How to Search for and Evaluate Medical Evidence

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Successfully practicing evidence-based medicine (EBM) requires becoming adept at retrieving and evaluating medical evidence. The EBM method involves 4 basic steps: framing a clinical question, performing a literature search, evaluating the search results, and applying the results to the individual patient. This article provides an overview of the first 3 steps of this process and offers recommendations for performing them efficiently.

Framing a Clinical Question

The first critical step in practicing EBM, referred to as *framing a clinical question*, requires deciding what information is needed to make a clinical decision. Busy clinicians often have little time to search for evidence, but taking the time to compose a well-built clinical question can lead the searcher to resources more likely to yield manageable and appropriate evidence and can aid in interpreting and evaluating the evidence retrieved. Clinical questions can be classified as *broad* or *specific*.

Broad clinical questions arise when the searcher requires general information about a single clinical topic (eg, a single disease, treatment, or test). Broad questions have only 1 part, or *component* (eg, "Tell me about ventricular ectopy," "Tell me about flecainide," or "Tell me about Holter monitors").

Specific clinical questions are more complex (eg, "In patients with premature ventricular complexes [PVCs], how much does flecainide, compared with placebo, reduce mortality?"). Specific questions should contain 4 components. The first component identifies the disease or patient population ("patients with PVCs"). The second component identifies the treatment, test, etiology, or prognostic factor ("flecainide"). The third component identifies the comparison or standard against which the second component will be evaluated ("placebo"). The fourth component identifies the outcome associated with the test, treatment, etiology, or prognostic factor in the disease or patient population in question ("reduced mortality").

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Importance of a Well-Built Question

The importance of carefully framing a clinical question cannot be overstated. The nature of the question directs the search for evidence, and the components of the question become the search terms for the resources. Often only the first 2 components of a specific question are used to determine initial search terms.

Choosing the best resources. To answer a broad clinical question, the clinician should seek traditional review articles from peer-reviewed journals, well-referenced chapters from current textbooks, and practice guidelines. These resources all provide easy-to-read, broad discussions. It should be noted that traditional reviews differ from systematic reviews (Table 1). Traditional reviews often are short opinions about a single clinical topic and may contain references to supporting evidence. Although systematic reviews and original research studies may provide more accurate evidence, these sources are not practical for broad questions.

To answer a specific question, systematic reviews, meta-analyses, and original research are the best resources. The clinician should first find the most recent, well-conducted systematic review or meta-analysis available. In a systematic review, authors address a specific clinical question by performing an objective and exhaustive literature search. Studies are then interpreted in a systematic and objective manner [1]. Systematic reviews in which results are pooled mathematically into a single result are called *meta-analyses*. Compared with traditional review articles, systematic reviews are more likely to be accurate and up-to-date [2,3] and to provide information on the methods used to locate and appraise the evidence retrieved [4]. Consequently, systematic reviews may more easily and efficiently yield more accurate answers compared with reading numerous individual randomized trials. However, because of the rapid rate at which clinical information may change, the clinician should also search for recent original research studies (published since the systematic review) that may alter or challenge the results of earlier systematic reviews or meta-analyses. Comparing the results of the newer studies with those included in the reviews may provide useful clinical information.

Appraising the evidence. The well-built question also directs the appraisal of the validity of medical evidence.

Unlike when searching for evidence, all 4 components of a question are critical when selecting articles and appraising the evidence. For example, performing a search to answer the question "In patients with PVCs, how much does flecainide, compared with placebo, reduce mortality?" will lead to the Cardiac Arrhythmia Suppression Trial [5]. This randomized controlled trial (RCT) shows that among patients with PVCs following myocardial infarction, flecainide, as compared with placebo, increases mortality. However, if mortality is not specified as the outcome, the search also leads to the Cardiac Arrhythmia Pilot Study [6], from which the searcher may conclude that flecainide is effective because it reduces ventricular ectopy.

Performing a Literature Search

After a well-built clinical question has been framed, the next step is performing a literature search. The clinician must decide where and how to search the literature. The type of information sought and species of literature searched vary according to the type of question asked and the range of sources available to the searcher. Without access to the Internet, searchers must rely on print materials or CD-ROMs, whereas searchers who have Internet access can seek information from a wide array of resources, search engines, and full-text databases. (*See Appendix on page 28 for a list of EBM resources.*)

Searching without Internet Access

Clinicians who do not have access to computers should begin their searches for answers to broad questions with peer-reviewed research journals and high-quality textbooks that address problems seen in their practice. If computers are available, CD-ROMs provide electronic versions of many textbooks. Although the printed page may be easier to read than a computer monitor, it is much easier to search through an electronic textbook than through the index of a printed one. Electronic textbooks, such as *Scientific American Medicine* and *UpToDate*, are especially well-referenced; some even allow the reader to link to MEDLINE abstracts directly from reference lists. In addition, CD-ROM libraries, such as *Stat!-Ref* and *MAXX*, allow users to search multiple textbooks simultaneously.

CD-ROMs can also provide limited access to useful databases such as MEDLINE. For example, *Best Evidence* contains over 1100 abstracts of articles. Every 2 months, the editors of the *ACP Journal Club* and its sister publication, *Evidence-Based Medicine*, summarize the most recently published research that meets objective markers of high quality. For example, regarding studies of medical treatments, *Best Evidence* only reviews RCTs. Standardized abstracts and commentaries of these articles are added to an ever-growing database that is also available through the Internet. When Internet access is not available, *Best Evidence* along with an electronic textbook make a useful pair. A textbook answers broad questions, and *Best Evidence* addresses specific questions and contains more recent research.

Searching with Internet Access

Searching for evidence using the Internet is an ideal way to efficiently retrieve high-quality medical information. To find answers for broad questions, many textbooks are now available online, such as *Scientific American Medicine*, *UpToDate*, the *Merck Manual*, and the *AIDS Knowledge Base*. The *Merck Manual* and *AIDS Knowledge Base* are unique in that Internet access to these resources is free. Although accessing textbooks over the Internet is slower than accessing from a CD-ROM, Internet textbooks do not require the user to install software or updates. In addition, searching with the Internet allows clinicians access to a wide range of resources. For example, MDConsult is a unique online library of over 35 textbooks, 48 journals, and more than 600 practice guidelines that can be searched simultaneously with MEDLINE.

Broad questions can also be answered by searching for traditional review articles, whose full texts may be available online. For this type of search, OVID, which is available by subscription, provides excellent access to MEDLINE. On OVID, users can frequently find full texts of review articles on topics too uncommon to be included in textbooks. In addition, the footnotes in review articles on OVID are hyperlinked to MEDLINE abstracts and full texts when available. Lastly, practice guidelines provide discussions for broad questions. The National Guidelines Clearinghouse (NGC), an Internet resource of the United States Agency for Health Care Policy and Research, provides an ever-growing collection of practice guidelines submitted by various medical societies and organizations.

Answering specific questions demands up-to-date answers, so the Internet search strategy will be different. Traditionally, educators have simply instructed learners who have questions to go to MEDLINE and "look it up." However, MEDLINE searching is no longer adequate. The author recommends "meta-searching" as an alternative strategy (*see discussion on page 10*).

Studies have shown that physicians' knowledge of medical innovations decreases after graduation from medical school [7], and the Internet provides an excellent remedy for keeping current with the medical literature. Online journal clubs such as Journal Watch and

Table 1. Characteristics of Traditional and Systematic Review Articles

Characteristic	Traditional Reviews	Systematic Reviews
Scope	Broad discussion of single medical topic	Focused discussion of specific clinical question
Methodology	Not specified	Structured, thorough literature search Explicit criteria for article selection Systematic and objective assessment of articles In meta-analyses, mathematical pooling of results
Use of references	Variable Less likely in textbook chapters	Extensive
Strengths	Easy to read Address multiple facets of clinical problem	More up-to-date Less subject to author bias

the *ACP Journal Club* vary in methodology and purpose, may require subscriptions, and sometimes offer continuing medical education credit.

Challenges to Effective Searching

Searching the medical literature can be both difficult and time consuming, for experts as well as for novices. The average clinician needs 30 minutes to perform a MEDLINE search [8] and will find half as many articles germane to a particular clinical question as will a medical librarian [9]. Even when medical librarians perform the search, only 50% of clinical questions submitted by clinicians can be answered [10,11]. Consequently, over 90% of physicians in practice do not search MEDLINE, and most questions that arise during patient care are left unanswered [12].

Much of the difficulty associated with searching is the result of an inconsistent use of synonymous text words by authors. As a solution, the National Library of Medicine (NLM) assigns medical subject heading (MeSH) terms to every article on MEDLINE. For example, clinicians can search for articles assigned the MeSH term “facial nerve paralysis” instead of separately searching for articles containing synonymous text words, such as “Bell’s palsy” or “seventh nerve palsy.” Unfortunately, even MeSH terms are imperfect [13]. For example, only 60% of cohort studies are coded as cohort studies in MEDLINE [14].

Using MEDLINE filters (also called *hedges*) in addition to appropriate search terms may help alleviate this problem [15]. Specific clinical questions often require evidence regarding treatment or diagnosis, and less often regarding etiology or prognosis, and MEDLINE filters use validated combinations of search terms to identify appropriate studies. The treatment filter, for example, identifies RCTs, and the prognostic filter identifies cohort studies. Although filters are available for common commercial MEDLINE search software, (eg, OVID), they are most easily accessed through PubMed, an online search engine provided free of charge by the NLM. Although PubMed has built-in filters, some people may prefer to use a PubMed page provided by the University of Texas Health Science Center at San Antonio (*see Appendix on page 28*), which is available to anyone on the Internet. Compared with the filters at the NLM’s PubMed page, this page also has a filter to locate systematic reviews; in addition, it facilitates selection of MeSH terms with the MeSH browser and allows editing of difficult searches in PubMed’s advanced mode. However, even with filters, MEDLINE may be difficult to use.

The development of additional databases, such as the NGC, the Database of Abstracts of Reviews of Efficacy (DARE), and the Canadian Task Force on Preventive Health Care may also make searching more complex and unwieldy. Searching each available database would be impractical, and innovative meta-search engines allow users to access a wider range of information.

Meta-Searching

Using one of the available meta-search engines (*see Appendix*) allows clinicians who have Internet access to use a single query to simultaneously search MEDLINE and several other resources. For example, MDConsult is useful for answering broad clinical questions because of the range of sources it contains. For specific clinical questions, SmartSearch is useful because it uses sophisticated MEDLINE filters for simultaneously finding both recent systematic reviews and original research studies. SmartSearch automates searching of MeSH terms and text words and improves sensitivity of MeSH terms by “exploding” terms. Exploding a MeSH term allows the user to search for more specific MeSH terms that exist within a broader term. For example, searching for the term "arrhythmia" does not include searching for the more specific term "premature ventricular complexes" unless "arrhythmia" is exploded.

In addition, SmartSearch simultaneously searches the *Merck Manual*, DARE, and the NGC. Depending on the nature of the question SmartSearch receives, it may also search the *AIDS Knowledge Base* and the websites of the Canadian Task Force on Preventive Health Care, the Food and Drug Administration, and the American College of Physicians–American Society of Internal Medicine. SmartSearch adjusts truncation for each web address and automatically refines and repeats searches based on initial results until an optimal number of articles are retrieved.

Because meta-search programs are not perfect, manual MEDLINE searches may need to be performed to answer complicated clinical questions if a meta-search fails to produce appropriate results. However, future developments in "natural language query" technology and the NLM's "meta-thesaurus" may further refine meta-searching. A natural language query allows the searcher to enter the text of a clinical question without using formal logic (ie, as though talking to a colleague), and an improved meta-thesaurus would improve search results through more accurate searching of synonymous clinical terms.

Entering a Clinical Question into a Search Engine

Before clinicians begin searching for answers to clinical questions, they should learn the basics of Internet browsing and the guidelines for translating clinical queries into search terms.

Internet browser and operating system shortcuts. Internet browsers, such as Netscape and Microsoft Internet Explorer, are increasingly the vehicles that deliver medical information. Becoming familiar with the features of these browsers can make searching the literature easier and more efficient. For example, when browsing the Internet in a Microsoft Windows operating system, opening (ie, "clicking") links with the right-sided mouse button allows users to open a new document in a second window while the original document remains visible in the first window; information in the two windows can then be simultaneously compared. On an Apple computer, maintaining the "click" of the mouse button similarly allows a second window to be opened.

The "Find" function is another helpful feature of Internet browsers. For example, a searcher reading a long practice guideline about cardiac dysrhythmias for a recommendation concerning flecainide or encainide may need to tediously scroll through the guideline, reading or skimming each line. However, using the "Find" function under the "Edit" menu allows the user to search long documents or Internet pages for words or roots of words. Searching for "cainide" will thus instruct the computer to find all instances of "flecainide" and "encainide" and potentially reduce search time.

Translating clinical queries into search terms. Learning the fundamentals of translating a well-built clinical question into appropriate search terms will also result in more efficient searches. Table 2 provides an overview of these guidelines, as well as examples of search properties unique to OVID. There is a steep learning curve for becoming adept at searching for evidence, but fortunately the NLM has designed PubMed in a way that allows external programs and meta-search engines to automate some of these difficult steps. Users of SmartSearch only need to be able to use the guidelines in the upper half of Table 2 ("All Searches"), because SmartSearch automates the guidelines in the lower half of Table 2 ("Manual Searches"). Users who perform manual searches with programs such as OVID should be able to use all of the guidelines in Table 2.

Retrieving Search Results

After the search is performed, the next step is to review abstracts of relevant articles and decide whether full-text retrieval (ie, downloading or obtaining print copies of articles) is necessary. Many traditional reviews do not have abstracts and will require full-text retrieval. Systematic reviews and meta-analyses generally have abstracts. Abstracts of original studies and systematic reviews frequently report key results (eg, rates of treatment responses, sensitivities of diagnostic tests) and will often suffice. However, because information may occaisonally be omitted from or incorrectly reported in abstracts [16], full-text retrieval may also be necessary.

Retrieving the full text of articles remains one of the biggest challenges for the physician trying to implement EBM strategies. Meta-search engines are quite useful for locating abstracts, but many provide only limited access to full-text articles. For example, although MDConsult allows users to access the complete texts of many journals and textbooks, it does not provide access to the "big 5" journals (ie, *New England Journal of Medicine*, *British Medical Journal*, *JAMA*, *Annals of Internal Medicine*, *Lancet*). Likewise, although PubMed and SmartSearch contain links to the full text of articles from over 350 journals, only 2 of these are in the big 5.

An alternative strategy is to identify potentially useful abstracts through PubMed or a meta-search engine, and then to retrieve the complete text of articles using OVID, which contains links to over 100 journals,

Table 2. Guidelines for Translating Clinical Questions into Appropriate Search Terms

Guidelines	Rationale	Example
All Searches		
Select appropriate filter, and search only for human studies	Limits number of articles found	Validated PubMed or SmartSearch filters
Add components of well-built question in sequence (often only 2 are needed)	Avoids retrieving too many or too few articles	—
Use MeSH browser to select broad / common terms	Increases likelihood of finding all available articles	"Facial nerve paralysis" instead of "Bell's palsy" or "seventh nerve palsy"
Use only 1 or 2 words per component	Avoids narrow terms and missing articles in which text words are not adjacent in title or abstract	"Heart failure" instead of "congestive heart failure"
Manual Searches		
Search each component as both a MeSH term and a text word	Increases likelihood of finding all available articles	"Premature ventricular complexes / " or "ventricular.tw."*
Consider exploding MeSH terms and truncating text words	Increases likelihood of finding all available articles	"Exp premature ventricular complexes / " or "ventric$.tw."*
If too many articles found		
Convert MeSH terms to MeSH major terms and text words to title words	Limits search to articles that emphasize search terms or text words	—
Use AIM limit	Limits search to the approximately 100 core clinical MEDLINE journals in the AIM	—

AIM = Abridged Index Medicus; MeSH = medical subject heading.
*These examples use terminology unique to OVID. All versions of OVID provide online help for readers seeking more information.

including all of the big 5. OVID is very powerful and often is used when performing searches for writing meta-analyses, but it requires a subscription, is too slow to use during patient care, and even with filters has a steep learning curve for new users. If OVID is available, full-text retrieval can be relatively simple if the user already knows the "unique identifier" (UI) code that PubMed assigns to each article in the database. This numerical code is located below the abstract or citation information on the PubMed screen. Although it is often overlooked by many PubMed users, the UI code, followed by the characters ".ui.", can be entered into OVID for easy and direct full-text retrieval.

Journal websites also may provide access to the complete text of articles. Although most journals (except the *British Medical Journal*) require a subscription for this service, users who have print subscriptions can register online for free and gain full access to article archives of some journals. In addition, many institutions also maintain such subscriptions, so clinicians affiliated with a hospital or academic medical center should consult their medical library.

Evaluating Search Results

It is easy to recognize a failed search when very few articles are retrieved. Often this results from search terms that are misspelled, too broad, or illogically combined (ie, with misused and's and or's). Using alternative or broader search terms will often solve the problem, and reading the abstracts of articles retrieved may reveal additional search terms. When too many articles are retrieved, using an appropriate search filter may help streamline the results.

When a search retrieves what appears to be an acceptable number of articles, however, it is nearly impossible to determine whether additional important articles have been missed. Although there are no easy solutions to this problem, knowing what types of studies should be available based on the prevalence of a disease can guide assessment of search results. For example, rare diseases such as babesiosis often have not been investigated with RCTs, and extensive diagnostic or treatment studies may not be available. For uncommon diseases, such as gout, many RCTs and diagnostic studies, but only a single systematic review, may be available. Searches for common diseases that have been extensively researched, such as heart failure, should yield many quality systematic reviews of treatment, diagnosis, or both. Thus, knowing a disease's prevalence should provide guidance to searchers concerned about the quality of their search results.

Evaluating Sources and Weighting Search Results

The quality of the evidence from the literature must be appraised before it can be used in making a clinical decision. In EBM, this step is known as *evaluating the search results*. Although entire courses in critical appraisal are available, several general guidelines can help the busy clinician.

For textbooks, traditional review articles, practice guidelines, and the vast majority of medical websites [17,18] consulted to answer broad clinical questions, evaluation should begin with assessment of the authors' qualifications, credibility, and potential conflicts of interest. Searchers should then determine whether the source of the information is outdated and whether it contains adequate references to the medical literature (referred to as *attribution*). Peer review is an additional indication of the quality of a source [19]. Textbooks such as *Scientific American Medicine* and *UpToDate* excel in using attribution. Traditional review articles (eg, the "Medical Progress" series in the *New England Journal of Medicine*) may use both attribution and peer review. Some guideline sources, such as the *Guide to Clinical Preventive Services* [20], use systematic literature reviews as well as peer review and attribution.

For specific questions, a formal guide for assessing the validity or "level" of evidence from systematic reviews and original research is available on the Internet [21]. A simple guide to comparing levels of evidence for original research studies is provided in Table 3.

For example, questions about therapy are best answered by results of RCTs. The RCT is followed, in descending order of quality, by nonrandomized cohort studies, case-control studies, and uncontrolled case series. If data from studies with similar results are free of undue variation (referred to as *homogeneous* by meta-analysts) and are pooled mathematically (eg, as in a meta-analysis), the level of evidence of the studies is improved. Therefore, a systematic review of RCTs (preferably RCTs with homogeneous results) offers the highest level of evidence. The next highest level of evidence is provided by a single RCT, followed by a systematic review of cohort studies, followed by a single cohort study, followed by a systematic review of case-control studies, and so on.

Table 3. Levels of Evidence for Original Research Data

Type of Study	Level of Evidence	Source(s) of Data
Experimental	I	Systematic review of homogeneous RCTs
		Single significant RCT
Observational	II	Systematic review of homogeneous cohorts
		Single significant cohort study
	III	Systematic review of homogeneous studies
		Single significant case control study
	IV	Case series data
	V	Case report

RCT = randomized controlled trial. (Adapted from Levels of evidence and grades of recommendations. Centre for Evidence-Based Medicine Web Site. Available at: http://cebm.jr2.ox.ac.uk/docs/levels.html. Accessed September 21, 1999.)

Although the author wrote the SmartSearch program, SmartSearch is a free product and the author receives no compensation from users.

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APPENDIX

Appendix. Useful Evidence-Based Medicine (EBM) Resources

Resource (Type)	Comments
ACP Journal Club (J, JC)	Internet and print; subscription
AIDS Knowledge Base (T)	Internet; free
Bandolier (J)	Internet; free
Canadian Task Force on Preventive Health Care (PG)	Internet; preventive care guidelines based on systematic literature review
CancerNet (PG)	Internet; free
Centre for Evidence-Based Medicine (I)	Historical and clinical EBM information
Clinical Practice Guidelines (PG)	Guidelines produced in Canada
Cochrane Collaboration (SR)	CD-ROM; subscription
Database of Abstracts of Review of Effectiveness (DARE) (SR)	Includes abstracts of Cochrane Collaboration meta-analyses
Evidence-Based Practice (JC)	Print; subscription
Harrison's Textbook of Internal Medicine (T)	Internet, CD-ROM, and print; referenced; subscription
Journal Club on the Web (JC)	Internet; free
Journal of Family Practice (POEMs feature) (J)	Internet (free) or print (subscription)
Journal Watch (JC)	Subscription; CME credit available
MAXX: Maximum Access to Diagnosis and Therapy (L)	CD-ROM only; over 20 Lippincott-Raven manuals
MDConsult (L, MS)	Internet; subscription; over 40 textbooks, including Lange Current series; limited MEDLINE access
Merck Manual of Diagnosis and Therapy (T)	Internet (free) or print; multidisciplinary
National Guidelines Clearinghouse (PG)	Guidelines produced in the United States
OVID with filters (ML)	Internet; subscription
PubMed with filters and MeSH browser (ML) (Alternate Pub Med access)	Internet; free
Rational Clinical Examination Series (SR)	Internet; free
Scientific American Medicine (T)	Internet, CD-ROM, and print; referenced; subscription
SUMSearch (MS)	Internet; free
Stat!-Ref (L, MS)	CD-ROM only; access to 6–31 textbooks, many from Lange Current series; limited MEDLINE access
Health Services / Technology Assessment Text (D, PG)	Internet; compendium of guidelines and other evidence-based resources
UpToDate (T)	CD-ROM only; referenced; subscription

CME = continuing medical education; D = online database; I = instruction in evidence-based medicine; J = journal; JC = journal club; L = library containing internal medicine textbooks; MeSH = medical subject headings; ML = MEDLINE search engine; MS = meta-search engine; PG = practice guidelines; POEMs = Patient Oriented Evidence that Matters; SR = systematic reviews; T = textbook or reference book.