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• *Session 1-Medical Information Systems and Management*

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Preface

This volume contains papers presented at the 2017 1^{st} International Conference on Medical and Health Informatics, which was held during May 20-22, 2017 in Taichung, Taiwan.

ICMHI provides a scientific platform for both local and international scientists, engineers and technologists who work in all aspects of medical and health informatics. In addition to the contributed papers, internationally known experts from several countries are also invited to deliver keynote and plenary speeches at ICMHI 2017.

The volume includes 18 selected papers which were submitted to the conference from universities, research institutes and industries. Each contributed paper has been peer-reviewed by reviewers who were collected organizing and technical committee members as well as other experts in the field from different countries. The proceedings tend to present to the readers the newest researches results and findings in the field of medical and health informatics.

Much of the credit of the success of the conference is due to topic coordinators who have devoted their expertise and experience in promoting and in general co-ordination of the activities for the organization and operation of the conference. The coordinators of various session topics have devoted a considerable time and energy in soliciting papers from relevant researchers for presentation at the conference.

The chairpersons of the different sessions played important role in conducting the proceedings of the session in a timely and efficient manner and the on behalf of the conference committee, we express sincere appreciation for their involvement. The reviewers of the manuscripts, those by tradition would remain anonymous, have also been very helpful in efficiently reviewing the manuscripts, providing valuable comments well within the time allotted to them. We express our sincere and grateful thanks to all reviewers.

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Medical Specialists Retrieval System Using Unified Medical Language System

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ABSTRACT

A large number of doctors and wide range of medical specialties can cause confusion in choosing the right medical specialist. This research aims to build a medical specialists retrieval system that corresponds with the user's disease. To make the system whole, it requires the ability to differentiate a query from common words and relate it to a disease, then associate the disease to related medical specialties. The Unified Medical Language System (UMLS) is used in query handling and finding relations between a disease and medical specialties. Additionally, the search results are sorted by the nearest medical practices based on user's location. This system has been evaluated by two internists which revealed an average score of 4.625 out of 5, which means relevant, of all points evaluated. Thus, provided a positive feedback to overall system performance.

CCS Concepts

• Information systems→Information retrieval • Information systems→Web search engines • Applied computing→Health informatics.

Keywords

Information retrieval; medical informatics; retrieval system; web.

1. INTRODUCTION

Medical information retrieval is being used widely by patients to prepare for their doctors' appointments and to find more information about other things that cannot be discussed in a limited time in the doctor's office. There are various ways of how a medical information can be retrieved. Conventionally, health-related information is obtained through a health promotion activity. Health promotion activities can be done at various places such as schools, workplaces, public places, also primary and secondary health care services. A successful health promotion activity mostly depends on good communications between health workers and each target audience [1]. An article in early 2000s discussed how technology, specifically internet, could improve access to health information for people in developing countries [2]. It is identified as a potentially radical and innovative area of information and communications technology (ICT) applications [3]. A local study in a region of Indonesia revealed that the internet has numerous advantages, which encourage people to search for medical information online rather than relying on the conventional methods [4].

In this era of advanced technology, the internet is mainly used as the source of information and search engines exist to help in such matters [5]. Most well-known search engines such as Google, Bing and Yahoo Search are designed to retrieve general information. A study by Wang, et al. [6], shows that those search engines are helpful in medical information search. However, the current ranking methods have some pitfalls. As there is no standard vocabulary or comprehensive cataloguing and quality filter, reaching the accurate and most relevant information is difficult most of the times [7]. Search results provided by existing medical web search engines often contain much semantic redundancy. To find useful medical information, user often has to go through a large number of web pages laboriously [8]. Thus, a specialized medical search engine with improved accuracy and efficiency is needed to fulfil both patients' and medical professionals' needs [6-9].

The aim of a medical search engine is to provide relevant medical information that can be used by common users. A medical search engine requires the ability to handle certain medical queries and distinguish them from common words to provide relevant results [8]. MedSearch is one of the examples of medical search engines. It is a prototype that improves usability and the quality of search results. MedSearch can handle long queries and automatically shorten them by selectively removing unimportant words. It can return diversified web pages and suggest medical phrases related to a query. MedSearch uses the MeSH medical ontology, the collection of crawled Web pages and the query itself to extract and rank medical phrases [8]. Another example of medical search engines is FindZebra. FindZebra is a specialized search engine for rare diseases designed to be used by clinicians [9]. To come up with a diagnosis, a physician needs to collect data based on anamnesis, physical examination and other diagnostic examinations [10]. FindZebra can accommodate long queries based on the diagnostic data collected by the physician and provide the most relevant rare disease diagnosis. To produce a diagnosis, FindZebra uses data from several sources such as the Online Mendelian Inheritance in Man (OMIM), Genetic and Rare Diseases Information Center (GARD), Orphanet and others. Document titles obtained through those sources are clustered by the UMLS medical concepts. But, not all queries can produce a relevant diagnosis. Because word preferences in diagnostic queries can differ according to the physician's background.

Most medical search engines provide information about medical conditions, treatments or medications. But there are also certain websites that provide a feature to find medical doctors based on user's needs. Before choosing a physician, patients are recommended to find more information about the physician competencies and practice locations [11]. LokaDok is a web application that stores a database of medical doctors currently practicing in Indonesia. User can search by the nearest practice location, medical specialty and physician's name. Physician data used in LokaDok is obtained through the Indonesian Medical Council and stored as temporary pre-listed accounts, which can be claimed and verified by the physicians [12]. User can also book an appointment with a verified physician and review their experience by giving ratings.

A large number of doctors and wide range of medical specialties can cause confusion in choosing the right medical specialist [13]. The Cleveland Clinic website allows user to search for physicians by specialty, disease or treatment. But, this feature is only available to find doctors who work under the Cleveland Clinic. Moreover, this feature is made possible by using specialty, disease or treatment tags on each doctor and does not require any special query handling.

To enhance user's experience in finding the right medical specialists, a search engine that can connect a disease to particular medical specialties is needed. Therefore, we present FindMD, a web search engine that can be used to find medical specialists using a disease query. The differences between FindMD and other websites mentioned before are defined in Table 1. The goal of FindMD is to provide an integrated medical specialists search engine that can combine the features of MedSearch, FindZebra, LokaDok and the Cleveland Clinic website using a refined query handling, association between diseases and medical specialties, location integration and a nationwide database of medical specialists in Indonesia. By using FindMD, user can find their desired medical specialists based on their needs and location.

The rest of this paper is organized as follows. Section 2 provides the details of methods used in this research. Section 3 evaluates the search results of queries obtained through a survey. Section 4 concludes what this research has achieved and further development prospects.

2. METHODS

2.1 Outline

In general, our proposed system handles 3 main problems. First, how to differentiate a query from common words and relate it to a disease concept. Second, how to associate a disease to related medical specialties. Third, how to sort the search results according to user's needs.

To answer the first problem, FindMD uses the Unified Medical Language System (UMLS), a repository of biomedical dictionaries developed by the U.S. National Library of Medicine. UMLS integrates more than 2 million names in about 900.000 concepts based on more than 60 biomedical sources [14]. One of the three components in UMLS is the Semantic Network. The Semantic Network provides information about semantic types or categories of all concepts in the UMLS Metathesaurus and relationships that exist between semantic types [15].

For the second problem, FindMD uses Medical Subject Headings (MeSH), one of biomedical sources in UMLS. MeSH is a controlled biomedical thesaurus created by the U.S. National Library of Medicine. MeSH is usually used in the indexing process of publications in MEDLINE [16]. MeSH consists of sets of terms naming descriptors arranged in an alphabetic and hierarchical structure. The hierarchical structure allows searching at various level of specificity [17].

The third problem can be answered by using geolocation. Distance or convenient location is the most discussed issue in accessing healthcare providers [18]. By using geolocation, the system can find the nearest medical practices by comparing user's location to pre-existing medical practices information stored in a database.

Table 1. The differences between FindMD and other websites

	MS	FZ	LD	CC	FM
Input					
Disease	+	+		+	+
Doctor's name			+		
Location			+		
Medical specialty			+	+	
Symptom	+	+			
Treatment				+	
Output					
Diseases		+			
Doctors			+	+	+
Web pages	+				
Query size					
One query			+	+	+
One or a few queries	+	+			
Data source					
Indonesian Medical Association					+
Indonesian Medical Council			+		
Institution's data				+	
Saved queries	+				
UMLS					+
UMLS MetaMap		+			
Crawled web pages	+				+
Web-registered doctors			+		
Others		+			
Biomedical dictionary					
MeSH	+	+			+
None			+	+	
Target user					
Clinician		+			
Public	+		+	+	+

Note: MS = MedSearch, FZ = FindZebra, LD = LokaDok, CC = Cleveland Clinic, FM = FindMD

2.2 Retrieval Mechanism

In general, a retrieval mechanism in FindMD is divided into 3 steps as in Figure 1:

1. Finding certain medical specialties related to a disease query.
2. Getting user's location.
3. Getting nearby medical specialists' data and data sorting by the nearest medical practices.

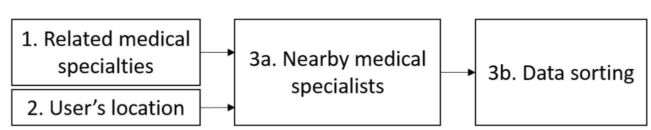

Figure 1. Retrieval Mechanism

2.2.1 *Finding Medical Specialties*

There are several steps in the process of finding certain medical specialties related to a query as defined in Figure 2. The whole process comprises two different operations:

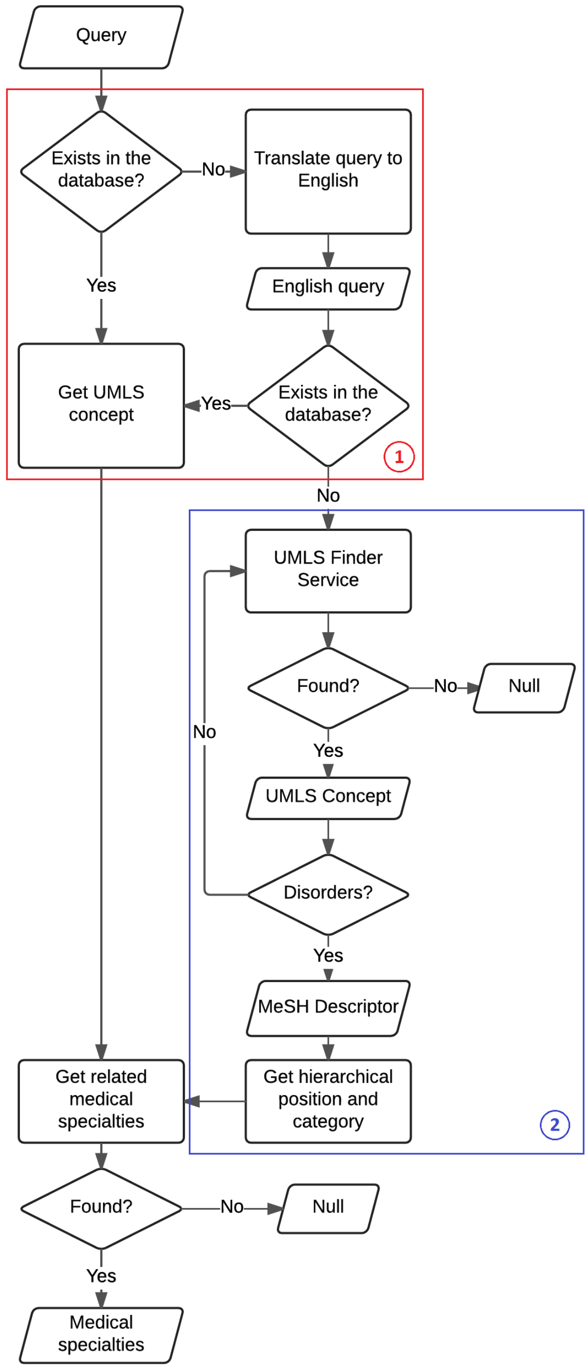

Figure 2. Finding related medical specialties flowchart

2.2.1.1 *Database-Related*

The first operation is mostly associated to the system's database as contained in box number 1 in Figure 2. When a query is received, the system checks whether that query exists in the database. If it exists, the system can get UMLS concepts related to the query and return medical specialties related to the first concept found. If it does not exist in the database, the system will use Google Translate API to translate the query to English. By using this method, FindMD covers all languages supported by Google Translate. Every query needs to be translated to English because UMLS Finder Service only allows searching in English and the contents of UMLS are not allowed to be translated to any other language. Once the query has been translated to English, the system will check again whether the English query already exists in the database. If it exists, the system can get UMLS concepts related to the query and return medical specialties related to the first concept found.

2.2.1.2 *UMLS-Related*

If the translated query does not exist in the database, the system will go to the second operation as encased in box number 2 in Figure 2. The second operation focuses on the use of UMLS. First, it uses the UMLS Finder Service to find UMLS concepts related to the query. If a concept has a semantic type included in the Disorders (DISO) semantic group, then the query is differentiated from common words and considered as a disorder. There are 12 semantic types in the DISO group [19] as shown in Table 2.

Table 2. Semantic Types in Disorders (DISO) Semantic Group

No.	Type	Semantic Type
1	T020	Acquired Abnormality
2	T190	Anatomical Abnormality
3	T049	Cell or Molecular Dysfunction
4	T019	Congenital Abnormality
5	T047	Disease or Syndrome
6	T050	Experimental Model or Disease
7	T033	Finding
8	T037	Injury or Poisoning
9	T048	Mental or Behavioral Dysfunction
10	T191	Neoplastic Process
11	T046	Pathologic Function
12	T184	Sign or Symptom

If the UMLS Finder Service returns more than one concept, the system will store the first disorder concept found as the main concept related to the query. Then it will store three more disorder concepts that come after it as other concepts that are related to the query. The three supplemental concepts are used in order to provide user with suggestions of other diseases that they might be looking for. If the system does not find any disorder concept throughout the search results of UMLS Finder Service, it will not return any related medical specialty. Once a concept is identified as a disorder, the system will use UMLS to find its MeSH descriptor and hierarchical position in the trees. After the position is located, the system will climb up the hierarchy and find any category that is related with a medical specialty. If it is found, the system will return related medical specialties.

2.2.1.3 *Example of Query Processing*

To illustrate how a query is processed throughout the system, a sample query *artritis reumatoid* in Indonesian language is used as shown in Figure 3. The English-translated query of *artritis* *reumatoid* is rheumatoid arthritis. It is then run through the UMLS Finder Service which returns Rheumatoid Arthritis as the first concept and other three related concepts, all identified as [T047] Disease or Syndrome semantic type. The first concept [C0003873] Rheumatoid Arthritis is stored as the main concept and its MeSH descriptor is identified as [D001172] Rheumatoid Arthritis.

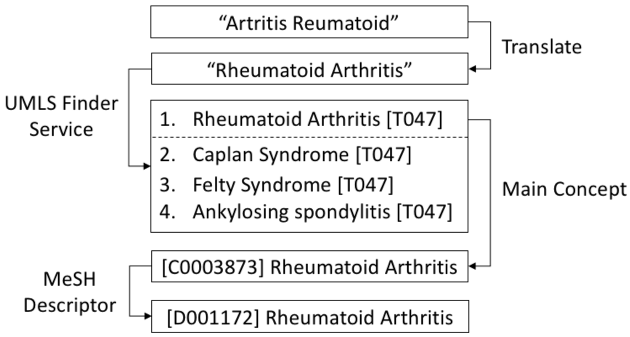

Figure 3. Query processing of *artritis reumatoid*

To get a relation between disease concept and medical specialty, previously acquired UMLS data containing medical specialty concepts and its relations were stored within the database. Figure 4 shows an example of how internal medicine contains its own concept and its subspecialty concepts. In this example, [C0035452] Rheumatology specialty is related to [C0035435] Rheumatism, among other concepts. The MeSH descriptor for [C0035435] Rheumatism is [D012216] Rheumatic Diseases.

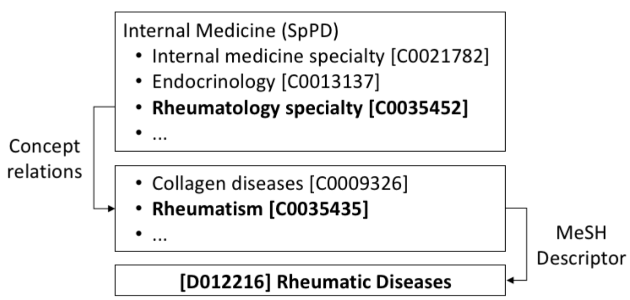

Figure 4. Internal medicine specialty concept relations

A part of MeSH tree structures that shows the position of descriptor [D001172] Rheumatoid Arthritis and [D012216] Rheumatic Diseases is laid out on Figure 5. Based on the hierarchy, it can be determined that [D001172] Rheumatoid Arthritis is placed within [D012216] Rheumatic Diseases, which its concept is related to [C0035452] Rheumatology specialty under internal medicine specialty.

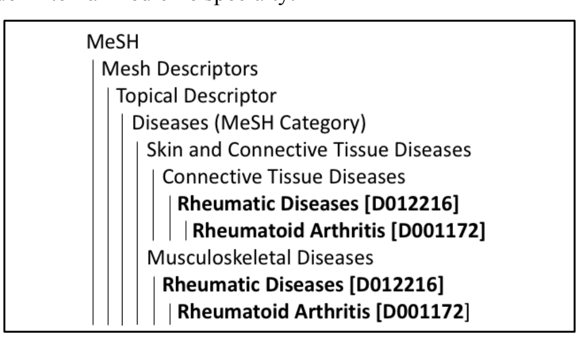

Figure 5. A part of MeSH tree structures

2.2.2 Location Integration and Data Sorting

Going into step 2 and 3 of the retrieval mechanism, user will be located by using geolocation. After the system gets the location, it will determine the nearest or current city where the user is in. Then it will get the medical specialists' data based on the city and medical specialties related to the query.

The search result returned is sorted by the nearest practice location and mainly consists of physicians' names, their specialties and details of their practice locations. User can also view a map, route and estimated travel time to a practice location. These are made possible because of Google Maps API. In addition to help user decide which physician to visit, FindMD provides supporting data such as research publications indexed on PubMed and social media accounts including Facebook, Twitter, Academia.edu and LinkedIn.

3. EVALUATION

3.1 Evaluation Dataset

Query samples used in this evaluation were obtained through a survey. Respondents were asked to provide personal data such as gender, age, occupation, recent education, field of study and if they work in healthcare. In total, there were 156 respondents who participated in this survey. Overall, respondents in this survey were dominated by females (n=112, 71.8%) and only a few males (n=44, 28.2%). Most of the respondents were aged between 16-25 (n=136, 87.2%), meanwhile the rests were aged between 26-35 (n=15, 9.6%), 36-45 (n=3, 1.9%), 46-55 (n=1, 0.6%) and older than 55 (n=1, 0.6%).

For the occupational background, there were students (n=128, 82.1%), government official (n=1, 0.6%), private employees (n=14, 9%), business owners (n=3, 1.9%), housewives (n=4, 2.6%), teachers (n=2, 1.3%) and other occupations (n=2, 2.6%). The respondents were mostly senior high school (n=74, 47.4%%) and bachelor's degree graduates (n=62, 39.7%). And there were also several associate degree (n=8, 5.1%), master's degree (n=4, 2.6%) and other (n=8, 5.1%) graduates.

About a quarter of the respondents studied medicine (n=43, 27.6%), whereas the others studied information technology (n=28, 17.9%), dentistry (n=1, 0.6%), nursing (n=16, 10.3%), biomedical engineering (n=1, 0.6%), pharmacy (n=4, 2.6%), psychology (n=3, 1.9%), economics (n=8, 5.1%), business (n=7, 4.5%), engineering (n=7, 4.5%), law (n=1, 0.6%), literature (n=5, 3.2%), arts and design (n=8, 5.1%), social science (n=4, 2.6%), music (n=2, 1.3%) and other studies (n=18, 11.5%). Finally, more than half of the participants did not work in healthcare (n=89, 57.1%), while less than half worked in healthcare (n=67, 42.9%).

Furthermore, the respondents were asked to provide 10 diseases that they know in their mother tongue and 5 diseases in English. Of all the answers, we took 20 most mentioned diseases in Indonesian and English to be used as query samples. Then, we ran it on the search engine, saved the main UMLS concept and medical specialties found as shown in Table 3.

3.2 Validation of Evaluation Dataset

Both results from Indonesian and English query testing were evaluated by two internists, who are active in teaching and practicing at a well-known hospital in Bandung, Indonesia. Evaluations were done by giving a relevance score between query and UMLS concept, then between UMLS concept and medical specialties, in a form of a 5-point Likert scale. Where 1 = not relevant at all, 2 = not relevant, 3 = neutral, 4 = relevant and 5 = very relevant. When there was a significant difference between scores given by both evaluators, the difference was re-evaluated by a third internist. There are a few factors which can contribute to the dissent, such as accessibility to technology, education and training background, treatment preference and diagnostic experience [20], patient's perception, cultural differences [21], and pattern recognition [22]. Table 4 shows the evaluation results between query and UMLS concept. E1 column contains scores given by the first evaluator, E2 by the second evaluator, and $\bar{x}$ for the average score.

Table 3. Example of Indonesian query testing results

No.	Query	Freq.	Concept ID	Concept Name	Specialties
1	Asma	47	C0004096	Asthma	SpPD[1], SpP[2]
2	Demam berdarah	47	C0011311	Dengue Fever	SpPD[1]
3	Diare	47	C0019911	Diarrhea	SpPD[1]
…	…	…	…	…	…

Note: [1]SpPD = Internal Medicine, [2]SpP = Pulmonary Medicine

Case example number 1 in Table 4 is an example where a query was handled accordingly. Diabetes in Indonesian is also known as *kencing manis* and *sakit gula*. In this case, all three queries refer to diabetes. However, there is also a case where a query has multiple interpretations. *Maag* in case number 2 is originally Dutch, which means stomach. Therefore, any disease that is related to the stomach can be called as *maag*. Commonly, *maag* in Indonesia is used when referring to gastritis or dyspepsia. In this case, the main UMLS concept returned was ulcer. The concept was returned due to the use of Google Translate, which translated *maag* as ulcer. As a response to this case, E1 and E2 gave a score of 4 and 2. The score differences were re-evaluated by the third evaluator who gave a score of 2. That score was given because the common use of *maag* is not equivalent to ulcer and there are a lot of other diagnoses related to the stomach.

Table 4. Example of query – UMLS concept evaluation results

No	Query	Concept Name	E1	E2	$\bar{x}$	Note
1	Diabetes	Diabetes Mellitus	5	5	5	
2	Maag	Ulcer	4[a]	2[a]	3	Gastritis*[?], Dyspepsia*[?]
3	Demam berdarah	Dengue Fever	3	3	3	DHF*[1]
4	Lupus	Lupus Vulgaris	3	2	2.5	SLE*[2]
…	…	…	…	…	…	…

Note: *The equitable concept, [?]Another concept related to the query, [1]Dengue Hemorrhagic Fever, [2]Systemic Lupus Erythematosus, [a]Re-evaluated by the third evaluator

3.3 Evaluation Result

When a query has multiple interpretations, it can affect the medical specialists involved directly and indirectly. For example, case number 3 in Table 4 has another concept related besides dengue fever, which is dengue hemorrhagic fever. But later on in Table 5, it is shown that both concepts are treated by internists. On the other hand, case number 4 shows that a query with multiple interpretations can affect the medical specialists involved. In this case, the UMLS Finder Service returned lupus vulgaris, popularly known as tuberculosis of the skin, on the top of the search results as a response to the query *lupus*. However, the common use of lupus refers to systemic lupus erythematosus (SLE), a systemic autoimmune disease mainly treated by internists and can involve other specialists depending on which organ involved.

The average scores given by both evaluators are contained in Table 6 for Indonesian query and Table 7 for English query. By and large, the evaluation results revealed an average score of 4.625 out of 5, which means relevant, of all points evaluated. Thus, provided a positive feedback to overall system performance.

Table 5. Example of UMLS concept – specialties evaluation results

No	Concept Name	Specialties	E1	E2	$\bar{x}$	Note
1	Diabetes Mellitus	SpPD[1]	5	5	5	
2	Ulcer	SpPD[1]	5	5	5	
3	Dengue Fever	SpPD[1]	5	5	5	
4	Lupus Vulgaris	SpPD[1], SpKK[2]	3	4	3.5	LV[a], SLE[b]
…	…	…	…	…	…	…

Note: [1]Internal Medicine, [2]Dermatology, [a]LV (Lupus Vulgaris) is treated mainly by SpKK[2], [b]SLE (Systemic Lupus Erythematosus) is treated mainly by SpPD[1] and additionally other specialists depending on which organ involved

Table 6. Average scores of Indonesian queries evaluation

	E1	E2	$\bar{x}$
Query – UMLS Concept	4.7	4.25	4.475
UMLS Concept – Specialties	4.55	4.7	4.625

Table 7. Average scores of English queries evaluation

	E1	E2	$\bar{x}$
Query – UMLS Concept	5	4.75	4.875
UMLS Concept – Specialties	4.45	4.6	4.525

4. CONCLUSION

FindMD is designed to accommodate user's needs in finding medical specialists. User can input a disease query to find certain medical specialists. The query will be processed through several processes, which mainly relies on the UMLS. By using MeSH ontology, medical specialties related to the UMLS concept can be found. In addition, the search results are sorted based on user's location and the system provides maps to medical practice locations. Additional data such as research publications and social media accounts of the medical specialists are also provided in search results to support user in choosing the most suitable physician. In order to evaluate the system, relevance scores between query and UMLS concept, then between UMLS concept and medical specialties were given by two internists. On the whole, the evaluation results revealed a good relevancy among those points observed. However, further evaluation between query and medical specialties is needed.

The system is not yet perfect. Though generally the whole retrieval mechanism has worked properly, the system has not yet to handle security issues. Also, it has only been tested to cover physicians in Bandung, Indonesia, and has not been evaluated on a user basis. Due to that reasons, FindMD has not been published publicly. Moreover, there is not any other search engine that works exactly the same input, output and mechanism as FindMD. So, it is difficult to compare the performance of FindMD with other existing systems.

This is a state-of-the-art research. The main idea is to establish an incentive medical specialist search engine which corresponds with the user's disease. Most medical search engines provide information about medical conditions, treatments or medications. But there are also certain websites that provide a feature to find medical doctors based on user's needs. To enhance user's experience in finding the right medical specialists, a search engine that can connect a disease to particular medical specialties is needed. Further development prospects of this research include an establishment of Indonesian biomedical ontology for a better query handling, including acronym handling. A refined method of building relations between query, disease concept and medical specialties to improve accuracy and relevancy. Also, a broader search spectrum covering pediatricians, medical subspecialists and a nationwide reach with secure access. In addition, a system that can suggest possible diseases related to a set of symptom queries can be embedded to enrich user's search experience.

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