The Comprehensiveness of Computer-Assisted Searches of the Medical Literature

Peter DeNeef, MD, PhD
Seattle, Washington

Bibliographic searches using MEDLINE, the National Library of Medicine computerized database, can usually be done in less time and with greater specificity than searches using Index Medicus. *To use a computer-assisted bibliographic retrieval system to full advantage, it is necessary to understand the indexing system. The study reported here compares both the number and the relevance of references retrieved using various search terms for two clinical questions. Based on the outcomes of these searches, recommendations are made for clinicians who plan to use MEDLINE services.*

M any physicians perform self-service computer-assisted bibliographic searches of the medical literature rather than looking through the printed volumes of *Index Medicus* or waiting for a medical librarian to conduct a search for them. With a microcomputer and readily available telecommunication equipment, end users can now search for information in the National Library of Medicine (NLM) databases such as MEDLINE by means of an ordinary telephone connection.[1-3] As 60 percent of MEDLINE records include the abstract, even physicians without convenient access to a medical library can obtain useful clinical information immediately. In addition, some vendors will mail copies of articles, and some offer immediate online retrieval of the full text of articles from selected journals.[4] New search skills are required so that self-service computer-assisted bibliographic retrieval can be used to full advantage,[5,6] and the purpose of this study is to help physicians plan search strategies that are efficient and that meet their needs.

The NLM computerized Medical Literature Analysis and Retrieval System (MEDLARS) was established in 1964 to assist in publishing *Index Medicus*. The MEDLINE (MEDLARS on LINE) database first became available for online searching from remote locations in 1971. Since that time the number of MEDLARS databases has increased to 18. More than 6 million citations from over 3,300 journal titles are contained in the most frequently used databases, MEDLINE, and the related files back to 1966. This vast amount of information is cataloged by indexers at the NLM who scan each article to be included.

The MEDLINE unit record is the computer-stored information representing one journal article or monograph portion. Table 1 displays the information in the MEDLINE unit record of a recently published article.[5,6] All vendors serving as intermediaries between end users and the NLM use MEDLINE unit records for retrieval.[5] A search can be performed by specifying the information contained in any of the data elements in Table 1 except the page, issue, and volume numbers. For example, every article published by a particular author in specific years or specific journals can be retrieved. The same search can be performed as well, albeit more slowly, using *Index Medicus*. Most searches are related to a particular subject, however, and the specificity of combining multiple terms in computer-assisted searches far exceeds that of *Index Medicus,* where articles appear under three individual headings at most.

A MEDLINE user can search for specific text words or for standardized medical subject headings (MeSH terms) assigned by indexers. Text word searches retrieve articles in which the specified word(s) appear in either the title or the abstract. Such searches are relatively easy to conceive, and they are useful if there is no standard MeSH term or convenient combination of terms for a concept. But text word searches are subject to errors resulting from unanticipated variations in spelling (eg, streptococcus and streptococci), synonyms (eg, chickenpox and varicella), and multiple meanings (eg, aids, which can refer to hearing aids and syndromes caused by the human immunodeficiency virus).[5,7] Spelling variations and synonyms may

TABLE 1. THE MEDLINE UNIT RECORD OF A RECENT ARTICLE

Data Elements	Example [with comments]
Unique identifier number	87059703
Author	DeNeef P
Title	Comparison of tests for streptococcal pharyngitis
Language	Eng [English]
Journal title abbreviation	J Fam Pract
Journal title code	I4L
International standard serial number	0094-3509
Date of publication	1986 Dec
Volume	23
Issue	6
Pages	551-5
Date of entry into MEDLINE	870114 [January 14, 1987]
Issue of *Index Medicus* containing citation	8703 [March, 1987]
Abstract	[Complete text of abstract—250 word limit with certain exceptions]
Medical subject headings and subheadings	Carrier state/DIAGNOSIS
	Comparative study
	Cost benefit analysis
	False-negative reactions
	False-positive reactions
	Human
	Latex-fixation tests/STANDARDS
	Pharyngitis/*DIAGNOSIS/ECONOMICS/ETIOLOGY
	Pharynx/MICROBIOLOGY
	Reagent kits, diagnostic/ECONOMICS/STANDARDS
	Streptococcal infections/*DIAGNOSIS/ECONOMICS
	Streptococcus pyogenes/ISOLATION AND PURIFICATION
Journal subset	A [*The Journal of Family Practice* is indexed in *Abridged Index Medicus*.]
	M [The abstract is included in the unit record.]
[Geographic] Tree number	Z1.107.567.875 [United States]

Note: Subheadings are printed in capital letters, and (*) indicates the primary concept identified by the indexer

cause a search to miss important articles, while multiple meanings lead to the retrieval of irrelevant citations.

MeSH terms, selected to avoid ambiguity, comprise a controlled, structured vocabulary of more than 14,000 terms. From five to 15 of these are assigned to each article, and standardized subheadings divide topics further. Each year the NLM publishes a list of the current medical subject headings including annotations in a three-volume set.[8-10] Also, online MeSH vocabulary files without annotation can be consulted during a search.

MEDLINE searches have been evaluated previously using a variety of criteria. Sewell[11] has demonstrated common errors in searches by health professionals, emphasizing the importance of instruction in search methods. McKibbon et al[12] evaluated a short course on MEDLINE and demonstrated that the clinicians' searches required more time but did not differ from two librarians' searches in the total number of references retrieved or the proportion of references judged to be relevant. Coverage of the medical behavioral sciences by MEDLINE has been compared with that of other databases.[13]

An important issue to clinicians is whether apparently well-executed MEDLINE searches miss relevant articles.

Haynes et al[1] compared 17 combinations of software and vendor access routes to MEDLINE using standardized searches designed and run by medical librarians. Although the searches differed in cost, efficiency, and ease of performance, each retrieved the single article judged to be most definitive for each of six clinical problems.

Incomplete or nonuniform indexing has been noted anecdotally,[14] and inconsistencies of indexing have been studied using twice-indexed articles.[15] Two studies concerning the retrieval of randomized clinical trials showed that a large percentage of relevant articles were missed.[16,17]

These experiences suggest that a single search using one or two MeSH terms may not be sufficient to retrieve all of the relevant citations, even when the purpose of the search is very specific. The study reported here tests this hypothesis.

METHODS

Two clinical questions were selected to evaluate MEDLINE searches: (1) What is the evidence that group A streptococcal infections are spread nosocomially? (2) How

TABLE 2. RESULTS OF MEDLINE SEARCHES FOR REFERENCES CONCERNING THE NOSOCOMIAL SPREAD OF GROUP A STREPTOCOCCAL INFECTIONS

Medical Subject Headings	Number of References (A)	Number of Relevant References (B)	Efficiency (B/A)	Comprehensiveness (B/38)
1. Streptococcus pyogenes	1,450	34	.02	.89
2. Streptococcus	7,723	0	0	0
3. Streptococcal infections	3,712	30	.008	.79
4. Cross-infection	3,663	33	.009	.87
5. Disease outbreaks	4,688	19	.004	.50
6. Pharyngitis	727	6	.008	.16
7. Streptococcus pyogenes and cross-infection	32	30	.94	.79
8. Streptococcus pyogenes and disease outbreaks	42	19	.45	.50
9. Streptococcal infections and cross-infection	99	26	.26	.68
10. Streptococcal infections and disease outbreaks	65	18	.28	.47

accurate are rapid antigen detection tests for group A streptococcal pharyngitis?

A separate bibliography was compiled for each question by collecting references from (1) the author's research files, (2) multiple MEDLINE searches, and (3) citations in the relevant articles. The two bibliographies served as the standards against which the results of various MEDLINE search strategies were compared.

The following inclusion criteria were used: (1) The reference is published in the English language in a journal indexed for MEDLINE. (2) For the question on nosocomial infections, only references published from January 1, 1977, to December 31, 1986, were included. For the question on antigen detection tests, the inclusion dates were from January 1, 1986, to December 31, 1986. The final date, December 31, 1986, was chosen so that no relevant citations would be added to MEDLINE during the course of the study in mid-1987. The starting dates were selected to include a convenient number of references in each bibliography. (3) In the author's judgment the reference directly addresses the clinical question.

The search strategies described in the next section were planned using annotated medical subject headings.[8-10] Also, the MeSH terms for each relevant reference were retrieved from MEDLINE and used to plan additional searches. An IBM PC XT microcomputer was connected directly to the NLM MEDLARS computer via the GTE Telenet network using a 1,200-baud Hayes-compatible modem. The searches were conducted using Crosstalk XVI communication software and the NLM ELHILL language.[5,6]

RESULTS

The 38 references making up the bibliography on the nosocomial spread of group A streptococcal infections were compiled from the author's files, multiple MEDLINE searches, and citations in the relevant articles. This bibliography served as the standard against which the results of various MEDLINE searches were compared. The results of using ten search statements constructed from one or two MeSH terms are displayed in Table 2. All figures refer to English language references only. The efficiency of a retrieval is defined as the fraction of references judged to be relevant. The comprehensiveness is the fraction of the bibliography retrieved.

No single MeSH term was assigned to every reference in the bibliography (Table 2). The first search statement is the most comprehensive, finding 34 of the 38 references; however, the user must scan 1,450 titles. The search for streptococcus (search 2) retrieves none of the relevant references because the indexers use the most specific entry possible, ie, S pyogenes.

When two MeSH terms are combined, as in search statements 7 through 10 in Table 2, only articles indexed with both terms are retrieved, so the number of references is reduced. Unfortunately, the number of relevant references is also decreased. Search statement 7 results in a good compromise between efficiency and comprehensiveness. Additional search statements can be included using the Boolean "or" command[5]: The combined search statements 7 and 8 locate 33 of the 38 references, and adding search statements 9 and 10 retrieves 37 of the relevant references.

The unit records of the articles in the bibliography were used to study the effectiveness of subheadings in increasing search specificity. The most commonly used subheading is *isolation and purification* (as a qualifier of the MeSH term S pyogenes), which is used for only 15 of the 38 references. Using *occurrence* as a subheading of cross-infection retrieves only 11 of the relevant references. Thus,

TABLE 3. RESULTS OF MEDLINE SEARCHES FOR REFERENCES CONCERNING THE ACCURACY OF RAPID TESTS FOR STREPTOCOCCAL PHARYNGITIS

Medical Subject Headings	Number of References (A)	Number of Relevent References (B)	Efficiency (B/A)	Compre- hensiveness (B/37)
1. Streptococcus pyogenes	166	32	.19	.86
2. Pharyngitis	109	29	.27	.78
3. Latex-fixation tests	109	17	.16	.46
4. Agglutination tests	185	3	.04	.08
5. Reagent kits, diagnostic	284	15	.05	.41
6. Streptococcus pyogenes and pharyngitis	47	26	.55	.70
7. Streptococcus pyogenes and latex-fixation tests	18	17	.94	.46
8. Streptococcus pyogenes and agglutination tests	5	3	.60	.08
9. Streptococcus pyogenes and reagent kits, diagnostic	14	13	.93	.35

for comprehensiveness, multiple search statements are also required when subheadings are used.

One indexing error was identified: A report of an outbreak of group A streptococcal infections in a hospital is indexed using S agalactiae (group B) rather than S pyogenes.

The bibliography for rapid tests for group A streptococcal pharyngitis contains 37 references. In Table 3, as demonstrated before in Table 2, no MeSH term or pair of terms identifies every relevant reference. Combining appropriate MeSH terms increases the efficiency with fewer lost references than before. Nevertheless, multiple search statements are again required to find all 37 references because no MeSH term uniquely expresses the concept of a rapid test. In this case a text word search can be helpful. Using the words "rapid" and "test" combined with the MeSH term S pyogenes retrieves 23 references, all of which are relevant (efficiency = 1.0, comprehensiveness = 0.62).

The most commonly used subheading, *diagnosis* qualifying the term *pharyngitis*, locates 45 references, 24 of which are relevant. When combined with S pyogenes, 30 references are retrieved, including 21 that are relevant (comprehensiveness = 0.57).

DISCUSSION

Clinicians who perform self-service computer-assisted bibliographic searches have at their command a powerful and comprehensive resource. It is important to understand the indexing system and to recognize that using this resource involves tradeoffs between efficiency and comprehensiveness. Tables 2 and 3 demonstrate these tradeoffs and show that a single search using one or two apparently appropriate MeSH terms usually identifies most, but not all, of the relevant references.

The concepts of nosocomial infections and of rapid tests for streptococcal pharyngitis do not correspond uniquely to particular MeSH terms or subheadings, so the indexer's judgment determines how each reference can be found. In general, search topics can be broader or narrower than the best available MeSH terms. During a search it is usually not known which of the multiple combinations of reasonable MeSH terms is best or whether important references are being missed. Consequently, when a comprehensive search is needed, multiple searches using MeSH terms and text words are advisable.

The comprehensiveness of a search is important, even when a physician only wants one or two articles for a brief answer to a question. If the scope of a search is too limited, it may fail to retrieve any helpful references, or it may prevent the searcher from selecting the most relevant article.

Computer-assisted bibliographic searches require skill, and few physicians can take the time to become expert. A survey shows that most end users learn search techniques by trial and error and by observing others.[18] Under these circumstances it is possible to miss important articles by not realizing either the importance or the limitations of MeSH terms.

RECOMMENDATIONS

When more than a random selection of relevant articles is required, the following steps are recommended:

1. Obtain instruction in MEDLINE search methods or consult a medical librarian. The National Library of Medicine offers a basic guide to searching[5] and sponsors local courses for physicians. Information on NLM courses is available from the MEDLARS Management Section, National Library of Medicine, 8600 Rockville Pike, Be-

thesda, MD 20894. Many medical libraries also offer courses.

2. When planning a literature search, use the annotated references on Medical Subject Headings[8-10] (available from the US Department of Commerce, National Technical Information Service, Springfield, VA 22161). Bibliographic retrieval systems vary in the amount of online advice that is offered. For example, the PaperChase system encourages the user at each step to choose MeSH terms.[19] The *Grateful Med* software distributed by the NLM includes an alphabetized MeSH listing for on-screen reference.[20] Both systems suggest additional terms based on references accepted by the searcher.

3. Understand the advantages and limitations of text word searches. They can be helpful when a subject, eg, a new concept, is not uniquely represented in the MeSH vocabulary. Text word searches, however, can lead to errors resulting from unanticipated spelling variations, synonyms, and multiple meanings.

4. Use a variety of combinations of MeSH terms, and retrieve from MEDLINE the MeSH terms of relevant articles to identify which terms the indexers use to describe the subject.

References

1. Haynes RB, McKibbon KA, Walker CJ, et al: Computer searching of the medical literature. Ann Intern Med 1985; 103:812–816
2. Haynes RB, McKibbon KA, Fitzgerald D, et al: How to keep up with the medical literature: V. Access by personal computer to the medical literature. Ann Intern Med 1986; 105:810–824
3. Wood MS, Horak EB, Snow B (eds): End User Searching in the Health Sciences. New York, Haworth Press, 1986
4. Collen MF, Flagle CD: Full-text medical literature retrieval by computer. JAMA 1985; 254:2768–2774
5. National Library of Medicine: The Basics of Searching MEDLINE: A Guide for the Health Professional. Springfield, Va, National Technical Information Service, 1985
6. Feingloss SJ: MEDLINE: A Basic Guide to Searching. Chicago, Medical Library Association, 1985
7. Wygant AC: Teaching end user searching in a health sciences center. In Wood MS, Horak EB, Snow B (eds): End User Searching in the Health Sciences. New York, Haworth Press, 1986, pp 127–135
8. National Library of Medicine: Permuted Medical Subject Headings. Springfield, Va, National Technical Information Service, 1987
9. National Library of Medicine: Medical Subject Headings—Annotated Alphabetic List. Springfield, Va, National Technical Information Service, 1987
10. National Library of Medicine: Medical Subject Headings—Tree Structures. Springfield, Va, National Technical Information Service, 1987
11. Sewell W: Overview of end user searching in the health sciences: An opinion paper. In Wood MS, Horak EB, Snow B (eds): End User Searching in the Health Sciences. New York, Haworth Press, 1986, pp 3–14
12. McKibbon KA, Haynes RB, Baker LM, et al: Teaching clinicians to search MEDLINE: Description and evaluation of a short course. In Proceedings of the Twenty-Fifth Annual Conference on Research in Medical Education. Washington, DC, Association of American Medical Colleges, 1986, pp 231–236
13. Griffith BC, White HD, Drott MC, Saye JD: Tests of methods for evaluating bibliographic databases: An analysis of the National Library of Medicine's handling of literatures in the medical behavioral sciences. J Am Soc Inf Sci 1986; 37:261–270
14. Tzamaloukas AH: The Achilles heel of computer-initiated bibliographic search, letter. West J Med 1987; 146:620–621
15. Funk ME, Reid C: Indexing consistency in MEDLINE. Bull Med Libr Assoc 1983; 71:176–183
16. Dickersin K, Hewitt P, Mutch L, et al: Perusing the literature: Comparison of MEDLINE searching with a perinatal trials database. Controlled Clin Trials 1985; 6:306–317
17. Poynard T, Conn HO: The retrieval of randomized clinical trials in liver disease from the medical literature. Controlled Clin Trials 1985; 6:271–279
18. Teitelbaum S, Sewel W: Survey of attitudes of pathologists and pharmacists toward nonmediated online searching. Proc Ann Meeting Am Soc Inf Sci 1982; 19:298–300
19. Horowitz GL, Jackson JD, Bleich HL: PaperChase—Self-service bibliographic retrieval. JAMA 1983; 250:2494–2499
20. Wyngaorden JB: New MEDLINE service lets your personal computer do the searching. JAMA 1986; 256:18