and unstructured data. The massive flow of internet data poses significant challenges to effective information retrieval. Semantic web mining examines web addresses using ontologies and semantic structures for effective information retrieval, and text feature extraction plays a crucial role in web mining and text mining.

Savolainen (2019) found that the primary feature of models for information interaction is the tripartite adjustment, which identifies information sources available through information systems, the intermediary/interface, and the user. Dialogue is the basis of information interaction. The early models proposed by Belkin and Ingwersen focused on user/intermediary interactions. At the same time, the newer frameworks developed by Ingwersen and Jarvelin pay more attention to the dialogue that constitutes the user-information system interaction.

Khan and Bhatti (2018) demonstrated that semantic web technologies are beneficial for digital libraries in creating semantic relations and enhancing access to digital content within the web environment. The next-generation digital library will utilize text awareness technology, intelligent agent software, and tracking sensors to analyze users' information needs and provide dynamic information services.

Munir and Sheraz Najam (2017) in their research stated that the significant increase in the use of scientific applications requires the creation of an advanced database that can retrieve the information needed by end-users. Users not only expect to understand the complex structure of the database but also be aware of the semantic relations between the concepts stored in the database. The research results, recommendations, and future challenges presented in this study can help bridge the gap between ontology and relational models, enabling the generation of accurate search queries and retrieval using ontologies.

According to the studies conducted both inside and outside the country, no relevant research was found on the applicability of semantic relations in information retrieval. Whatever will exist will only be the examination of one or two of its variables. Additionally, this research is novel from this perspective. Research on the applicability of semantic relations in databases and search engines, under the intense light of recent studies, has emerged as a new field in linguistics, which will be solved through the coordinated efforts of linguists and information science workers. The networks of semantic relations are valuable tools in natural language

processing. These networks are formed based on the semantic relations between words, representing an attempt to capture what exists in people's minds regarding words and their relationships.

Additionally, they attempt to utilize as many words as possible in a language to establish a network of relations. What types of relations exist between words in the minds of language speakers is a topic that linguists have been paying attention to for a long time. The formation unit of lexical networks is a synonym. After the formation of synonymous categories according to the synonym relation, it is time for other relations. In fact, the lexical network is the result of relations between synonymous categories that are connected with different relations and have formed a network. Generally, the review and analysis of the results of research in this field showed that the conducted studies in the field of the applicability of semantic relations in the storage system and information retrieval in the library have often paid attention to the single use of semantic relations and highlighted the use of some semantic relations in the context of the library. Although domestic and foreign studies have been conducted in all fields related to information retrieval, and appropriate solutions and methods have been developed and reached the operational stage, the issue of managing and discovering the applicability of semantic relations in information retrieval remains largely unaddressed. Thus, this research aimed to present a model of the applicability of semantic relations in the libraries of medical sciences universities using the grounded theory approach.

Materials and Methods

This research employed a qualitative approach grounded in theory. The reason for using this grounded theory method is its applicability. The grounded theory approach is an inductive and exploratory research method rooted in reality, providing explanations for events as they occur. This method enables the researcher to formulate their own theory and proposition, rather than relying on existing and pre-formulated theories. These theories and propositions are formulated systematically and based on real data (Bazargan Harandi, 2012).

The statistical population of this research consisted of librarians and information specialists from the medical departments in the central libraries of medical sciences universities in Iran. About 15 of them were selected as a sample by purposive non-probability sampling. The specifications of the experts are listed in Table 1. Approximately five open-ended questions were proposed during data collection, as some participants were uncomfortable with face-to-face communication. Additionally, they were sent electronically to the target sample to express their opinions based on their knowledge and perspectives. In the questionnaire, the framework of the interview was first presented by posing questions that included the introduction, an explanation of the reason for the interview, a general definition of the applicability of semantic relations, and information retrieval. Then, the open questions of the research were asked based on the designed structure. The general structure of the questionnaire included the following questions:

1. What are the effective strategies for the applicability factors of semantic relations in information retrieval in libraries of medical sciences universities?
2. What are the necessities of the applicability factors of semantic relations in information retrieval in libraries of medical sciences universities?
3. What background or factors are effective on the applicability of semantic relations in information retrieval in the libraries of medical sciences universities?

4. What are the effective intervening factors on the applicability factors of semantic relations in information retrieval in the libraries of medical sciences universities?

5. What are the impressive consequences of the applicability of semantic relations in information retrieval in libraries of medical sciences universities?

After completing the questions, the text of the answers was carefully implemented and used for analysis along with the notes taken from the answers and the ideas of the respondents. The thematic analysis method, widely used in qualitative research, was employed to analyze the text of the answers. Sending questions continued until theoretical saturation was reached. Repetition in the received information was observed from the 16th person onwards, when sending questions. However, this procedure was continued up to the 20th person. After completing the questions and implementing them, the data was analyzed using the open and axial coding methods and classification. Existing textual units were identified, and the text of the answers was cut, conceptualized, and categorized into main and sub-categories based on significant and logical classification. Compliance with the principles of confidentiality in publishing information and maintaining confidentiality, the freedom of research units to withdraw from the study, and respect for authors' rights in using texts were among the ethical principles observed in this study.

In this research, the collected data were analyzed through theoretical coding to develop the research theory. Therefore, first, appropriate codes were assigned to different parts of the data. These codes were determined as a concept, known as open coding, and the researcher then proceeded to axial coding by considering the different dimensions of these categories and identifying the links between them. Notably, the researcher collected data about various people, events, and situations during these encodings using theoretical sampling, and according to the concepts that emerged from the data, a clearer picture of the resulting concepts and categories was provided. Finally, the categories were refined by selective coding, and the theoretical framework of the research emerged through these processes. Later, one of the dimensions is the central category (the central category is the conceptual label that is considered in the study), after identifying the dimensions and components, and the relations between the elements and the identified dimensions. In addition, other dimensions in the classes of causal conditions (these conditions cause the creation and development of the central phenomenon); intervening conditions (intervening conditions are general conditions that affect strategies along with contextual factors); contextual conditions (which are general and extensive conditions that affect the development or threat of the phenomenon, or in other words, the prosperity or importance of the phenomenon); strategies (strategies that express the interactions and activities that are adopted in response to the central phenomenon and impressed by intervening conditions and contextual factors); and consequences (refers to the consequences of using the strategies and actions used by the organization) were included in the model (Danayifard, Alvani & Azar, 2019).

Table 1
Demographic information of interviewees

row	interviewee	status	education	Working experience	female	male
1	P1	Management	Ph. D.	11	-	*
2	P2	Management	Ph. D.	15		*

3	P3	senior librarian	Masters	14	*	-
4	P4	Management	Ph. D.	12		*
5	P5	Management	Ph. D.	10		*
6	P6	senior librarian	Masters	8		*
7	P7	Management	Ph. D.	14	*	
8	P8	Management	Ph. D.	8		*
9	P9	senior librarian	Masters	9	*	
10	P10	senior librarian	Masters	12	*	
11	P11	Management	Ph. D.	8	*	
12	P12	senior librarian	Masters	6	*	
13	P13	Management	Ph. D.	12		*
14	P14	senior librarian	Masters	8		*
15	P15	Management	Ph. D.	10		*

Notably, the identified codes and some statements from the interviewees are presented as witnesses in Table 2. Regarding the applicability of semantic relations in information retrieval, it is worth noting that during the data coding stage in each interview, the interviewee may mention the same thing several times. To avoid repeating and interfering with codes in each interview, sentences that were considered more closely related to the target code were used.

Table 2

A sample of identified verbal propositions regarding the applicability of semantic relations in information retrieval

Interviewee's code	Sample sentences	Conceptualization	Categories
A2, 11, A3, A4, A15, 10, A11, A5, A9, A12	The use of semantic relations enables the user to search by suggesting lexical synonyms. The selection of the domain is specific. In fact, searching with semantic relations for information retrieval can help establish connections between terms by searching the metadata of each work. It is better to search according to the relation between related terms to use semantic relations in information retrieval.	1. Extending the user's search by suggesting lexical synonyms 2. Expanding the user's query by selecting a specific contextual domain 3. Expansion of the user's query according to the relation between related terms 4. Expansion of the user's search according to the location of terms 5. Searching for information sources at the same time in several databases Search the metadata of each work	Semantic search
A12, A14, A8, A1, A5, A7, A3. A5, A12, A1	The existence of ambiguities caused by human, machine, written, and semantic errors in words creates problems in finding information using semantic relations, as most search engines lack a disambiguation process. We have a text, and it contains an	1. Ambiguity caused by machine error 2. Ambiguity caused by human error 3. Written ambiguity of words 4. The semantic ambiguity of words	Ambiguity in the meaning of words

Interviewee's code	Sample sentences	Conceptualization	Categories
	ambiguous word. There must be other words that can be used to disambiguate inside this text. Those other words become our entities. We match the entities with the knowledge base.	Ambiguity is also phonetic	
A7, A3. A11, A12, A10, A6, A13.A9	Typically, users encounter issues such as lexical dependency and lexical core during information retrieval that involves semantic relations. Or with words that have multiple meanings. In addition, these factors will complicate information retrieval, as the existence of the mentioned items creates an unrealistic connection between the texts, diverting the user from the central concept and goal.	1. The presence of multiple meanings 2. Confusion in the selection equation 3. Selection equivalent regardless of the lexical core Equivalent selection regardless of lexical dependency	Cross-linguistic retrieval

Lincoln & Guba (1985) proposed the terms credibility, transferability, dependability, and confirmability, rather than validity and reliability, to evaluate the quality of qualitative studies. Four methods have been employed in this research.

1- credibility: the researcher has increased the reliability of research data to an acceptable level by spending enough time, confirming the research process by three experts, using two codes to code several text samples of open questions to gain confidence from the coders' point of view, using measurable objective questions such as reminding people to provide objective examples of semantic applicability relations in information retrieval. In general, the criteria of continuous involvement, integration in research, revision, monitoring, and the use of evidence are the key elements that have been employed to achieve credibility in determining the validity level of research.

2- Portability: The objective of this criterion is the transferability and generalization of the obtained results to other groups and similar environments (Hariri, 2016). Three experts were consulted about the research findings to ensure the portability of the research findings. Furthermore, the demographic information of the participants in this research, which aims to confirm the portability criteria, shows that the participants were a group of academic staff members and librarians who have been working on the research subject for many years. Additionally, they were among the active academic staff members and research experts in the fields under investigation. Research details and notes were accurately recorded throughout all stages of the research.

3- Reliability: It is necessary to have a procedure and consistency in data collection to reach some reliability scales (Burla, Knierim, Barth, Liewald, Duetz & Abel, 2008). Suppose the findings of a research study are closely related to each other. In that case, it means that the reader can evaluate the adequacy of the analysis by following the researcher's decision-making process. Thus, reliability is achieved when the researcher has demonstrated the scientific validity of the findings. In this regard, first, the researchers took notes on all the text, and then

the prepared texts were converted into propositions for coding to verify the scientific accuracy of the findings in the current research.

4- Verifiability: Verifiability is a gradual and continuous process criterion. The step-by-step recording of data and the time sequence of the data collection process are crucial to verifiability. All findings in this research, along with the methods used to analyze and interpret them for verifiability, have been documented, recorded, and reported at each stage. The researchers carefully recorded all details at every stage to confirm the research findings.

Results

The data of this research were analyzed according to the guidelines of Strauss & Corbin (2011). This method comprises three main stages: open coding, axial coding, and selective coding. Finally, the qualitative research model is stated:

During the process of open coding, six categories (main factors), 23 sub-factors (sub-categories), and 88 conceptual propositions (identifiers) were extracted from the central libraries of the University of Medical Sciences, Iran, and their characteristics were identified in the examined groups. At the stage of axial coding, the dimensions of the coding paradigm are established, comprising six categories: axial categories, causal conditions, intervening conditions, contextual conditions, strategies, and consequences (Table 3). Therefore, the analysis of the data obtained from the open questionnaire has been explained in this research according to the dimensions of the coding paradigm.

Table 3
Results of the executed coding in the examined groups

Dimensions	Axial coding (category)	Open coding (concepts)
Main components	Applicability of semantic relations in information retrieval	- Accelerating information retrieval using semantic relations - Changing the philosophy and paradigm of information retrieval - Developing a strategic and operational plan for the use of semantic relations in information retrieval
	Qualitative processes of applicability of semantic relations in information retrieval	- Expanding the search and drawing relations between words - Enhance search tools or semantic development - Creating a semantic structure of a domain - Categorize queries based on user knowledge level
Casual conditions	Semantic search	- Expand user search by suggesting lexical synonyms - Expand the user's query by selecting a specific niche domain - Extending the user's query according to the relation between related terms - Expanding user queries by locating terms - Searching for information sources at the same time in several databases - Search metadata of each work
	Semantic retrieval	- The connection between related words - Creating links between words and subject areas related to each word

Dimensions	Axial coding (category)	Open coding (concepts)
		- Connection between existing works based on thematic similarity
	Semantic ambiguity	- Vocabulary control during search - Link data when searching - Identify beneficial relations between dissimilar concepts - The existence of semantic ambiguity in thematic search
	Cross-linguistic retrieval	- Multiple meanings - There is confusion in the selection equation - Equivalent selection regardless of the lexical core - Equivalent selection regardless of lexical dependency
	Rooting capability	- Not paying attention to the emotional load of words - Lack of attention to the lexical cluster - The existence of many inputs against a concept - Not paying attention to the semantic harmony between the term and the input
Intervening factors	The presence of different semantic tools during information retrieval	- The existence of tools such as URI, XML, OWK SWRL, SQWRI
	The existence of complex semantic relations between words	- The existence of relations such as emanation in words - The presence of sub-events in words - Existence of relations with members
	Lack of understanding of natural language by search engines	- Existence of tagging speech habits - Word segmentation - Demystifying the meaning of the word
	Ambiguity in the meaning of words	- Ambiguity caused by machine error - Ambiguity caused by human error - Written ambiguity of words - Semantic ambiguity of words - Ambiguity is also phonetic
Contextual factors	The user's ability to use semantic relations in information retrieval	- Efficient search tools - Information storage systems - Use of search engines - Existence of technological literacy - Use of data access mechanisms
	User information needs	- The user's information needs during the search. - The informational need of the user to analyze the textual content of the information - The user's information needs for the vocabulary network - The user's information needs to search the metadata of each work - The user's informational need for lexical synonyms - The user's informational need for lexical contrast - The user's informational need for polysemous vocabulary
	Applicability of	- The applicability of relations in information extraction

Dimensions	Axial coding (category)	Open coding (concepts)
	semantic relations	- Application of semantic relations in information sharing - The applicability of semantic relations in data linking
	User needs for new systems in information retrieval	- The need for disambiguation systems and semantic graph construction - The need for identification systems of known entities - The need for semantic search engine creation systems - Need for a query expansion system - The need for a question-and-answer system - The need for a text summarization system
Strategies	System strategy	- Motivating the use of semantic relations in information retrieval - Demystifying semantic relations in an information retrieval system - Storing semantic information in information retrieval systems
	Security strategy	- Existence of security standards in the use of semantic relations - Information security management
	Response strategy	- Existence of effective support systems - Existence of feedback mechanisms to the end user
Consequences	Harmony of goals and strategies	- Improving the position of semantic relations in information retrieval - Adaptation of semantic search systems with information retrieval strategies and structure - Simplifying the process of resource discovery and retrieval
	Practical understanding of semantic relations in information retrieval	- Extracting sets of synonyms, contrasts, and antonyms of words - Expanding the search and drawing relations between words - Auto-suggest terms for queries - Increase search tools or semantic development - Solving keyword search problems - Support for learning and structured representation of information

Reference: Research findings

In the selective coding stage, a conceptual model with a main category, 23 subcategories, and 88 concepts was designed based on the dimensions and indicators identified regarding the factors affecting the applicability of semantic relations in information retrieval. Therefore, the approach of Strauss & Corbin in grounded theory was used, and the resulting paradigm model is presented in Figure 1.

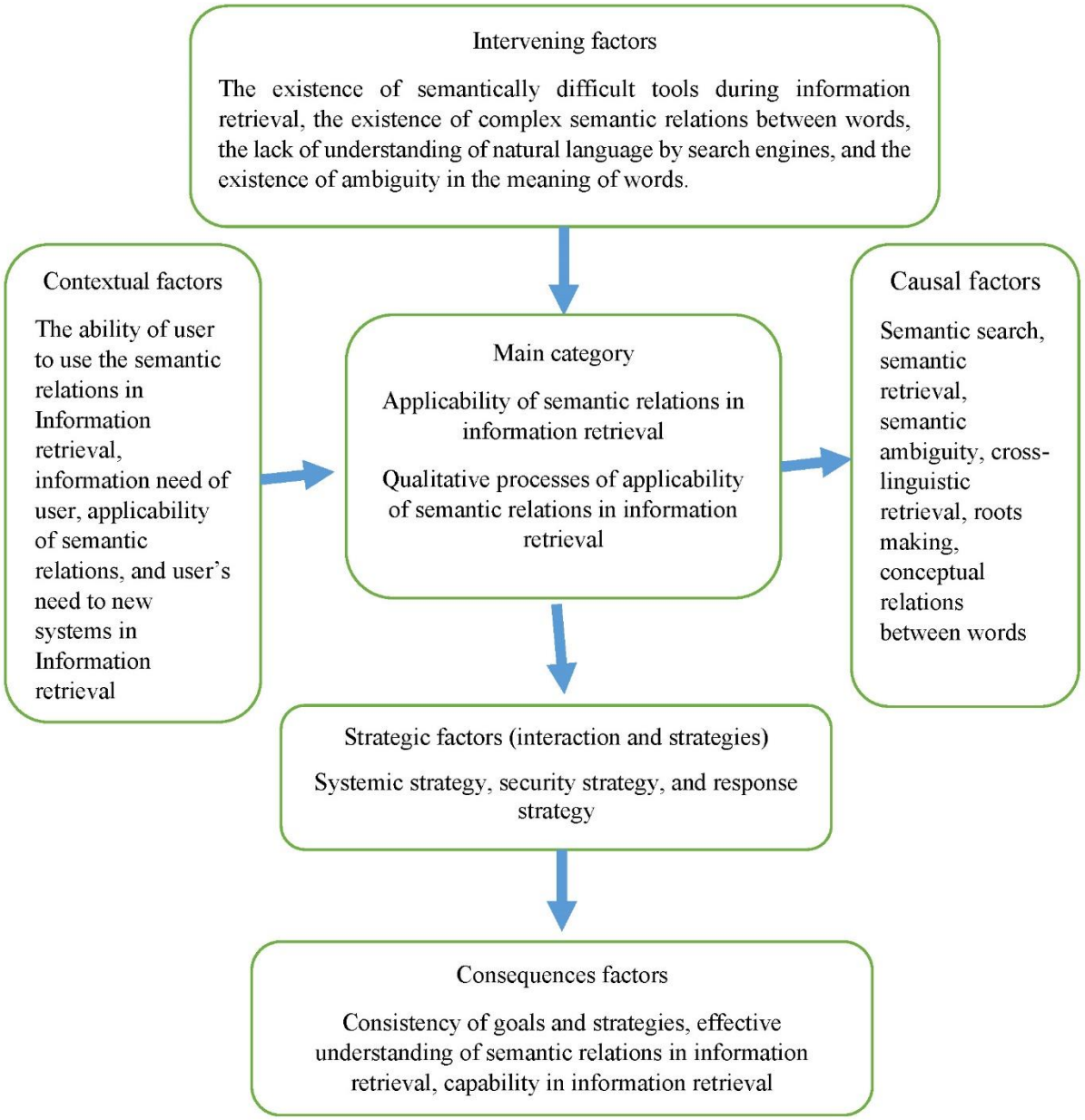

Figure 1: Paradigm model of applicability of semantic relations in information retrieval

As seen in Figure 1), causal and strategic components are among the categories that directly and indirectly influence the phenomenon and cause the phenomenon to occur. Furthermore, more general categories have been extracted, which are indirectly effective on phenomena through their impact on the main categories. The intervening factors are among the categories that indirectly influence the phenomenon, impressing the causal conditions and facilitating the execution of strategies. The category of contextual conditions is another indirect factor that indirectly influences the applicability of semantic relations in information retrieval by imposing the causal conditions and intervening factors.

Discussion

According to the research data, the total set of applicability patterns of semantic relations in information retrieval in the libraries of medical sciences universities was displayed in six

classes, based on the importance and frequency of the relevant data in encodings, which represents the emphasis of the interviewees. These classes include casual, intervening, contextual, and consequential strategies. The obtained courses from the research findings explain the desired condition of the applicability of semantic relations in information retrieval in the libraries of medical sciences universities. About six categories (main factor), 23 secondary factors (criterion), and 88 conceptual propositions (identifiers) effective on the applicability of semantic relations in information retrieval in the libraries of medical sciences universities were obtained from these propositions of the interviews conducted with the interviewees, which were for the six classes of the applicability of semantic relations in information retrieval in the libraries of medical sciences universities. After analysis, the contextual theory of the research and the proposed research model were presented based on the findings. Therefore, the maximum frequency is for the category of ambiguity in word meaning, with subcategories including ambiguity caused by machine error, ambiguity caused by human error, written ambiguity of words, semantic ambiguity of words, and phonetic ambiguity.

Additionally, the minimum ambiguity applies to the system strategy category, which includes subcategories such as motivation for using semantic relations in information retrieval, disambiguation of semantic relations in information retrieval systems, and storing semantic information in information retrieval systems. The number of categories for the main factors in presenting the model of the applicability of semantic relations in information retrieval for medical sciences university libraries is 2, and the number of subcategories is 7. The applicability of semantic relations in information retrieval (accelerating information retrieval using semantic relations, changing the philosophy and paradigm of information retrieval, developing a strategic and operational plan for using semantic relations in information retrieval) and the quality processes of semantic relations in information retrieval (expanding searching and drawing relations between words, increasing search tools or semantic development, creating a semantic structure from a domain, categorizing queries based on the user's knowledge level) are the key factors in presenting the model of the applicability of semantic relations in information retrieval in the libraries of medical sciences universities. The maximum frequency refers to the category of qualitative processes related to the applicability of semantic relations in information retrieval.

According to experts, the themes derived from the concepts of the interviews, as well as the main categories and classes, demonstrate the applicability of semantic relations in information retrieval for libraries in medical sciences universities. Additionally, the presence of exposed agents is crucial for this research, particularly in information retrieval based on technology. The six revealed factors, along with their constituent categories, subcategories, and concepts, are important themes that have been embodied and considered necessary in the minds of the interviewees for the applicability of semantic relations in information retrieval in the libraries of medical sciences universities. These factors can provide a proper solution for libraries to move beyond traditional approaches and integrate modern technologies.

The model comprises six categories and 26 subcategories. Semantic search, semantic retrieval, semantic ambiguity, cross-linguistic retrieval, rooting ability, and conceptual relations between words are the components of causal conditions in presenting the model of factors for the applicability of semantic relations in information retrieval in the libraries of medical sciences universities. The maximum frequency corresponds to the categories of semantic ambiguity and cross-language retrieval, while the minimum frequency corresponds to the category of semantic retrieval. According to the research findings, these factors contribute to

the primary phenomenon of applying semantic relations in medical sciences university libraries. Moreover, these factors influence the phenomenon of applying semantic relations in information retrieval within the libraries of medical sciences universities, contributing to its growth and expansion. In fact, these factors refer to why and how experts react to the applicability of semantic relations in information retrieval in the libraries of medical sciences universities. Therefore, these factors can be effective in managing information retrieval by influencing the central phenomenon. The model has four categories for the intervening component and 12 subcategories. The existence of different semantic tools during information retrieval, the existence of complex semantic relations among words, the lack of understanding of natural language by search engines, and the existence of ambiguity in the meaning of words are the intervening components of the model for the applicability of semantic relations in information retrieval in the libraries of medical sciences universities. The maximum frequency is for the category of ambiguity in the meaning of words, and the minimum frequency is for the category of the existence of complex semantic relations between words. The number of categories for the contextual component of the model is ,4, and the number of subcategories is 21.

The user's ability to use semantic relations in information retrieval, the user's information needs, the applicability of semantic relations, and the user's need for new systems in information retrieval are in a contextual category in presenting the model of factors for the applicability of semantic relations in information retrieval in the libraries of medical sciences universities. The maximum frequency corresponds to the category of applicability of semantic relations, and the minimum frequency corresponds to the category of the user's ability to utilize semantic relations in information retrieval. The model has three categories for the strategic component and seven subcategories. System strategy, security strategy, and response strategy are the strategic components of the model for the applicability of semantic relations in information retrieval in the libraries of medical sciences universities. The maximum frequency corresponds to the response strategy category, and the minimum frequency corresponds to the systemic strategy. The number of categories for model outcomes is 4, and the number of subcategories is 15. Harmonization of goals and strategies, practical understanding of semantic relations in information retrieval, development of standards, and the ability to retrieve information are key factors in the applicability of semantic relations in information retrieval in the libraries of medical sciences universities. The maximum frequency corresponds to the category of practical understanding of semantic relations in information retrieval, while the minimum frequency corresponds to the category of ability in information retrieval.

As the applicability pattern of semantic relations in information retrieval is observed in Fig. 1 as the main category of research, the applicability pattern of semantic relations in information retrieval was selected as the central phenomenon and examined at the center of the pattern. Then, the other identified categories are related to the main category by their hidden characteristics and themes. Based on this research, the data analysis and interpretation show that the final results adopted from the presented paradigm pattern are aligned with the findings of studies by Bagheri et al. (2022), Rezaei Dinani (2022), Kaabomeyr et al. (2021), Amirhosseini (2021), Osareh et al. (2021), Nateghifar, Ziaei, Momeni Delqandi (2017), Norouzi (2019), Jafari Pavarsi et al. (2020), Abdolhosseini (2013), Saravana Kumar & Santhosh (2020), Savolainen (2019), Munir and Sheraz Najam (2017). Based on the desired model, one of the essential features of an efficient and effective information system is to provide

quality information services, meet the user's information needs, and ultimately satisfy the user. The advancement of information technologies and the increase in users' access to information have significantly increased the importance of aligning the library's storage and information retrieval systems with advanced information technologies. The ideal storage and information retrieval system should be able to respond to users' required information in the shortest possible time. There are problems such as proper keywords for searching, how to fill in the information in the search form, how to select adequate search filters, unfamiliarity with search operators, shortcomings of information-seeking behavior, ignorance of classification, indexing systems, and vocabulary, uncertainty, connection, and coherence of information retrieval results in searching for information from retrieval systems. Word-based retrieval has long presented users with challenges, including a lack of familiarity with proper words to search for and the ambiguities of keywords and specialized terms in texts. Classically, users' searches are classified into two groups: searches related to a specific information source and thematic searches. In the second group, users typically attempt to find documents that are closely related to their desired subject and meet their information needs using noun phrases. Since there were no specific documents that the user wanted during these kinds of searches, relevance estimation plays a vital role in information retrieval systems. Showing the relations between words is one of the most important and, at the same time, the most difficult activities that have been mentioned by experts in the field of information science and epistemology, as well as the field of computer science, because considering each of these relations in its place can provide the possibility of expanding or limiting the search and its results.

Conclusion

The approach of today's information retrieval systems has evolved from merely matching keywords and descriptors to encompassing the concepts of content and data. Users are searching for more accurate information provided to them in the shortest possible time. This is possible only by semantic web tools and languages, and by checking semantic relations. Practitioners have contributed to the certainty of the relevance of results retrieved from databases by developing semantic web tools and utilizing semantic relations, as well as by incorporating semantic features. In addition, the level of effectiveness of information retrieval systems has increased from the user's perspective, allowing users to define their search requests using these features. In this regard, semantic search has been replaced by keyword search. Semantic search in the library system will be realized when a chain of structured data is assembled to generate new knowledge using semantic markup. New technology is needed to establish a connection between existing information and other information, thereby obtaining a precise meaning in the field of information presentation. This will enable the structure of information, improve searches, and display the meanings and content of the information. It is time for search engines to extract keywords, themes, and content from information sources. Semantic tools can revolutionize information retrieval. Semantic tools accelerate the information retrieval process by extracting sets of synonyms, contrasts, and antonyms of words, expanding the search and drawing relations between words, automatically suggesting terms for queries, increasing search tools or semantic development, solving keyword search problems, supporting learning, and structured display of information, which will satisfy users. In other words, utilizing semantic relations in the field of information retrieval facilitates a more effective interaction between humans and machines, thereby enabling more accurate information retrieval. According to the

obtained results and considering the importance of applying semantic relations, a strategic and operational plan should be developed for libraries at medical sciences universities to enhance the applicability of semantic relations in information retrieval. It is recommended to research, investigate, and identify the advantages and disadvantages of applying semantic relations and information retrieval, as well as the necessary solutions. The limitations of this research are the lack of face-to-face interviews. Furthermore, the limited population and research sample of the libraries at medical sciences universities in the country may limit the generalizability of the results to other libraries.

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