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Retrieval Effectiveness of Search Engines in the field of Nursing

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Abstract

Purpose: *The present study evaluates the retrieval performance of three search engines, i.e., Google, Yahoo, and Bing, using four evaluation parameters: precision, recall, duplicate links, and comprehensiveness in nursing.*

Methodology: *The three popular search engines in health sciences, i.e., Google, Yahoo, and Bing, were selected for evaluation. Clarivate Analytics' Web of Science was used to extract the queries in the nursing field.*

Findings: *Bing achieves the highest total mean precision. However, Google has the highest overall mean relative recall and number of results. The overall mean precision, duplicate links, and number of hits of select search engines are highest for three-word queries. However, overall relative recall is equal for all the query intents. Furthermore, Yahoo retrieves a maximum number of duplicate links.*

Research implications: *The study will be helpful for researchers and healthcare professionals to understand the retrieval efficiency of Google, Yahoo, and Bing in seeking answers to queries in the field of nursing. Search engines' retrieval effectiveness determines the users' precise health decision-making capability. The study offers the best platform for executing different query structures across select search engines to achieve desired results without losing key results. The results may also prove helpful to search engine companies for improving the retrieval efficiency of their services in the area of health sciences in general and nursing in particular.*

Originality: *Several performance schemes have been employed to evaluate the retrieval effectiveness of search engines. Nevertheless, users may not know which search engine is best for retrieving relevant information from the Internet in nursing. The study highlights the retrieval effectiveness of generally used search engines in nursing.*

Keywords: *Search engines, Retrieval effectiveness, Google, Yahoo, Bing, Precision, Recall, Evaluation Criteria's Nursing, Health Information, Search queries*

Introduction

The Web is the largest library ever constructed in human history and has become the largest unorganized repository of data and information **(Baeza-Yates, 2003)**. To locate what we need in the deluge of information is an increasingly important and urgent problem, for which Search Engines (SEs) are the best tools **(Kim & Carvalho, 2011)**. According to **Mahajan (2023)**, SEs have revolutionized discovering and accessing information online. The evolution has been remarkable from the early days of simple keyword-based indexing to the complex algorithms powering today's intelligent SEs. SEs are the most significant tools available for resource

discovery with an ability to handle the dynamic changes posed by the Web **(Bar-Ilan, 2002)** and have grown in popularity to fulfil the information needs of people **(Hassan & Zhang, 2001; Zhu et al., 2011)**. A good amount of health-related information is available on the Web. Healthcare professionals continuously search the Web to discover reliable facts and research related to diseases and wellness **(Corrigan, 2015)**. Healthcare professionals also consult scholarly SEs to obtain high-quality information on health topics **(Cai et al., 2021)**.

People increasingly depend on the Internet for health information **(Sbaffi & Rowley, 2017)**. SEs, especially in the nursing domain, can help nurses find relevant and reliable information for their practice, education, and research **(Hersh, 2008)**. Nurses, the first point of health contact, are important in improving patients' health literacy and evaluation skills. Healthcare providers have an important role in promoting digital equity and serve as advocates for helping patients navigate the digital health landscape **(Shaw, 2023)**. The reasons nurses seek information online include targets such as improving patients' care and Continuing Professional Development. It is believed that using online Health-Related Information (HRI) improves the quality of care **(Gilmour et al., 2011)**. However, the primary challenges nurses face in retrieving information on the Internet are time limitations and a lack of search procedures **(Younger, 2010)**. According to **Weng et al. (2013)**, nurses mostly use web portals like Google and Yahoo to retrieve information.

Statement of Problem

The predominant use of Google for seeking health information has got it the title "Dr Google" **(West et al., 2020)**. The accessibility of Google makes it a highly attractive source of health information. However, the content and delivery are attached, and issues are further exacerbated by retrieving the voluminous information when searching, resulting in information overload **(Lee et al., 2015)**. The retrieval of information on the Internet is also compounded by SEs generating different results for the same search terms. Also, several SE types have been designed and implemented based on different retrieval methods, algorithms, and database techniques. Therefore, it is highly imperative to weigh the information retrieved and understand the pros and cons of SEs to establish their relevance in the healthcare system **(West et al., 2020)**. One such way is the evaluation of SEs using several parameters like precision, recall, accessibility, coverage, response time, etc., that identify the most effective one and help the users find the required information with less effort in one of the important fields of healthcare, i.e. nursing.

Review of Literature

Search Engines have always remained the focus of the research studies. **Garoufallou (2012)** states that different methodologies and parameters have been employed to evaluate search engines. Studies have mainly focussed on the technical mechanism, including crawling, quality of indexing and ranking algorithms, interface design, features, and database coverage of search engines **(Brophy & Bawden, 2005; Chowdhary & Soboroff, 2002; Hassan & Zhang, 2001; Introna & Nissenbaum, 2000; Oppenheim et al., 2000; Spink et al., 2001; Xie, 2004)**. Research also predominantly evaluated search engines on various measures like precision, coverage, response time, and recall **(Bilal, 2012; Deka & Lahkar, 2010; Gordon & Pathak, 1999; Griesbaum, 2004; Kumar & Bhadu, 2013; Kumar & Prakash, 2009; Shang & Li, 2002; Samadzadeh et al., 2013; Usmani et al., 2012).** The other parameters for the evaluation include page-level keywords **(Goel & Yadav, 2012)**, time-instability in web search results **(Kim & Carvalho, 2011)**; results descriptions **(Griesbaum, 2004; Lewandowski, 2008)**; results diversification **(Denecke, 2012; Wu et al., 2019)**; accuracy, relevance and the quality of results **(Kumar, 2005; Purcell et al., 2012; Tang et al., 2006)**; query nature or type **(Broder, 2002; Hammo, 2009; Song et al., 2008)**; and Inactive or broken links **(Nasios et al., 1998; Wu & Li, 1999).**

Search studies have also evaluated search engines by focussing on different research areas:

Ali and Gul (2016) highlighted the retrieval effectiveness of Google and Yahoo using queries from the Library and Information Science field. Google performed best for mean precision and relative recall. The higher retrieval performance of Google and Yahoo in the Library and Information Science is also reported by **Deka and Lahkar (2010)**. Similarly, **Wang et al. (2012)** compared the usability of four major search engines (Google, Yahoo!, Bing, and Ask.com) in retrieving health and medical information using the keyword breast cancer. The results indicated that Google has the highest search validity and less redundancy; however, search results highly overlap between the search engines. Also, Bing has the highest usefulness. Search engines have also been evaluated based on queries related to business **(Gordon & Pathak, 1999)**; e-commerce **(Jansen & Molina, 2006)**; earth sciences **(Wishard, 1998)**; biotechnology **(Shafi & Rather, 2005)**; medical & health information **(Jones & Timm, 2008; Spink et al., 2004; Wu & Li, 1999);** mental health **(Tang et al., 2006);** oncology and condensed matter physics **(Bakkalbasi et al., 2006),** etc.

Tober (2011) assessed the retrieval performance based on recall, precision, and importance of the four most popular search engines, i.e., PubMed/MEDLINE, ScienceDirect, Scopus, and Google Scholar in laser medicine. The results show that the search features of PubMed/MEDLINE,

designed explicitly for medical documents, are exceptional. Also, the most effective search engine is Scopus. However, for "importance", Scopus and Google Scholar are better performers. **Samadzadeh et al. (2013)** evaluated the four search engines: PubMed, Science Direct, Google Scholar, and the federated search of the Iranian National Medical Digital Library in the area of addiction. The search engines showed significant differences in the selected criteria, with PubMed, Science Direct, and Google Scholar being the best in recall, preciseness, and importance, respectively. **Cai et al. (2021)** assessed the Google search engine for health and nutrition information. The study concluded that Google SE has limitations in searching for information on health and nutrition.

Similarly, **Lopes and Ribeiro (2011)** compared the health information retrieval effectiveness of general (Bing, Google, Sapo, and Yahoo) and health-specific search engines (MedlinePlus, SapoSau'de, and WebMD). They revealed that general search engines have higher precision than health-specific search engines, with Google having the highest performance. **Anders and Evans (2010)** compared the search results of PubMed and Google Scholar in respiratory care. PubMed and Google Scholar showed similar recall; however, PubMed had better precision than Google Scholar for respiratory care topics. Similarly, **Nourbakhsh et al. (2012)** evaluated the article quality and relevance of PubMed and Google Scholar search results for clinical questions. The study establishes that Google Scholar searches were more relevant than results retrieved by the PubMed databases.

Objectives of the Study

a) Select SEs and search queries for the study.
b) Evaluate and compare the retrieval effectiveness of select SEs on two basic measures: precision and relative recall.
c) Identify duplicate results in the select SE results.
d) Compare the select SEs based on comprehensiveness.

Methodology

Selection of search engines and search queries

For our research study, we selected three general SEs, namely Google, Yahoo, and Bing, based on their popularity in the area of health information (**Fox & Duggan, 2013; Spink *et al.,* 2004; Weng *et al.,* 2013; West *et al.,* 2020).**

The queries were extracted from the author keywords of the highly cited papers published in the nursing field, as indexed by the Web of Science. The structure of queries in the field of 'Nursing' was categorized into three different query intents viz; one-word, two-word, and three-word queries. A total of thirty (30) keyword inquiries were used, of which ten (10) were

one-word, ten (10) were two-word, and ten (10) were three-word queries **(Table 1)**.

Table 1: Distribution of Query Structure

S.No.	1-word	2-word	3-word
1	Nursing	quasi-anonymity	health services research
2	Pain	pain assessment	Numerical Rating Scale
3	Delphi	Postpartum Depression	Health care organization
4	Triangulation	gender issues	Critical appraisal tool
5	Stress	chronic disease	middle-range theory
6	Psychometrics	Patient-centered	molecularly targeted therapy
7	Anonymity	Delphi method	tumor-treating fields (TTFields)
8	Dementia	genomic profiling	symptom management model
9	Surgery	snowball sampling	non-probability sampling
10	Temozolomide	caregiver burden	evidence-based medicine

Retrieval Effectiveness

a) Estimation of Precision and Recall

Each query was submitted to the select SEs, which retrieved many results, but only the first ten results/hits/sites were evaluated. The first ten results were selected because most users usually look up the first ten hits of a query. The two vital retrieval measures were used to check the retrieval effectiveness of search engines viz; precision and relative recall. The formula for calculating precision and recall, as also used in previous studies such as **Kumar and Prakash (2009); Kumar and Pavitra (2010); Shafi and Rather (2005,** is given below:

$$\textbf{Precision}(\mathbf{P}) = \frac{\text{Sum of scores of sites retrieved by a search engine}}{\text{Total number of sites selected for evaluation}}$$

$$\textbf{Relative Recall} = \frac{\text{Total number of sites retrieved by a search engine}}{\text{Sum of sites retrieved by all search engines}}$$

b) Identification of duplicate results and comprehensiveness/coverage of select search engines

In an attempt to manipulate the ranking of search engines or to win more web traffic, contents are deliberately duplicated within or across domains, and either the same or significantly similar content appears on the Internet in more than one place. Duplicate content comes in different forms, but a significant scenario is multiple URLs that point to the same page. The duplicate results were identified based on similar content appearing under different URLs in the retrieved hits for each query.

Comprehensiveness is the capacity to understand and provide a broad range of topics to the query given by a user to a search engine. The ability of a search engine to have an extensive collection in a dataset and to provide a large number of results to the users is known as the comprehensiveness of that search engine. The coverage of a search engine

can be determined as the total number of pages returned by the search engine. Accordingly, the comprehensiveness/coverage of a search engine was calculated as the total number of pages returned by the search engine.

Pointing Scale for Scoring

A five-point Likert scale was employed to estimate precision to determine the relevance of each page. The Likert scale has been used in several studies to determine the retrieval efficiency of SEs **(Ding & Marchionini, 1996; Gul *et al.,* 2019; Shafi & Rather, 2005; Su *et al.,* 1998)**. The following scoring was specified for different web pages (sites) to estimate the precision of search engines for the selected queries.

- The page or result representing the full text of a research paper, seminar/conference proceedings, or patent was scored 4.
- The page corresponding to an abstract of a research paper or giving brief information was given a score of 3.
- The results that reflected secondary information, including books, monographs, etc., were allocated a score of 2.
- The results revealed information like the homepage of some organizations/institutions or websites, which were assigned a score of 1.
- If a page occurred more than once under different URLs, it was assigned a score of zero (0).
- In a situation where the server did not respond or "File not Found" occurred, it was assigned a score of zero (0) (after three attempts).

Data Analysis and Interpretation

Precision of One-word Queries in Google, Yahoo, and Bing

In Google, the highest precision score of 26 is attained for the one-word query "Triangulation", with the highest mean precision value of 2.6. However, in the case of Yahoo, the highest precision score of 28 is also achieved for "Triangulation", with the highest mean precision value of 2.8. Similarly, Bing's highest precision score of 25 is attained for the query "Psychometrics", with a mean precision value of 2.5. However, the lowest precision score of 14 is for "Nursing" and "Anonymity", with a mean value of 1.4 in Google and Yahoo. The query "Nursing" also has the lowest precision score, 12 in Bing.

Furthermore, in one-word queries, Google attains the highest mean precision of 18.4; Yahoo and Bing have a mean precision of 17 and 16.4, respectively. However, the overall mean precision of search engines Google, Yahoo, and Bing for one-word queries in the field of Nursing is 17.27 (Table 2).

Table 2: Precision of Google, Yahoo, and Bing for One-Word Queries

Search Terms	1	2	3	4	5	6	7	8	9	10	∑P	AVP*
Google												
Nursing	1	2	1	2	1	1	1	1	2	2	14	1.4
Pain	1	2	1	3	2	2	1	2	2	2	18	1.8
Delphi	1	2	1	1	2	2	1	2	1	2	15	1.5
Triangulation	4	2	4	2	2	2	2	3	2	3	26	2.6
Stress	1	2	2	2	2	2	2	1	4	1	19	1.9
Psychometrics	3	2	2	2	1	4	1	2	3	2	22	2.2
Anonymity	1	1	1	2	1	1	3	1	2	1	14	1.4
Dementia	1	2	2	2	1	2	2	2	2	2	18	1.8
Surgery	1	2	2	2	2	1	2	2	2	1	17	1.7
Temozolomide	2	1	2	2	2	4	1	2	2	3	21	2.1
											Mean	**18.4**
Yahoo												
Nursing	1	2	1	2	1	1	1	1	1	1	12	1.2
Pain	1	4	2	4	1	4	1	3	2	2	24	2.4
Delphi	1	2	2	1	1	2	1	1	2	1	14	1.4
Triangulation	4	2	4	2	1	3	3	3	4	2	28	2.8
Stress	1	2	2	1	2	1	1	1	1	2	14	1.4
Psychometrics	3	2	1	3	2	1	0	1	1	2	16	1.6
Anonymity	1	1	2	1	1	1	1	2	1	1	12	1.2
Dementia	2	1	1	2	2	3	1	2	2	1	17	1.7
Surgery	2	2	2	1	2	3	2	2	1	1	18	1.8
Temozolomide	3	2	1	2	1	1	2	0	2	1	15	1.5
											Mean	**17**
Bing												
Nursing	1	1	2	1	1	2	1	1	1	1	12	1.2
Pain	1	2	1	1	1	1	1	1	4	1	14	1.4
Delphi	2	2	1	1	1	1	2	1	1	1	13	1.3
Triangulation	2	1	1	1	2	1	2	3	2	2	17	1.7
Stress	1	2	2	1	1	1	2	2	1	1	14	1.4
Psychometrics	2	1	3	2	2	3	3	4	2	3	25	2.5
Anonymity	1	1	2	1	1	1	1	4	1	1	14	1.4
Dementia	2	1	1	2	1	1	4	2	1	4	19	1.9
Surgery	2	2	1	1	1	2	4	1	1	3	18	1.8
Temozolomide	2	1	2	2	2	1	1	2	1	4	18	1.8
											Mean	**16.4**
											Total Mean	**17.27**

***AVP = Average Precision =∑P/n**

Precision of Two-word Queries in Google, Yahoo, and Bing

In Google, the highest precision score of 25 is acquired for the query "Caregiver burden", with the highest mean precision value of 2.5. However, regarding Yahoo and Bing, the query "Quasi-anonymity" has the

greatest precision score of 29, with the highest mean precision value of 2.9. The query "Gender issues" achieves the lowest precision in all three search engines, with the lowest mean precision of 1.6 in Google and Bing and 1.2 in Yahoo.

Bing achieves the highest mean precision of 22.6 for two-word queries and is ahead of Google and Yahoo, which have mean precisions of 21.4 and 19.6, respectively. However, the overall mean precision of search engines Google, Yahoo, and Bing for two-word queries in the field of Nursing is 21.2 (Table 3).

Table 3 Precision of Google, Yahoo, and Bing for Two-Word Queries

Search Terms	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**∑P**	**AVP***
Google												
Quasi-anonymity	4	2	2	3	3	1	1	3	3	2	24	2.4
Pain assessment	4	4	2	2	1	1	2	1	2	2	21	2.1
Postpartum depression	3	1	1	2	2	2	1	2	1	2	17	1.7
Gender issues	1	3	3	2	1	1	1	1	1	2	16	1.6
Chronic disease	3	3	2	2	2	1	3	1	1	3	21	2.1
Patient-centered	1	2	2	3	2	2	3	2	2	4	23	2.3
Delphi method	2	2	2	1	4	1	2	3	4	1	22	2.2
Genomic profiling	3	1	3	4	4	1	1	1	2	4	24	2.4
Snowball sampling	2	2	2	1	2	2	2	2	4	2	21	2.1
Caregiver burden	2	4	2	3	1	1	3	4	4	1	25	2.5
										Mean		**21.4**
Yahoo												
Quasi-anonymity	4	3	3	3	3	3	4	2	2	2	29	2.9
Pain assessment	1	2	2	2	1	2	2	4	1	1	18	1.8
Postpartum depression	1	2	2	2	1	1	3	1	1	2	16	1.6
Gender issues	2	1	1	2	1	1	1	0	2	1	12	1.2
Chronic disease	2	1	2	2	1	2	1	1	3	2	17	1.7
Patient-centered	2	1	0	2	3	4	1	4	3	1	21	2.1
Delphi method	1	2	2	2	2	2	4	1	1	2	19	1.9
Genomic profiling	1	3	1	2	1	1	1	1	3	4	18	1.8
Snowball sampling	2	2	2	2	3	1	2	2	2	4	22	2.2
Caregiver burden	1	4	2	3	3	1	3	3	0	4	24	2.4
										Mean		**19.6**
Bing												
Quasi-anonymity	3	4	3	2	3	3	4	1	4	2	29	2.9
Pain assessment	2	2	2	4	4	1	4	1	2	3	25	2.5
Postpartum depression	1	2	1	1	4	2	2	1	2	2	18	1.8
Gender issues	2	1	1	3	2	1	1	1	2	2	16	1.6
Chronic disease	2	4	1	2	2	3	2	1	2	2	21	2.1

Search Terms	1	2	3	4	5	6	7	8	9	10	∑P	AVP*
Patient-centered	1	2	2	1	3	4	0	4	4	3	24	2.4
Delphi method	4	2	2	2	2	3	1	3	2	1	22	2.2
Genomic profiling	2	1	3	2	4	4	2	1	4	1	24	2.4
Snowball sampling	2	0	2	2	4	2	4	2	2	2	22	2.2
Caregiver burden	4	4	2	3	4	2	1	1	1	3	25	2.5
											Mean	**22.6**
											Total Mean	**21.2**

***AVP = Average Precision =∑P/n**

Moreover, Bing achieves the highest mean precision of 23.6 for three-word queries and is ahead of Yahoo and Google, which have mean precisions of 22.4 and 21.6, respectively. However, the overall total mean precision of search engines Google, Yahoo, and Bing for three-word queries in the field of Nursing is 22.57 (Table 4).

Table 4: Precision of Google, Yahoo, and Bing for Three-Word Queries

Search Terms	1	2	3	4	5	6	7	8	9	10	∑P	AVP*
Google												
Health services research	1	1	1	1	3	2	2	3	1	2	17	1.7
Numerical Rating Scale	4	3	2	2	3	2	4	4	1	3	28	2.8
Health care organization	1	1	1	1	3	1	1	2	4	1	16	1.6
Critical appraisal tool	1	1	1	1	2	3	1	4	2	3	19	1.9
Middle-range theory	2	2	1	3	1	1	2	3	3	3	21	2.1
Molecularly targeted therapy	1	3	2	4	4	3	2	1	1	2	23	2.3
Tumor-treating fields (TTFields)	3	1	3	4	1	3	2	1	1	1	20	2
Symptom management model	3	4	3	4	3	4	0	3	4	2	30	3
Non-probability sampling	2	2	2	2	2	2	2	2	3	4	23	2.3
Evidence-based medicine	2	2	4	2	1	3	1	3	2	0	20	2
											Mean	**21.7**
Yahoo												
Health services research	1	2	2	3	1	3	1	0	2	1	16	1.6
Numerical Rating Scale	3	2	2	1	2	4	2	4	3	1	24	2.4
Health care organization	1	2	2	2	1	3	2	4	1	4	22	2.2
Critical appraisal tool	1	1	1	3	4	4	1	4	0	4	23	2.3

Search Terms	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**∑P**	**AVP***
Middle-range theory	1	2	3	1	2	3	3	1	1	3	20	2
Molecularly targeted therapy	2	4	0	2	1	4	4	4	4	4	29	2.9
Tumor-treating fields (TTFields)	2	2	4	4	2	2	3	4	1	1	25	2.5
Symptom management model	4	2	4	3	3	1	1	3	2	4	27	2.7
Non-probability sampling	2	2	2	2	2	2	2	1	2	2	19	1.9
Evidence-based medicine	1	2	2	2	4	1	2	1	1	3	19	1.9
											Mean	**22.4**
Bing												
Health services research	1	2	2	3	2	2	2	1	3	1	19	1.9
Numerical Rating Scale	3	2	4	2	2	2	3	2	2	1	23	2.3
Health care organization	1	3	2	2	1	1	1	3	2	2	18	1.8
Critical appraisal tool	1	1	4	1	3	4	1	1	4	1	21	2.1
Middle-range theory	2	3	3	4	3	2	1	1	3	3	25	2.5
Molecularly targeted therapy	4	1	2	3	2	4	3	3	3	4	29	2.9
Tumor-treating fields (TTFields)	2	4	4	4	4	3	3	2	4	1	31	3.1
Symptom management model	4	4	2	3	3	4	1	1	2	4	28	2.8
Non-probability sampling	2	2	2	2	2	0	2	1	4	1	18	1.8
Evidence-based medicine	2	2	2	4	2	3	2	2	1	4	24	2.4
											Mean	**23.6**
Total Mean												**22.57**

***AVP = Average Precision =∑P/n**

Overall Mean Precision of Google, Yahoo, and Bing for Different Query Intents

Google, Yahoo, and Bing attain different results for query structures (one-word, two-word, and three-word). However, SE Bing achieves the highest total mean precision of 20.87, followed by Google and Yahoo, with a total mean precision of 20.5 and 19.67, respectively (Table 5).

Relative Recall of Google, Yahoo, and Bing for One-Word Queries

Google attains the highest relative recall of 0.99 for one-word queries “Pain” “Psychometrics” and “Anonymity”. However, the relative recall of

Yahoo & Bing for one-word queries is higher for a similar query, "Delphi", with a relative recall of 0.05. The lowest relative recall of 0.96 is for the query "Temozolomide" in Google; whereas "Psychometrics" has a relative recall of 0.00 in Yahoo and Bing. Furthermore, the average relative recall for one-word queries is 0.97 for Google and 0.01 for Yahoo and Bing. Therefore, Google has the highest mean relative recall value of 0.97 (Table 6).

Table 5: Query Wise Mean Precision of Google, Yahoo, and Bing

Query Category	Google	Yahoo	Bing
One-word	18.4	17.0	16.4
Two-word	21.4	19.6	22.6
Three-word	21.7	22.4	23.6
Total Mean	**20.5**	**19.67**	**20.87**

Relative Recall of Google, Yahoo, and Bing for Two-word Queries

For two-word search queries, Google attains the highest relative recall of 1.00 for queries "Gender issues" and "Genomic profiling". The relative recall of Yahoo is higher for queries "Quasi-anonymity" and "Snowball sampling" with a similar relative recall value of 0.10. The highest relative recall of 0.10 is for Bing for the query "Quasi-anonymity". In Google, the lowest relative recall of 0.80 is for the query "Quasi-anonymity"." In contrast, in Yahoo and Bing, the queries "Gender issues", "Chronic disease", and "Genomic profiling" have a relative recall of 0.00. Further, the average relative recall for Google, Yahoo, and Bing is 0.95, 0.03, and 0.02, respectively, with a mean relative recall of 0.95. Thus, Google attains the highest score (Table 7).

Relative Recall of Google, Yahoo, and Bing for Three-word Queries

Similarly, for three-word queries, Google achieves the highest relative recall value of 1.00 for queries "Critical appraisal tool," "Middle-range theory," and "Non-probability sampling." The relative recall of both Yahoo and Bing is higher, i.e., 0.15 for the query "Molecularly targeted therapy," which has the lowest relative recall of 0.69 in Google. The queries "Critical appraisal tool," "Middle-range theory," and "Non-probability sampling" have a relative recall of 0.00. Furthermore, the average relative recall for Google is 0.96, and for Yahoo and Bing, it is 0.02 each. As a result, Google thus receives the highest score of 0.96 (Table 8).

Table 6: Relative Recall of Google, Yahoo, and Bing for One-Word Queries

Search Term	Google results	Relative Recall	Yahoo Results	Relative Recall	Bing result	Relative Recall	GYB Results
Nursing	5250000000	0.98	50300000	0.01	50200000	0.01	5350500000
Pain	9520000000	0.99	60500000	0.01	60300000	0.01	9640800000
Delphi	160000000	0.89	9700000	0.05	9680000	0.05	179380000
Triangulation	61500000	0.98	794000	0.01	764000	0.01	63058000
Stress	5130000000	0.98	45800000	0.01	45700000	0.01	5221500000
Psychometrics	112000000	0.99	342000	0.00	313000	0.00	112655000
Anonymity	102000000	0.99	618000	0.01	617000	0.01	103235000
Dementia	906000000	0.98	7580000	0.01	7570000	0.01	921150000
Surgery	6650000000	0.98	54400000	0.01	54400000	0.01	6758800000
Temozolomide	8610000	0.96	195000	0.02	198000	0.02	9003000
Total Relative Recall		**9.72**		**0.14**		**0.14**	
Mean		**0.97**		**0.01**		**0.01**	

GYB = Google, Yahoo, and Bing

Table 7: Relative Recall of Google, Yahoo, and Bing for Two-Word Queries

Search Term	Google results	Relative Recall	Yahoo Results	Relative Recall	Bing result	Relative Recall	GYB Results
Quasi-anonymity	1310000	0.80	159000	0.10	169000	0.10	1638000
Pain assessment	1100000000	0.92	49100000	0.04	48600000	0.04	1197700000
Postpartum depression	84800000	0.97	1480000	0.02	1520000	0.02	87800000
Gender issues	1010000000	1.00	1390000	0.00	1460000	0.00	1012850000
Chronic disease	2700000000	0.99	7540000	0.00	7500000	0.00	2715040000
Patient-centered	2510000000	0.97	34000000	0.01	35100000	0.01	2579100000
Delphi method	26900000	0.98	333000	0.01	344000	0.01	27577000
Genomic profiling	215000000	1.00	314000	0.00	334000	0.00	215648000

Search Term	Google results	Relative Recall	Yahoo Results	Relative Recall	Bing result	Relative Recall	GYB Results
Snowball sampling	14000000	0.88	1640000	0.10	198000	0.01	15838000
Caregiver burden	24500000	0.97	351000	0.01	355000	0.01	25206000
Total Relative Recall		**9.48**		**0.30**		**0.22**	
Mean		**0.95**		**0.03**		**0.02**	

GYB = Google, Yahoo, and Bing

Table 8: Relative Recall of Google, Yahoo, and Bing for Three-Word Queries

Search Term	Google results	Relative Recall	Yahoo Results	Relative Recall	Bing results	Relative Recall	GYB Results
Health services research	4720000000	0.99	29800000	0.01	29900000	0.01	4779700000
Numerical Rating Scale	52000000	0.98	542000	0.01	540000	0.01	53082000
Health care organization	1620000000	0.98	16700000	0.01	16500000	0.01	1653200000
Critical appraisal tool	263000000	1.00	548000	0.00	547000	0.00	264095000
Middle-range theory	879000000	1.00	507000	0.00	920000	0.00	880427000
Molecularly targeted therapy	1840000	0.69	407000	0.15	406000	0.15	2653000
Tumor-treating fields (TTFields)	20800000	0.98	263000	0.01	265000	0.01	21328000
Symptom management model	116000000	0.98	896000	0.01	897000	0.01	117793000
Non-probability sampling	172000000	1.00	410000	0.00	402000	0.00	172812000
Evidence-based medicine	1680000000	0.99	9640000	0.01	9600000	0.01	1699240000
Total Relative Recall		**9.58**		**0.21**		**0.21**	
Mean		**0.96**		**0.02**		**0.02**	

Overall Mean Relative Recall of Google, Yahoo, and Bing for Different Query Intents

The overall mean relative recall of Google, Yahoo, and Bing in the field of Nursing on different query intents appear to produce distinct outcomes, with Google achieving the highest overall mean relative recall at 0.96, followed by Yahoo and Bing with 0.02 each, respectively (Table 9).

Table 9: Query Wise Mean Relative Recall of Google, Yahoo, and Bing

Query Category	Google	Yahoo	Bing
One-word	0.97	0.01	0.01
Two-word	0.95	0.03	0.02
Three-word	0.96	0.02	0.02
Total Mean	**0.96**	**0.02**	**0.02**

Duplicate Links of Google, Yahoo, and Bing for One-Word Queries

Yahoo returns the most duplicate links (2). The "Psychometrics" and "Temozolomide" queries return one duplicate link for each. Google and Bing, however, do not retrieve any duplicate links. Thus, for the Yahoo Search Engine alone, there are two (2) duplicate links for one-word queries (Table 10).

Table 10: Duplicate Links of Google, Yahoo, and Bing for one-word Queries

Search Terms	Google	Yahoo	Bing
Nursing	0	0	0
Pain	0	0	0
Delphi	0	0	0
Triangulation	0	0	0
Stress	0	0	0
Psychometrics	0	1	0
Anonymity	0	0	0
Dementia	0	0	0
Surgery	0	0	0
Temozolomide	0	1	0
Total	**0**	**2**	**0**

Duplicate Links of Google, Yahoo, and Bing for Two-Word Queries

Yahoo returns the most duplicate links of three (3) in the two-word query category. The queries "Gender issues," "Patient-centered," and "Caregiver burden" all retrieve one duplicate link each. Bing returns two (2) duplicate links for queries "Patient-centered" and "Snowball sampling." However, Google does not have any duplicate links in the results, with Yahoo (3) and Bing (2) retrieving the most duplicate links, respectively (Table 11).

Table 11: Duplicate Links of Google, Yahoo, and Bing for two-word Queries

Search Terms	Google	Yahoo	Bing
Quasi-anonymity	0	0	0
Pain assessment	0	0	0
Postpartum depression	0	0	0
Gender issues	0	1	0
Chronic disease	0	0	0
Patient-centered	0	1	1
Delphi method	0	0	0
Genomic profiling	0	0	0
Snowball sampling	0	0	1
Caregiver burden	0	1	0
Total	**0**	**3**	**2**

Duplicate Links of Google, Yahoo, and Bing for Three-Word Queries

Google returns two (2) duplicate links for the queries "Symptom management model" and "Evidence-based medicine." For the queries "Health services research," "Critical appraisal tool," and "Molecularly targeted therapy," Yahoo returns three (3) duplicate links. However, Bing returns only one (1) duplicate link for the query "Non-probability sampling." Thus, Yahoo has the most duplicate links (3), followed by Google (2) and Bing (1) (Table 12).

Table 12: Duplicate Links of Google, Yahoo, and Bing for three-word Queries

Search Terms	Google	Yahoo	Bing
Health services research	0	1	0
Numerical Rating Scale	0	0	0
Health care organization	0	0	0
Critical appraisal tool	0	1	0
Middle-range theory	0	0	0
Molecularly targeted therapy	0	1	0
Tumor-treating fields (TTFields)	0	0	0
Symptom management model	1	0	0
Non-probability sampling	0	0	1
Evidence-based medicine	1	0	0
	2	**3**	**1**

Total Duplicate Links of Google, Yahoo, and Bing for Different Query Intents

All three search engines return different results; however, Yahoo results in most duplicate links (8), followed by Bing (3) and Google (2) (Table 13).

Table 13: Query Wise Duplicate links of Google, Yahoo and Bing

Query Category	Google	Yahoo	Bing
One-word	0	2	0
Two-word	0	3	2
Three-word	2	3	1
Total Duplicate Links	**2**	**8**	**3**

Comprehensiveness of Google, Yahoo, and Bing for One-Word Queries

Google produces the highest results (9520000000) for the "pain" query among one-word queries. However, Yahoo and Bing returned the same number of hits (54400000) when "Surgery" was used as a search term. All three SEs retrieve the least number of hits for the query "emozolomide" with Google, Yahoo, and Bing retrieving 8610000, 195000, and 198000 results, respectively. Furthermore, Google overall retrieves the most results (27900110000), followed by Yahoo (230229000) and Bing (229742000) **(Table 14)**.

Table 14: Comprehensiveness of Search Engines for One-Word Queries

Search Terms	Google	Yahoo	Bing
Nursing	5250000000	50300000	50200000
Pain	9520000000	60500000	60300000
Delphi	160000000	9700000	9680000
Triangulation	61500000	794000	764000
Stress	5130000000	45800000	45700000
Psychometrics	112000000	342000	313000
Anonymity	102000000	618000	617000
Dementia	906000000	7580000	7570000
Surgery	6650000000	54400000	54400000
Temozolomide	8610000	195000	198000
Total	**27900110000**	**230229000**	**229742000**

Comprehensiveness of Google, Yahoo, and Bing for Two-Word Queries

For two-word queries, Google has the highest number of results (2700000000) for the query "Chronic disease." In the case of Yahoo and Bing, the highest number of results (49100000 and 48600000) are retrieved for the query "Pain assessment." However, Google, Yahoo, and Bing retrieved the least results, with 1310000, 159000, and 169000 hits, respectively, for the term "Quasi-anonymity." Furthermore, overall, Google retrieves the most results (7686510000), followed by Yahoo (96307000) and Bing (95580000) (Table 15).

Comprehensiveness of Google, Yahoo, and Bing for Three-Word Queries

For the same query, "Health services research," Google, Yahoo, and Bing return the most results in the three-word query category (4720000000, 29800000, and 29900000 results, respectively). However, the lowest number of results is for the query "Molecularly targeted therapy" in Google, Tumor-treating fields (TTFields) in Yahoo and Bing, with 1840000, 263000, and 265000 results in the respective search engines.

For the three-word queries, Google produces the most number of results (9524640000), followed by Yahoo (59977000) and Bing (59713000) (Table 16).

Table 15: Comprehensiveness of Google, Yahoo, and Bing for Two-Word Queries

Search Terms	Google	Yahoo	Bing
Quasi-anonymity	1310000	159000	169000
Pain assessment	1100000000	49100000	48600000
Postpartum depression	84800000	1480000	1520000
Gender issues	1010000000	1390000	1460000
Chronic disease	2700000000	7540000	7500000
Patient-centered	2510000000	34000000	35100000
Delphi method	26900000	333000	344000
Genomic profiling	215000000	314000	334000
Snowball sampling	14000000	1640000	198000
Caregiver burden	24500000	351000	355000
∑=	**7686510000**	**96307000**	**95580000**

Table 16: Comprehensiveness of Google, Yahoo, and Bing for Three-Word Queries

Search Terms	Google	Yahoo	Bing
Health services research	4720000000	29800000	29900000
Numerical Rating Scale	52000000	542000	540000
Health care organization	1620000000	16700000	16500000
Critical appraisal tool	263000000	548000	547000
Middle-range theory	879000000	507000	920000
Molecularly targeted therapy	1840000	407000	406000
Tumor-treating fields (TTFields)	20800000	263000	265000
Symptom management model	116000000	896000	897000
Non-probability sampling	172000000	410000	402000
Evidence-based medicine	1680000000	9640000	9600000
Total	**9524640000**	**59713000**	**59977000**

Overall Comprehensiveness of Google, Yahoo, and Bing for Different Query Intents

The overall comprehensiveness of Google, Yahoo, and Bing in the field of Nursing on different query intents viz; one-word, two-word, and three-word queries vary, with Google achieving the highest number of results

(45111260000), followed by Yahoo (386249000) and Bing (385299000) respectively (Table 17).

Table 17: Query Wise Total Comprehensiveness of Search Engines

Query Category	Google	Yahoo	Bing
One-word	2790011000	230229000	229742000
Two-word	7686510000	96307000	95580000
Three-word	9524640000	59713000	59977000
Total	**45111260000**	**386249000**	**385299000**

Findings

Precision of search engines for Different Query Intents

Google attains the highest mean precision for one-word queries. However, Bing achieves the highest mean precision for two-word and three-word queries. For distinct query categories (one-word, two-word, and three-word), Google, Yahoo, and Bing produce diverse results, with Bing achieving the highest total mean precision, followed by Google and Yahoo. Also, the overall mean precision of selected search engines in the field of Nursing is highest for three-word queries, followed by two-word and one-word.

Relative recall of search engines for Different Query Intents

Google attains the highest average relative recall across all the query categories, i.e., one-word, two-word, and three-word. Google achieves the highest overall mean relative recall, followed by Yahoo and Bing. However, the overall relative recall is equal for three-word, two-word, and one-word queries.

Prevalence of Duplicate Links across search engine results

Across all the query categories, Yahoo retrieves the maximum number of duplicate links, followed by Bing and Google. However, Google does not result in any duplicate links for one-word and two-word queries. Further, across all the query categories, duplicate links are more prevalent in the results of three-word, followed by two-word and one-word queries.

Comprehensiveness of selected search engines

Across all the query categories, Google retrieves the highest number of results, followed by Yahoo and Bing. Further, the highest number of results is retrieved for three-word queries, followed by two-word and one-word.

Conclusion

Search engines are one of the foremost tools for seeking health-related information. The study evaluated the retrieval effectiveness of three search engines, viz. Google, Yahoo, and Bing using different query structures, i.e., one-word, two-word, and three-word, related to the field

of Nursing. The evaluation measures included precision, relative recall, presence of duplicate links, and comprehension of search engines using 30 test queries. The study revealed that the search engine Bing achieves the highest mean precision, although slightly higher than Google and Yahoo. Google has the highest mean relative recall and comprehension and lacks duplicate links.

Google's performance is also better for retrieving more unique results than other selected search engines. This may be the reason for attributing Google as the preferred search engine for health-related information among the general search engines. However, each search engine has unique features and does not have total precision and recall. Further, satisfaction with the search results of SEs is also determined by the interaction of users with the search engines **(Samadzadeh *et al.,* 2013)**.

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