Review ■

MEDLINE: The Options for Health Professionals

ELIZABETH H. WOOD, MA, MSLS

Abstract The bibliographic database MEDLINE, produced by the National Library of Medicine (NLM), is a computerized index to the world's biomedical literature. The database can be searched back to 1966 and contains 6.8 million records. The various means of access are divided, for the purposes of this article, into three categories: logging onto a remote host computer by telephone and modem or by the Internet; subscribing to part or all of the database on compact disc (CD-ROM); and leasing the data on a transport medium such as magnetic tape or CDs for loading on a local host computer. Decisions about which method is preferable in a given situation depend on cost, availability of hardware and software, local expertise, and the size of the intended user population. Trends include increased access to the Internet by health professionals, increased network speed, links from MEDLINE records to full-text databases or online journals, and integration of MEDLINE into wider health information systems.

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MEDLINE, the leading online index to the world's biomedical information, is a fundamental resource for anyone involved in the health sciences. Ten years ago, The GPEP Report recommended the inclusion of information management and lifelong learning skills in all medical curricula.⁷ There is increasing evidence that searching the literature has a direct, beneficial influence on patient care.^{36,41,53,67,72} The medical literature contains much discussion by clinicians of the benefits of being able to search while in the clinic, home, or office, and discussion comes from many subject disciplines, many health care settings, and many countries beyond the United States.^{8,9,19,33,34,48,61,62,64,73,74,76}

It is possible for any individual health professional to gain access to MEDLINE through a personal computer and modem or over the Internet, but there are advantages for institutions in providing access on a wider scale. Institutions are in the best position to provide access to MEDLINE where it is needed most—at the point that care is to be provided or that a decision is to be made. Ready access to MEDLINE is becoming an expectation of new graduates of health

science schools and is likely to become a standard of care. This article attempts to describe the various options for making MEDLINE available to health professionals, according to staffing, the physical environment, the budget, and computer expertise.

Background

What Is MEDLINE?

The National Library of Medicine (NLM) and its predecessor, the Surgeon-General's Office of the U.S. Army, have been indexing the world's medical literature since 1879, when the predecessor to today's *Index Medicus* was first produced. MEDLINE, the computerized version of the index, has been produced by the NLM since 1966 and now contains 6.8 million records.¹⁻³ Each MEDLINE record provides author, title, source, and other information for locating an article, and gives the assigned subject headings that indicate an article's content and coverage. About 70% of the records include abstracts.* In 1993, over 3,700 journals from 75 countries were being indexed. They are published in many languages; 80% are in English.

The database was and is used to produce printed products such as *Index Medicus* and the companion

Affiliation of the author: Norris Medical Library, University of Southern California, Los Angeles, CA.

Correspondence and reprints: Elizabeth H. Wood, MA, MSLS, Norris Medical Library, University of Southern California, 2003 Zonal Avenue, Los Angeles, CA 90033. e-mail: ewood@hsc.usc.edu

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*Further factual information is contained in many NLM "Fact Sheets" and may be obtained by contacting the NLM at the address listed at the end of this article. These documents can also be obtained by anonymous FTP to nlmpubs.nlm.nih.gov

dental and nursing indexes. Its usage saw exponential growth as access methods progressed from batch file searching to the ELHILL online service, launched in 1971.⁴⁻⁶ The initial online service involved using a modem to call into a computer at the NLM to enter search criteria and to browse selected citations. With the advent of personal computers and sophisticated communication software, it became possible to download a retrieval to a file for later printing or for transfer to a database management system.

The past decade has been one of constant innovation in the ways that the MEDLINE database can be accessed and distributed. A gateway program, Grateful Med, has been developed to make it possible for health care workers to search MEDLINE using the computer at the NLM. It allows the health care worker to construct the search using user-friendly menus on a personal computer. Grateful Med then connects to the remote computer, enters the search criteria, and brings back the results so that they can be browsed at leisure. At the same time, the database has been leased to vendors who have built proprietary user and search interfaces. These vendors have then made the database available via remote access or via subscription to a CD-ROM package. Several institutions have mounted the MEDLINE database within their libraries or clinical systems.

MEDLINE data are also being included in other information resources. *The Online Journal of Current Clinical Trials*, an electronic publishing venture of the American Association for the Advancement of Science and the Online Computer Library Center (OCLC), includes MEDLINE data for relevant references in the bibliographies of its articles. Entrez, a CD-ROM product from the NLM, provides access to DNA and protein sequence databases and also includes MEDLINE references relevant to those molecular sequences.

MEDLINE is part of the MEDLARS (Medical Literature Analysis and Retrieval System) family of databases. MEDLARS consists of over 40 databases such as Health Planning and Administration, AIDSLINE, CancerLit, TOXLINE, and PDQ (a full-text source for cancer information and protocols). The NLM's newest offerings include HSTAR (Health Services Technology Assessment and Research), a bibliographic database of health services research literature, and HSTAT (Health Services and Technology Assessment Text), a full-text database that includes Clinical Practice Guidelines and National Institutes of Health (NIH) Consensus Development Conference reports. HSTAT is available via "traditional" character-based searching and via the graphic interfaces of Gopher and Mosaic for computers with access to the Internet.

Medical Subject Headings

A major aspect of MEDLINE is its thesaurus, MeSH (Medical Subject Headings). A thesaurus brings control to indexing: specialist indexers assign MeSH headings to each article, depending on its content, regardless of the words the authors may have used. MeSH is a hierarchical thesaurus with subject headings arranged indented under one another in "trees." By "exploding" parts of a tree, a searcher can retrieve specific headings as well as general ones. For example, HEART DISEASES will retrieve only articles about these diseases in general, while exploding HEART DISEASES will also find articles about all of the specific types of heart disease, such as AR-RHYTHMIA, MYOCARDIAL INFARCTION, and ANGINA PECTORIS.

The MeSH thesaurus, like the MEDLINE database itself, is a standard developed by the NLM. The user interface and the search engine, on the other hand, are proprietary products that vary from one vendor to another.⁷⁸

Providing Access to MEDLINE

There are three basic options to consider for providing access to MEDLINE searching. The options are described in detail after the following brief outline and listing of some important considerations for decision making. In the order in which they are listed, the three options can be seen as progressions: from individual to institutional use, from lesser to greater expense, and from requirements for minimal to considerable computer expertise, including the assistance of programmers.

1. Logging onto a remote host computer by telephone and modem or by the Internet,[†] where the database is loaded and updated by the vendor. The vendor provides an interface at the remote site and sends the requested data over the telephone line or the Internet to the local monitor, printer, or storage device. Searchers have little control over the interface, but little training is required to set up the system. Charges may be on an individual basis by usage or on a flat-fee basis for individuals or institutions.
2. Subscription to a CD-ROM product. Subscribers lease parts of the database on CDs that are accessed via a CD player that is attached to a personal computer or via a network file server. Software for the interface (sometimes located on the CD) is provided by the CD-ROM producer and loaded locally. The

[†]The Internet connection may also involve a telephone line if the user is calling into an Internet node from a remote site.

updated CDs from the vendor maintain the database. Retrieval and printing are handled locally. Searchers incur no online costs and installation usually requires minimal computer skills.

3. Leasing of the data on magnetic tape or CDs for local mounting on a host computer such as a mainframe.† Updating and maintenance are performed locally. The retrieval engine that provides the interface may be obtained from a vendor or may be developed locally. As with CD-ROM, there are no connect charges once the data have been leased, but maintenance and overhead charges can range up to thousands of dollars per month for the institution. Considerable computer expertise is required for installation and operation.

Important Considerations

Within these options there are variations dependent on:

1. Budget
2. Hardware and space for workstations
3. In-house or readily available expertise
4. Number of potential users at a given site
5. Types of users (e.g., physicians, nurses, or researchers)
6. The amount of searching anticipated
7. Educational and clinical objectives

Database coverage and currency. All of the options discussed here provide the same basic bibliographic information: author, title, source, abstract, etc. Variables that must be considered include: the number of years searched simultaneously, the frequency of updating, limitations on the number of journals included, and the ability to restrict searching to in-house journal subscriptions.

MEDLINE is updated weekly by the NLM except in November and December, when it is updated monthly. The frequencies with which other suppliers update the database vary and should be considered if currency is important. Most vendors divide the database into four or more files of several years each. This has the advantages of faster searching (because the files are smaller) and retrieval of fewer records for the

busy clinician to browse. Most users probably want to search only a limited range of years.

The search interface. The strategies used for retrieval vary among interfaces.^{28,68} Searchers may be presented with a command line or a series of menus. They may be prompted during the search session to use MeSH more effectively, to add subheadings, or to restrict the search to articles in the English language or about only human subjects. This assistance may be offered before, during, or after incurring any online connect charge. The NLM is experimenting with a system called COACH that is designed to improve search strategy.⁷¹

Ease of use may result in a sacrifice of sophistication in strategy construction. Users' needs are critical in this decision: the clinician or student may be content with finding a few good articles about a topic, but the researcher preparing a grant proposal needs to know that the search has been exhaustive and that no published study has been overlooked. *Needs and expectations* may not be the same. Analyses of end users' searching techniques reveal that although the end users may often fail to retrieve good articles, what they do find satisfies them.^{12,16-18,20,21,28-31,38,44,57,58,75} A good system should accommodate both the casual browser who wants a few good articles and the comprehensive searcher who needs everything about a topic.

Option I: Logging onto a Remote Host Computer

Individual access to an online vendor system (originally by direct telephone line but increasingly over the Internet) is the oldest of the end-user search systems. It is usually paid for by usage, with connect-hour charges, royalties, and printing costs. Flat-fee arrangements can also be made if a large volume of searching is anticipated. Individual passwords require the least investment in hardware and software, and can be easy to use and inexpensive. The health professional may acquire a personal password and take care of his or her own billing. If an institution provides workstations and passwords, however, it may have little control over the charges that users are incurring, though this problem can be solved with the flat-fee arrangements mentioned above. For the larger organization that wants to accommodate multiple simultaneous users of the databases and wants to tie searching to a network of other information systems, individual passwords are probably not practical. For the private searcher or the small institution, however, passwords may be ideal. Beyond the expense of a personal computer, direct access to a vendor system can cost as little as a few dollars for each online search.

†In this case the CDs are being used as a transportation medium. For clarity, in this article the expression "CD-ROM" is used only for discs that are searched directly.

The physical requirements are a personal computer, a telephone line, and a modem (or either a direct Internet connection or a remote Internet connection by telephone); telecommunications software; and a printer. Searching can also be provided through a local area network, with a modem pool attached to a file server and with the communication software presented on a menu. This arrangement naturally involves more expense and expertise than does using stand-alone workstations.

Typically, a user signs an agreement with the database vendor and is given a "username" and password. The user is billed according to time spent online and may pay royalties in the form of a fee for each piece of information retrieved and/or printed.

Vendors. The major online vendors for MEDLINE include BRS Information Technologies, Dialog Information Services, PaperChase, and the NLM itself. BRS and Dialog are major database vendors, offering hundreds of databases in addition to MEDLINE. PaperChase is unique in that a physician designed it for his own use and for that of his colleagues.^{10,16,22,25,37} Full information for contacting the various vendors and suppliers mentioned in this article is listed in the appendix. Some vendors also offer full-text databases for searching, which usually contain limited numbers of titles. This option may appeal to searchers who desire ready access to a few major journals rather than comprehensive surveys of the literature.

Although MEDLINE searches have been available through librarians since the beginning of the database, the advent of the personal computer has enabled increasing numbers of health professionals to do their own searching. Vendors have responded by creating easy-to-use programs and advertising them directly to end users. The NLM has been appealing directly to health professionals ever since the introduction of Grateful Med in 1985. Grateful Med has the additional feature of LOANSOME DOC, which allows the searcher to request copies of complete articles. The desired articles are highlighted while online and the request is sent electronically to a library with which the searcher has made a prior financial arrangement. The provision for delivery of complete articles is known to libraries as "document delivery."

Costs and special features. The NLM's connect-time charges are modest and there is no additional royalty fee. The NLM has already made flat-fee arrangements with professional organizations such as the American College of Physicians and the American College of Cardiology, so that individual members

can perform unlimited searching for a fixed sum per annum (currently \$200). PaperChase is also offering flat-fee arrangements to individual members of the American Medical Association (currently \$180 per annum) and a free service to student members during off-peak hours.

Searching through vendors such as BRS, Dialog, and PaperChase is more expensive because of higher connect charges and royalties, but there are also advantages. Like the NLM, the vendors appeal to individuals with easy-to-use systems, cheaper off-peak searching times, and their own forms of document delivery. PaperChase offers the whole MEDLINE file back to 1966 in one database and has an interactive interface that encourages searchers to learn more about MeSH and Boolean techniques. BRS and Dialog offer hundreds of other databases besides MEDLINE, some of which contain the full text of journals, monographs, and textbooks. If searchers are unsure whether MEDLINE is the best database for their immediate needs, BRS and Dialog allow a form of preliminary searching across many databases, usually at lower cost, that will indicate the best information source for a given topic. Finally, institutions may already have agreements with the vendors to search other databases, perhaps at lower cost depending on the volume of searching.

The various vendors all offer training programs nationwide, and the National Network of Libraries of Medicine (NN/LM) offers regular sessions (contact the NLM for details). The NN/LM has a commitment to reach health professionals who do not have easy access to training and will arrange for specially trained librarians to organize instructional sessions.

Companies or institutions with Internet access may save telephone charges and increase searching speed by using a telnet connection to any of the vendors. Telnet addresses are listed in the appendix.

Option II: CD-ROM

Nearly a dozen vendors offer MEDLINE on CD-ROM (Compact Disc-Read Only Memory).§ All require that the user have a personal computer and a player for the CD, or that the CD be loaded on a CD-ROM server attached to a network. Users subscribe to the service, and updated CDs arrive once or twice a month, depending on the vendor. Once the subscription has been paid, there is no further charge.

Loading CD-ROM software and setting up the system may require more computer expertise than deal-

§This article follows the convention of using "disk" for floppy disks and "disc" for optical storage media.

ing with a telephone connection or an Internet connection. Given the considerably greater cost of a CD-ROM subscription, potential subscribers probably will be institutions or groups and may therefore have easier access to computer expertise. With CD-ROM, users can enjoy the more relaxed pace of searching without incurring connect charges. Searchers can take time to experiment with different strategies and to refine their retrieval more precisely. Libraries that provide MEDLINE on CD-ROM usually offer training sessions. Librarians have published their experiences, and these articles may be valuable to those considering CD-ROM.^{1,13-15,23,24,32,35,39,49,52,66,69,77}

Subscribers lease rather than own the data on CD-ROM. Over the course of a year, the user returns outdated CDs as updated ones arrive. When the searching software is upgraded, the producer may send an entirely new set of CDs and the subscriber returns the old set.

CD-ROM networking. With the right hardware, a CD can be searched by more than one user at a time by loading it on a kind of jukebox or "tower" that obviates the need for handling the CD. A local area network can be used to provide multiple users with simultaneous access. The search software may be loaded behind a menu "shell" to permit the tying of the CD-ROM system to a larger institutional network. Security becomes an issue when the subscription agreement limits usage to an institution's staff or to faculty and students. In a public situation, control may be accomplished by requiring identification to check out a CD or keys to turn on the hardware. The cost of the subscription usually varies according to the possible number of simultaneous users, though producers vary in their interpretations of a site's actual usage.

An important consideration for CD-ROM networking is the speed of the system. Use of the system by many users simultaneously may cause significant slowing and may frustrate the users at peak times. Two techniques that alleviate speed problems are "caching" and "mirroring." These involve network file servers with large memories, using multiple copies of the CD. Other factors that affect speed are the type of search engine (the software that retrieves the data) and the capabilities of the network on which it is loaded. At this time, CD-ROM technology continues to improve, with faster retrieval and enhanced searching capabilities.

The PlusNet system from CD-Plus demonstrates another way of supporting a larger number of simultaneous users. It involves copying the database from the CD-ROM to a magnetic disk on a network-at-

tached file server. This approach is a middle ground between a pure CD-ROM solution and mounting the database on a local host computer. The vendor provides both a mechanism for loading the database and a user interface, but on-site expertise is required to manage the file server.

Costs. Vendors' offerings vary widely, from a limited list of journals for only recent years to the entire database. A one-year individual subscription to MEDLINE on CD-ROM costs several hundred dollars; subscription prices vary for multiple simultaneous users and may be negotiable. Complete back files (to 1966) are available for a one-time price of several thousand dollars. An individual CD player costs several hundred dollars, while a tower costs around \$15,000.

Option III: Locally Mounted Database on a Host Computer

For institutions that expect to have large numbers of end users searching regularly, leasing MEDLINE data on magnetic tape for mounting on a local host computer may be a desirable option. This option requires a large amount of money and a large investment in equipment. It also requires a team approach between a computing center and the coordinators of the end-user searching program. There are currently over 60 locally mounted MEDLINE sites nationwide, mostly in academic institutions that have computer programmers and librarians to load, maintain, and customize the data and software and to teach end users how to use the system. The database can be transported on nine-track tape or CD-ROM (as mentioned above, this is a different, more recent use of CD-ROM). The drives on which it is loaded will need gigabytes of storage. Typical machines that can be used include: mainframes, minicomputers, and Unix workstations.

Besides allowing for high-speed searching by many users at numerous remote sites simultaneously, this option provides the greatest flexibility. The MEDLINE data can be limited by year or by a list of journals. Fields for display and printing can be controlled. There is a wide choice of search engines, or software for the interface; this software can in turn be manipulated by programmers to provide other options. Programmers may also devise their own original search engines. Interface options include: menu design, online documentation and help screens, searching techniques such as exploding MeSH and limiting by language or date, provision of printing or downloading, the ability to save strategies for later use, and the addition of local journal-holdings information.

With a network, it is possible to provide dedicated terminals or publicly accessible workstations as well as dial-in options for users at remote sites. MEDLINE can thus be shared by thousands of users in libraries, clinics, offices, and homes.

The cost of the data and the software alone for this option can easily be ten times that of a single CD-ROM. In addition, the cost includes many variables such as the lease of a mainframe operating system (if such is being used), software maintenance contracts, programming personnel, and overhead charges. Creating a local database-retrieval system and loading MEDLINE from raw files on magnetic tape require sophisticated computer expertise.

With this option, management, personnel, and other human issues are of major importance. The various units of an institution may have differing needs and different ideas about how to meet these needs. The computing staff who load and maintain the database should be cognizant of the realities of the clinic where the health professionals are looking for patient information. If computer departments are involved in working with other units (such as clinics or libraries), they may require payment from these other units for their time and assistance. A team approach may be needed, with direction from the institution's administration, to resolve any difficulties with personal or financial agreements.

When MEDLINE is locally mounted on a host computer, it is commonly part of larger information systems that may include other bibliographic databases, library catalogs, and patient information. The NLM has sponsored a number of projects under the Integrated Advanced Information Management Systems (IAIMS) program. These projects have been described and discussed at length.^{26,27,40,42,43,46,47,50,51,54,55,60,65,70} The projects aim to integrate the disparate computerized resources of medical centers so that a unified system is presented to users. This unified system has been described by one developer as "one-stop information shopping"⁶³ by which any individual workstation has access to a host of informational and clinical databases, to computer-assisted instruction, and to a campus/institutional network. An additional component in many cases is the Unified Medical Language System (UMLS), a "metathesaurus" developed by the NLM that combines the languages of MeSH with other classification systems and thesauri. The UMLS project is a long-term endeavor to facilitate the integration of information from multiple electronic biomedical information sources. This "common-language" system is being used to link information sources.⁵⁶

The Future

The development of faster networks and the emergence of standards for bibliographic records will lead to new ways of providing access to the MEDLINE database. The former will mean that a remote database can be accessed as rapidly as a local one. It will no longer be necessary to compromise currency of the database for speed of access. The latter will lead to separation of the user interface from the search engine and database. It will no longer be necessary to locally mount the database to integrate it into a local information system.

Will all health professionals accept the idea that they can and should have access to MEDLINE? An informal LISTSERV survey by this author showed that while librarians have eagerly begun searching on the Internet, health professionals have been slower to grasp the importance of being able to search for themselves in this way, and librarians are devising ways to introduce them to it. This discussion of the options should demonstrate that anyone can afford MEDLINE and learn to search it effectively. Institutions should explore the possibilities of making MEDLINE available in the clinic or office and at the bedside or nurses' station, as well as in the medical library.

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APPENDIX

*Vendors and Sources for MEDLINE**

Individual passwords

MEDLARS Management Section
National Library of Medicine
Bldg. 38A., Rm. 4N421
8600 Rockville Pike
Bethesda, MD 20894
(800) 638-8480
Internet*: medlars.nlm.nih.gov

CDP Online
CD Plus Technologies
333 7th Avenue
4th Floor
New York, NY 10001
(800) 950-2035
(212) 563-3006
Internet*: brs.com

Dialog Information Services, Inc.
3460 Hillview Avenue
Palo Alto, CA 94304
(800)-3-DIALOG
(415) 858-3785
Internet*: dialog.com

*Internet addresses are for searchers who already have accounts with these vendors.

PaperChase
350 Longwood Avenue
Boston, MA 02115
(800) 722-2075
(617) 278-3900
Internet*: pch@bih.harvard.edu

CD-ROM

Aries Systems Corporation
200 Sutton Street
North Andover, MA 01845
(508) 975-7570

CD-Plus, Inc.
333 Seventh Avenue, 6th Floor
New York, NY 10001
(212) 563-3006

Dialog Information Services, Inc.
3460 Hillview Avenue
Palo Alto, CA 94304
(800)-3-DIALOG
(415) 858-3785

DNASTAR, Inc.
1228 S. Park Street
Madison, WI 53715
(608) 258-7420

EBSCO Electronic Information
P.O. Box 325
447 Old Boston Road, Suite 10
Topsfield, MA 01983

Health Care Information, Inc.
2335 American River Drive, Suite 307
Sacramento, CA 95825
(800) 468-1128
(916) 648-8075

MacMillan New Media
124 Mount Auburn Street
Cambridge, MA 02138
(617) 661-2955 Ext 20
(800) 342-1338

SilverPlatter Information
100 River Ridge Drive
Norwood, MA 02062-0064
(617) 769-2599
(800) 343-0064

Teton Data Systems
235 East Broadway
P.O. Box 3082
Jackson, WY 83001
(307) 733-9528
(800) 755-7828