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Best, Useful and Objective Precisions for Information Retrieval of Three Search Methods in PubMed and iPubMed

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Abstract

MEDLINE is one of the valuable sources of medical information on the Internet. Among the different open access sites of MEDLINE, PubMed is the best-known site. In 2010, iPubMed was established with an interaction-fuzzy search method for MEDLINE access. In the present work, we aimed to compare the precision of the retrieved sources (Best, Useful and Objective precision) in the PubMed and iPubMed using two search methods (simple and MeSH search) in PubMed and interaction-fuzzy method in iPubMed. During our semi-empirical study period, we held training workshops for 61 students of higher education to teach them Simple Search, MeSH Search, and Fuzzy-Interaction Search methods. Then, the precision of 305 searches for each method prepared by the students was calculated on the basis of Best precision, Useful precision, and Objective precision formulas. Analyses were done in SPSS version 11.5 using the Friedman and Wilcoxon Test, and three precisions obtained with the three precision formulas were studied for the three search methods. The mean precision of the interaction-fuzzy Search method was higher than that of the simple search and MeSH search for all three types of precision, i.e., Best precision, Useful precision, and Objective precision, and the Simple search method was in the next rank, and their mean precisions were significantly different ($P < 0.001$). The precision of the interaction-fuzzy search method in iPubMed was investigated for the first time. Also for the first time, three types of precision were evaluated in PubMed and iPubMed. The results showed that the Interaction-Fuzzy search method is more precise than using the natural language search (simple search) and MeSH search, and users of this method found papers that were more related to their queries; even though search in PubMed is useful, it is important that users apply new search methods to obtain the best results.

Introduction:

Medical information databases are the most important resources for providing medical related information which has flourish steadily during recent years. This flourishment has facilitated biomedical research, which has the aim of developing knowledge and using it in the diagnosis, prevention, and treatment of diseases (Cohen & Hersh, 2005). The result of such flourishment is an

unprecedented increase of information in the medical sciences and the creation of millions of databases for storing, organizing, managing, and presenting information to users (Hariri & Nadi Ravandi, 2014). One of the most important databases is the PubMed (<http://www.ncbi.nlm.nih.gov/pubmed/>), which provides access to MEDLINE citations since the 1960s (<http://www.hubmed.org>). However, the number of similar

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databases for access to MEDLINE literature citations has increased in recent few years. Some of these sites are HubMed (<http://www.hubmed.org/>), Deutsches Institut für Medizinische Dokumentation und Information (DIMDI) (<http://www.dimdi.de/static/en>), Infotrieve (<http://www.infotrieve.com/document-delivery-service>), and iPubmed (<http://ipubmed.ics.uci.edu/>). These databases have become a necessary part of researchers' efforts, and they are being used increasingly by physicians and patients as necessary tools for answering clinical questions (Wang et al., 2010). However, each one of these hosts has different search methods and use different search techniques and algorithms. Thus, the quality of the searches, with their different strategies, specifications, and updating distance, are different for each site, and researchers must try to decide which site can provide more accurate information in the shortest period of time (Zohour et al., 2003). This decision is very difficult, and information retrieval is a challenge for users since search tools are very complex to navigate (Giustini & Barsky, 2010). The question is what methods and strategies provide more accurate information. For example, Hariri & Nadi Ravandi (2014) indicated the mean precision of the visual method was greater than that of the MeSH search for all three types of precision, i.e., Best precision, Useful precision, and Objective precision, and their mean precisions were significantly different ($P < 0.001$) (Hariri & Nadi Ravandi, 2014). The retrieval and precision of all five free MEDLINE sites were significantly higher in natural language searching in comparison to control vocabulary searching ($P < 0.05$) (Zohour et al., 2003), and another study on MEDLINE indicated specificity of the subject search was greater than the text word search (i.e., 66% versus 47%), and the subject search sensitivity was 78% versus 88% for the other method (Jenuwine & Floyd, 2004) or using MeSH terms in the index does not affect the searched queries different users (Liu, 2010). But Shariff et al. (2013) reported that the average search in Google Scholar retrieved (22%), which was better than PubMed (11%), and the precisions were similar (6% for PubMed and 8% for Google Scholar, $P = 0.07$). The most important factor that the researchers must wish to know that is which of these methods and strategies is the best and the most accurate. Each of the methods has its own advantages and disadvantages possessing special characteristics from the user's viewpoint. However, some of the methods are more popular among users due to the types of algorithms that have been designed based on their own special needs and characteristics. There are two classic criteria, i.e., precision and recall (López-Herrera et al., 2008) that are the basic measures used in evaluating these information-retrieval systems. The recall is the ratio of the number of retrieved relevant records to the number of retrieved and not retrieved relevant records in the database. Precision

also is the ratio of the number of retrieved relevant records to the number of retrieved records retrieved (irrelevant and relevant) and it shows the acceptability of the evaluated documents and is measurable considering special conditions.

The determination of precision can clarify the efficiency and effectiveness of these methods if only it is determined by real users of information and their judgments at the time they were searching for the real information they needed (Hariri & Nadi Ravandi, 2014). The researchers in this research decided to compare three methods (simple search and MeSH search in PubMed and interaction-fuzzy search method in iPubmed) in six biomedical subject areas to determine which would be the most precise from the viewpoint of real users of the two databases. One of the methods which are based on the natural language (simple search), and the second method is based on the control of words and terms, and the other is based on fuzzy theory. Of course, the researchers made calculations to assess the three methods and also determined the three types of precision for each method based on the Best precision, Useful precision, and Objective precision formulas (Gwizdka & Chignell, 1999), and the three methods would be compared on the basis of the obtained results. The results of such research would also clarify the comparative efficiencies of these methods for designers of different search methods in databases, and they could also help users to choose the search methods that provide the best results for their specific needs. On the basis of various searches, the researchers concluded that the precision of the search methods in the medical databases had not been evaluated to date based on the three types of precision, i.e., Best precision, Useful precision, and Objective precision, which makes the results of this research more effective. The purpose of this study was to compare the precision of information retrieval of the three search methods in PubMed and iPubMed. The following were set as the specific objectives of the study:

- 1- To determine the Best precision of the retrieved sources among the three search methods (the simple search, MeSH search, and interaction-fuzzy Search) in six biomedical subject areas.
- 2- To determine the Useful precision of the retrieved sources in three search methods (the simple search, MeSH search and interaction-fuzzy search) in six biomedical subject areas.
- 3- To determine the Objective precision of the retrieved sources in three search methods (the simple search, MeSH search and interaction-fuzzy search) in six biomedical subject areas.
- 4- To compare the precision of the retrieved sources (Best, Useful and Objective precision) in three search methods (the simple search, MeSH search and

interaction-fuzzy search) in six biomedical subject areas.

- 5- To compare the precision of the retrieved sources (Objective precision) in three search methods (the simple search, MeSH search and interaction-fuzzy search) in cut-off point (Giustini *et al.*, 2005; Yap & Wu, 2005).

Methods and Materials:

Research design and setting: this research was conducted using a semi-empirical method in which sixty-one fresher(s) (students) from intensive care nursing, geriatric nursing, medical surgical nursing, parasitology, microbiology, and the health information technology disciplines agreed to participate in the study in 2013. The fresher(s) were selected so that the participants of the study must be had the same levels of information literacy, which meant that their previous experience and knowledge should not affect the results.

Sampling: the number of search queries was determined by considering the precision that the researchers expected from any method and using the ratio comparison formula for both groups and a sample size of 305 obtained for each method.

$$\text{Formula (1): } n = \frac{(Z_{1-\alpha/2} \sqrt{2P(1-P)} + Z_{1-\beta} \sqrt{P_1(1-P_1) + P_2(1-P_2)})}{(P_1 - P_2)}$$

$$P_1 = 0.5, P_2 = 0.4 \quad \alpha = 0.5, \beta = 0.2$$

Measurement tool: the study tool was a form that was filled-up by the participants. The participants had to answer about their disciplines, age, gender, familiarity rate with Pubmed and iPubMed, search query, search keywords, and their judgment search results based on the study method. The authenticity of the form was approved by experts. With a statistical specialist's opinion, this form was not used to confirm the reliability of the information provided.

Data collection: to collect the information, 61 fresher(s) were divided into six groups on the basis of their respective disciplines. Training workshops were held for each group. In the first workshop, an overview of search, simple search, and general search strategy was taught to the students. In the next session, using PubMed, particularly the use of simple search, query formulation, and the use of Boolean operators were covered. Then, the participants learned how to use Medical Subject Heading (MeSH) for searches. Finally, the participants were trained how to search in the iPubMed system and the method of interactive-fuzzy search. Of course, to prevent bias towards the search results of one of the methods, the trainees changed the training order of the search methods in the different workshops and taught three methods in some cases. For this work, the researchers used a matrix to change the

teaching methods.

To determine the three types of precision (Best, Useful, and Objective precision), the researchers trained the judgment method of 20 primary results of any search method (20 cut-off point) for the users. The reason for studying only the first 20 findings was that the users usually tended to review a small part of the findings of each search (between the first 10 to 20 findings), which were referred to in different research reports, such as those of Gwizdka & Chignell (1999) and Hariri & Nadi Ravandi (2014). Total 152 workshops were held.

The Judgment method was based on Gwizdka & Chignell (1999)'s prescribed method (Table 1). The participants were taught the three search methods of PubMed and iPubMed and asked to judge the title, abstract, and full text of the article (if available) in the first 20 findings. Because in calculating the precision, Gwizdka & Chignell (1999)'s formula, links were important, the participants even considered whether links were available in the articles to other related articles and scored them based on the relevance of the articles to the subject of interest. Though the experience that the participants may gain from searching through any search method can affect the results obtained in the next search methods, each group was asked to use the designed matrix of the different search methods. Finally, the participants judged 305 searches for each method and completed checklists. After collecting the students' forms, scores were determined for each search, and then the mean precision of each search was determined using the Best precision, Useful precision, and Objective precision formulas in the cut-off point (Giustini & Barsky, 2005; Yap & Wu, 2005) as follows:

$$\text{Formula 2: MAPreBest (minFnHits)} = \frac{\sum \text{count of (score=3)}}{N(\text{minFnHits})}$$

$$\text{Formula 3: MAPreUse (minFnHits)} = \frac{\sum \text{count of (score} \geq 2)}{N(\text{minFnHits})}$$

$$\text{Formula 4: MAPreObj (minFnHits)} = \frac{\sum \text{count of (score} \geq 1)}{N(\text{minFnHits})}$$

minFnHits = 20 for cut-off point = 20 and minFnHits = 10 for cut-off point = 10, N = 305

Statistical analyses: the data were entered into SPSS version 11.5. The Kolmogorov-Smirnov test showed that the data distribution was not normal. For this reason, the non-parametric Friedman Test was also used to compare the three types of precision in the three search methods and for analyzing the data of the three types of precision in the six subject categories in the three search methods. Also, the Wilcoxon Test was used to compare the mean of Objective precision in the cut-off point (Giustini & Barsky, 2005; Yap & Wu, 2005).

Results:

The 61 fresher(s) who participated were from six different

disciplines. There were 40 women and 21 men, in the age group of 26-30 (Table 2). Among the participants, 57 were not earlier familiar to iPubmed. Most of the participants were from the disciplines of geriatric nursing and medical-surgical nursing than the other disciplines (Table 3).

Researchers analyzed their search queries and classified them into six subject categories and 20 subcategories. The six categories were 1-Trauma, Nervous System/nursing, 2-Nursing, 3-Management Information Systems, 4-Geriatric nursing, 5-Microbiology, and 6-Parasitology. The subcategories are specified in Table 4. The subject categories and subcategories were controlled and standardized in MeSH.

The participants judged 305 searches for each method, and a total of 457,500 titles and abstracts and 274,531 full texts of articles were studied and scored by the students.

The comparison of the mean of Best precision in the three search methods showed that best precision of the fuzzy-interaction search method in iPubmed was greater than that of the simple search and MeSH search methods (0.1275 versus 0.0975 and 0.0225, respectively). Our research findings revealed that the mean of useful precision in the fuzzy-interaction search method was equal to 0.2246 and, for the simple search and MeSH search methods, the values were 0.2126 and 0.1061, respectively (Table 5). The comparison of the mean of objective precision of the three search methods showed that the mean precision of the fuzzy-interaction method (0.4785) was greater than that of the simple search method (0.3662) and the MeSH-controlled search method (0.2330). The Kolmogorov-Smirnov test indicated that the data distribution was not normal ($P < 0.001$). Thus, due to the non-normal data distribution and replication of the questions in each of the three search methods, the non-parametric Friedman test was used to test the hypotheses. Statistical analysis of results using the Friedman Test at the 95% confidence level showed that the mean of Best precision of the Fuzzy-Interaction method was significantly different from that of the Simple search and MeSH-controlled search methods ($P < 0.001$). Also, the findings indicated that the mean average Best precision of the Simple method was significantly different from that of the MeSH-controlled search method ($P < 0.001$).

The Friedman Test at the confidence level of 95% showed that there was a significant difference in mean of Useful precision between the Fuzzy-Interaction with Simple search ($P < 0.001$) and Fuzzy-Interaction search with MeSH-controlled search ($P < 0.001$) and also between Simple search and MeSH-controlled search ($P < 0.001$). The comparison of the mean of Objective precision of these three methods indicated that there was a significant difference between the means of the precisions of the three methods ($P < 0.001$).

Table 1: Description Subjective Relevance Scores (Gwizdka and Chignell, 1999)

Description	Rs*
The most relevant	3
Partly relevant or contains a link to a page with a score of 3	2
Somewhat relevant, for example, short mention of a topic within a larger page, technically correct (i.e., terms appear on a page – including metatags) or contains a link or links to a page ranked 2	1
No relevance, no query terms found (metatags were examined as well) or a “bad” hit	0

*Relevance Score

Table 2: Numbers of participants by age, gender and discipline

Index	Index Type	Number	Percent
Gender	Female	40	66%
	Male	21	34
Age	22-26	14	39%
	27-30	26	48%
	>30	21	13%
Disciplines	Critical Care Nursing	11	17%
	Geriatric Nursing	12	20%
	Medical Surgical Nursing	12	20%
	Microbiology	11	18%
	Parasitology	4	6%
	Health Information	11	18%
	Technology		

Table 3: Familiarity rate of participants with Pubmed and iPubmed

Database	Very much	Much	Average	Low	Never	Total
Pubmed	1	2	12	28	18	61
iPubmed	1	1	1	1	67	61

Table 4: Distribution and frequency of search queries in the study for each Group and Subgroup

No.		Groups		Number of Question	Frequency
Subject Groups		Subgroups	Frequency		
1	Trauma, Nervous System/ nursing	Coma, Post-Head Injury	35%	72	24%
		Intracranial Hemorrhage, Traumatic	29%		
		Skull fracture	28%		
		Other	8%		
2	Nursing	Emergency Nurs.	39%	72	24%
		Oncology Nurs.	39%		
		Education Nurs.	17%		
		Other	5%		
3	Management Information System	Hospital Inf. Sys.	48%	55	18%
		Clinical Pharmacy Inf. Sys.	32%		
		Radiology Inf. Sys.	9%		
		Other	1%		

4	Aged	Health Services for the Aged & Standards	61%	30	10%
		Health Services for the Aged & Methods	24%		
		Other	15%		
5	Microbiology	Helicobacter pylori	48%	56	18%
		Cross Infection	39%		
		Cloning, Molecular	13%		
6	Parasitology	Leishmania	50%	20	6%
		Toxoplasma	50%		

Table 5: Descriptive information about the comparison of the mean a precision in the three search methods

Precision Type	Search Methods	MP*	SD**	Min	Max
Best precision	Fuzzy-Interaction search	0.1275	0.6107	0	0.25
	Simple Search	0.0975	0.04257	0	0.20
	The MeSH-Controlled search	0.0225	0.3552	0	0.15
Useful precision	Fuzzy-Interaction Search	0.3246	0.08102	0	0.60
	Simple Search	0.2126	0.07136	0	0.40
	The MeSH-Controlled search	0.1061	0.05198	0	0.96
Objective precision	Fuzzy-Interaction search	0.4785	0.08962	0.10	0.70
	Simple Search	0.3662	0.08136	0.20	0.60
	the MeSH-Controlled search	0.2330	0.06454	0	0.40

*Mean Precision, **Standard Deviation

Table 6: Mean precision of Best, Useful, and Obj. in three Search Method in six Subject Groups

Subject Group	Search Method	B.P.	U.P.	O.P
Trauma, Nervous System/nursing	Interaction-Fuzzy Search	0.1333	0.3132	0.4750
	Simple Search	0.0917	0.2111	0.3292
	MeSH Search	0.0208	0.0903	0.1133
Geriatric	Interaction-Fuzzy Search	0.1683	0.3683	0.5250
	Simple Search	0.0850	0.1917	0.3333
	MeSH Search	0.025	0.1150	0.1250
Management information System	Interaction-Fuzzy Search	0.1182	0.2345	0.4600
	Simple Search	0.01080	0.2109	0.3500
	MeSH Search	0.0300	0.1136	0.1136
Nursing	Interaction-Fuzzy Search	0.1250	0.3292	0.6165
	Simple Search	0.778	0.2167	0.3903
	MeSH Search	0.0389	0.1301	0.1317
Microbiology	Interaction-Fuzzy Search	0.0875	0.3000	0.4991
	Simple Search	0.0950	0.1750	0.3557
	MeSH Search	0	0.06	0.0733

Parasitology	Interaction-Fuzzy Search	0.1250	0.3348	0.3292
	Simple Search	0.0902	0.2357	0.4156
	MeSH Search	0.0036	0.0929	0.0946

Discussion:

This study also focused on the effect of one of the information retrieval algorithms, i.e., the Interactive-Fuzzy algorithm on the precision of information retrieval in the iPubMed medical database. The findings showed that the mean Best, Useful, and Objective precisions in the Interactive-Fuzzy method were greater than those in the three types of precision for the Simple Search and MeSH-controlled search methods and that the mean of the three precisions in the Interactive-Fuzzy method was significantly different from those for the other two methods in the six subject categories. Various studies have confirmed that the Fuzzy method increases the rate of search precision in information retrieval systems. Pereda & Taghva (2011) showed that the mean precision of the Fuzzy search method was greater than that in the Token method, i.e., 55% vs. 25%. Also, Ye (2007) reported that using this logic in the thesaurus increased the performance of information retrieval. Yap & Wu (2005) compared the precision of the Fuzzy method with that of the Simple Search method and confirmed the high precision of the Fuzzy method. Gehanno & Dong (2009) concluded that the precision of Fuzzy clustering search method was greater than that in the binary search method.

In the present study, the mean objective precision in the three search methods at the cut-off point of 10 depicted that the mean precision of the fuzzy search method was greater than those of the other two search methods. Also, compared with the mean precision at a cut-off point of 20 in the three methods, the mean precision of cut-off point of 10 appeared to be higher. Thus, the PubMed can rank the results based on relevance, and the iPubMed can rank the results based on relevance as the default, we can conclude that the two systems operated successfully in finding ranking based on relevance. This is a very important feature for information retrieval systems. Rating of the retrieved results related to the users' needs rather than their questions has remained as one of the main challenges of designers of information retrieval systems. Hariri stated that, from the user's point of view, the precision of the retrieved results on the first page of Google, which sorts the results according to their relevance, is higher than other findings, so that in 47.5 and 50% of the cases, the most related results have gained scores of 1 and 5, which were on the first page (Hariri, 2011). The findings of the present study confirmed that there is a significant difference among best, useful, and objective precisions of the interactive-fuzzy search method and the other two simple and MeSH search methods as mentioned by Hariri & Nadi Ravandi (2014). In this respect, Samadzadeh *et al.*

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(2013) reported that the mean precision of the simple search method in the PubMed database in the cut-off point of 10 was 0.162, which was lower than the best mean precision of the simple search method in the current study (0.4593). The involvement of the hypertext links may effectively contribute to higher precision and more relevant articles. According to Bajpai *et al.* (2011), a study of citations can elevate search precision. Lower precision in the MeSH-controlled search method may indicate problems in the information retrieval using subject headings. The difference of the findings of this study with that of Hariri & Nadi Ravandi (2014)'s study may be due to an application of only one keyword in the second study for searching articles in MEDLINE. According to Garnett *et al.* (2010) study, using two keywords rather than one decreases the precision of the search significantly. For instance, the precision was decreased from 61% to 26% while searching using two keywords instead of one. In increasing the number of keywords, the questions formulating and keyword combinations due to different spellings, various synonyms, different abbreviations, and absence of users' experience are found difficult. However, based on studies performed in the libraries of Marquette University (2011), one of the priorities of MEDLINE compared to PubMed is better compliance of search expressions with the subject headings of MeSH, which results in more desirable findings. In addition due to the algorithm structure of PubMed, most of the users' choices are hidden behind links and, consequently, the MeSH search encounters problems.

It is obvious that lower compliance of keywords of natural language with subject heading affects the number of retrieved documents. Thus, it could be inferred that this tool would function very poorly in a precise search of articles. For example, Ugolini *et al.* (2006) proved that, out of 176 molecular epidemiologic studies, only two articles were indexed properly. This matter necessitates the use of other kinds of search methods, such as textual and phrasal searches, along with the controlled method. However, the use of the MeSH subject heading cannot be thoroughly neglected for search. Some believe that a free textual search is a good opportunity in such case where there are no keywords matched with our keywords (Pappas & Owen, 2003; Vincent *et al.* 2006). A desirable search is achieved whenever a free textual search is conducted along with a MeSH-controlled search (Harrison, 1997; Vincent *et al.* 2006). Some studies have compared the mean precision of the natural language search method in PubMed with that of the MeSH-controlled search method, and our study confirms the findings of the earlier such studies. Zohour *et al.* (2003) reported that the mean precision of the natural search method in the five famous free versions of MEDLINE, i.e., Dimidi, PubMed, IGM, Infotrieve, and BiomedNet, was meaningfully higher than that in the

MeSH-controlled search method. These findings also were in good agreement with the report of Heynez *et al.* (1985) and Zhou *et al.* (2006) which were independently published in a gap of more than twenty years. Walter (2011) showed that the mean precision of the natural search method was somewhat better than that in the advanced search method in PubMed (80% for the cut-off point of 20 versus 70%). This represents the efficacy of the natural language search method. Pollter *et al.* (2008) emphasized this matter as well.

Of course, some studies have been directed in this respect, which has produced findings that are totally different from those offered by recent studies. For instance, Chang *et al.* (2006) emphasized the high mean precision of the controlled search method compared to the simple search method. Soumela & Andrade (2005) insisted on the high precision of the controlled method in PubMed compared to the simple method as well. Nevertheless, what is of importance is that, despite differences, the advantages of each search method must not be neglected. This means that unique and related articles may be found in each search method that could not have been retrieved through other search methods (Jenuwine & Floyd, 2004). Despite all the capacities that each of these search engines possesses and the different search methods they offer, users cannot be encouraged and directed towards choosing one particular database or search method. All the search methods are advantageous and contribute to better searches and findings (Acharya *et al.* 2008).

One of the limitations of this study was that there were no similar research efforts in the medical field that could be used for comparative purposes. Therefore, it was impossible to make any meaning comparison with other results. Also, it was not possible to standardize the method of the study that was performed. In this context, for a performance of the study, the researchers based their assessment on the experience gained from previous research and the situation at the time of the study (Hariri & Nadi Ravandi, 2014). This issue may do not affect the generalized ability of the findings because each study has its own particular circumstances.

Conclusively, on the basis of this research, we can state that Interactive-Fuzzy method in iPubMed had better performance than the MeSH-Controlled method. Our findings are important because, unlike the traditional method, three types of precision were measured, i.e., Best precision, Useful precision, and Objective precision, for the first time in a medical database from the perspective of real users. This new method could provide an improved approach for the evaluation of methods that are used to search databases. Future research should focus on comparing this type of precision with different searching methods available in the MEDLINE database or other

medical databases. The results of such research can lead to the improvement of the evaluation of the methods used to search databases, and they can help designers produce better, more appropriate search algorithms. Further research in other medical fields and with the participation of experts in each field can evaluate the effectiveness of such an approach for medical information retrieval systems in providing more specific information.

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