A Survey of Scholarly Literature Databases for Clinical Laboratory Science

DONNA L O'MALLEY

This article reviews the use of journal literature databases including CINAHL, EMBASE, and Web of Science; summarizing databases including Cochrane Database of Systematic Reviews, online textbooks, and clinical decision-support tools; and the Internet search engines Google and Google Scholar. The series closes with a practical example employing a cross-section of the knowledge and skills gained from all three articles.

ABBREVIATIONS: CDSR = Cochrane Database of Systematic Reviews; CINAHL = Cumulative Index to Nursing and Allied Health Literature; GDM = gestational diabetes; SCI = Science Citation Index.

INDEX TERMS: algorithms; bibliographic databases; information storage and retrieval; Internet; medical technology; online systems.

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LEARNING OBJECTIVES

1. Describe what is meant by "primary literature" in the health sciences.
2. Discuss the characteristics of the major primary and summarizing databases used by health professionals.
3. Discuss the advantages and disadvantages of searching the Internet for professional health information.
4. Illustrate how popular Internet search engines can be used to find unique information in the health sciences.

The primary literature in the health sciences consists of reports of original research generally published in the form of articles in scholarly/academic journals. The articles in these journals are indexed by searchable databases such as MEDLINE, CINAHL, and EMBASE, which function as an aid to finding articles on a desired topic. The primary literature has the advantage of being a direct communication from the researchers who performed the investigations. By studying the methodology used, the results of the research, and the investigators' reasoning, readers are able to reach their own conclusions regarding the validity of the research findings. However, until they have stood the test of time, the findings of original research must be interpreted with caution.

Since the primary literature is such an enormous body of work, much of which will later be disproved or substantially revised, many scientists and health professionals rely on secondary and tertiary forms of literature to summarize original research. These forms of literature provide the essential background knowledge required to understand and interpret the primary literature and for making professional and clinical decisions. Examples of such literature include review articles, yearbooks, print and online textbooks, and clinical decision-making tools.

This final article in the FOCUS series will examine several databases of the primary literature, as well as several secondary and tertiary resources commonly used by health professionals. It will also examine the use of popular Internet search engines for finding forms of literature not usually included in proprietary databases. Finally, the article will close with a practical example utilizing a cross-section of the concepts, techniques, and skills described in the entire series.

PRIMARY LITERATURE DATABASES

Though MEDLINE is the premier database for the professional health sciences literature, research shows that it does not provide complete coverage of all the journals relevant to clinical laboratory science.[1] To cover a topic comprehensively, other literature databases such as CINAHL, EMBASE, or Web of Science may need to be searched in addition to or instead of MEDLINE. These databases may cover a different mix of journal titles representing a slightly to markedly different subject area coverage; their records may contain unique elements of information not found in the other databases; or they may utilize alternative mechanisms for identifying related records. As a result, a search in one of these databases will frequently bring up articles not found in MEDLINE.

CINAHL

The focus of the Cumulative Index to Nursing and Allied Health Literature (CINAHL)[2] database is evident from its title. CINAHL includes over one million records for journal articles, book chapters, doctoral dissertations, conference proceedings, websites, and other types of publications. CINAHL covers publications from 1982 to the present. Although there is considerable overlap with MEDLINE, CINAHL indexes many publications important to health sciences professions that are not covered by MEDLINE. Access to CINAHL is available through EBSCO Information Services and Ovid Technologies. Like the MEDLINE records described in the first article, CINAHL records include standard bibliographic elements, such as author, title, journal name, volume, issue, page numbers, and publication date, plus abstracts and CINAHL subject headings. CINAHL records also include several unique fields, such as the Cited References field and Journal Subset (Table 1).

The search algorithm used by CINAHL depends largely on which vendor's version is being searched. Ovid Technologies' advanced search actively encourages the searcher to utilize CINAHL subject headings rather than relying solely on key-

Table 1. Important fields in a CINAHL record

Field	Contents
Author	The personal name or names of the authors of this document
Institution	Contact information for the author to whom correspondence should be addressed
Title	The title of the article
Source	The information necessary to locate the document. In the case of a journal article it is the journal name, volume, issue and page numbers.
Journal subset	CINAHL allows searchers to limit their searches to subsets of the database. Subsets include subject areas, country of publication, and peer review status.
CINAHL subject headings	Just as Medline uses the MeSH vocabulary, CINAHL uses an approved list of subject headings. These subject headings overlap with MeSH, but include specialized terms related to allied health and nursing.
Abstract	A summary of the document
Publication type	Journal article, book, audiovisual, pamphlet, software, dissertation, research instrument, etc.
Language	Most documents referred to in CINAHL are in English.
Citations	The references in the document's bibliography

word searching, while the EBSCO Publishing system offers a unique Visual Search feature which sorts results into topics represented by colored circles. Databases that assign subject headings to their records, such as CINAHL and MEDLINE, can be searched most effectively by using both subject headings and synonymous keywords.[3,4] All vendors of CINAHL offer a means of identifying CINAHL subject headings.

Like MEDLINE, several options exist for limiting a CINAHL search to create a small set of highly focused results. These include the familiar limits for language, age groups, and publication types, and more specialized limits such as special interest category, geographic journal subset, and clinical queries. For example, a search can be restricted to the professional literature, thus eliminating articles written for consumers or patients, by limiting the publication type to "Journal Article" or "Research", or by limiting to the "Peer-reviewed Journals" subset.

EMBASE

EMBASE[5] is a biomedical literature database published by Elsevier, headquartered in Amsterdam, The Netherlands. EMBASE contains records for over 11 million journal articles from over 5,000 biomedical journals published in 70 countries. EMBASE excels in coverage of European and non-English language publications, as well as in the subject areas of pharmaceuticals, psychiatry, toxicology, and alternative medicine. EMBASE's earliest articles are from 1974 and new records are entered on a weekly basis. EMBASE is available through various vendors, including Dialog/Datastar, DIMDI, Lexis/Nexis, NERAC, OVID Technologies, and STN. Elsevier also offers its own version of EMBASE through EMBASE.com.

EMBASE records contain the usual citation details, plus abstract, subject headings, drug descriptors, medical descriptors, medical devices, brand names, and manufacturer names. EMBASE uses a list of approved subject headings comparable to MEDLINE's MeSH headings called the EMTREE thesaurus. EMTREE allows searchers to include all narrower terms under broader terms, much like MEDLINE's "explode" feature. Though EMTREE makes no effort to use the same subject headings as MeSH, the EMBASE.com version of EMBASE includes MeSH terms in its records in addition to its own subject headings.

To search EMBASE, begin with a keyword search. Then, from the complete record of relevant articles, identify searchable terms that can be used to narrow, expand, or otherwise revise the search. In addition to a search box to enter terms, a link to the EMTREE thesaurus is provided to enable browsing for subject headings. An EMBASE search is especially useful for identifying articles in European journals that are covered less comprehensively by MEDLINE, and for searches in subject areas in which EMBASE is particularly strong.

Web of Science/ Science Citation Index

Web of Science[6] is produced by Thompson Scientific, an international information company with a wide range of products for academia, business, and government. Web of Science contains over 38 million records and consists of three databases: Science Citation Index, Social Sciences Citation Index, and Arts & Humanities Citation Index, each of which may be searched separately or in combination with the others. Science Citation Index (SCI) contains references to over 6,300 peer-reviewed journals in science, medicine, and engineering. SCI provides data from as far back as 1900, with weekly updates.

Although SCI has a general search function, its real strength is in cited reference searching. In addition to basic bibliographic information (author, article title, journal name, publication date, etc.), SCI records contain the full list of references cited by the articles indexed (Table 2). The cited and citing articles are connected by the database software in such a way that a concept can be tracked backward and forward in time through the articles' bibliographies. Suppose a searcher has located a useful but older article, and wants to identify more recent articles that have been published on that topic. By bringing up the SCI record for the original article and clicking on the "Times Cited" link, one can easily obtain a list of articles that used the original article in their bibliographies. Presumably, more recent articles that cited the original article will be on the same or a similar topic. Although other literature databases, including CINAHL, have a similar feature, because SCI indexes such a large number of journals crossing many disciplines, its cited reference searching is far more useful.

Like PubMed, SCI has a "related articles" feature, but it is structured on a completely different algorithm. In PubMed, related articles are identified on the basis of their shared subject headings. In contrast, related articles in SCI are identifed based on shared references in their bibliographies. Articles that share many of the same references with the original record will appear higher in the list than those that share just a few references.

Lacking a formal thesaurus of subject headings, SCI relies on keywords for general subject searching. As a search mechanism, this is not nearly as powerful as the subject heading searches available in MEDLINE, CINAHL, or EMBASE. Hence, general subject searches are best performed in these other databases, at least initially. However, SCI's cited reference search is an excellent tool for expanding a search, especially when only a small number of articles can be found.

Table 2. Important fields in a Science Citation Index record

Field	Contents
Title	Title of the journal article
Authors	Journal article authors
Source	Journal title, volume, issue and page numbers
DOI	Digital Object Identifier. For records that do not have page numbers and an article number, the record displays the DOI, if available.
Language source	Language in which the article was published
Abstract	A summary of the article
Document type	Journal article, letter, or review article
Author keywords	Keywords as listed by the author
Keywords plus	Words or phrases that frequently appear in the titles of an article's references, but do not necessarily appear in the title of the article or in a list of author keywords
Subject category	Broad subject category of the journal
Bibliography	The full record also includes the references from the article's bibliography.

DATABASES THAT SUMMARIZE

Literature that summarizes the primary research of a given field serves a vital role in the communication of knowledge. It saves the time of the reader and highlights important points that someone less familiar with a topic might not appreciate. It is especially useful for gaining background information on topics outside one's area of expertise. In the clinical arena, secondary literature serves as a valuable source of ready information regarding diagnostic indicators and treatment guidelines. However, since they are removed from the original documents, summarizing publications run the risk of introducing misinterpretations, biases, and omissions. With this caveat in mind, databases of secondary literature can be highly useful.

Journal articles that summarize research regularly appear in MEDLINE, CINAHL, EMBASE, and Web of Science as review articles. Review articles may take the form of literature reviews, often with hundreds of references, or they may be in the form of academic tutorials, such as this article. Most literature databases have an option to limit searches to review articles only. Other databases, such as the Cochrane Database of Systematic Reviews, electronic textbooks, and clinical decision-making tools, contain only summaries.

Cochrane Database of Systematic Reviews

The Cochrane Database of Systematic Reviews (CDSR)[7] is a full text database of a specialized type of review article designed to summarize all relevant research on a specific healthcare intervention. High quality research studies, primarily randomized controlled trials, are identified through an exhaustive search of the literature, coupled with a hand search of selected journals, and their findings compared following a standardized protocol. The completed systematic review analyzes the results of all the studies and derives an overall conclusion regarding the intervention. Each review concludes with implications for clinical practice and suggestions for future research. As a summary of the most rigorous research studies available, the Cochrane systematic review represents the highest level of evidence available for that particular intervention. Of course, not all possible interventions or treatments will have been studied, so not all topics will have a review in CDSR. Approximately 4,800 systematic reviews have been published.

The CDSR is updated quarterly, and is available from Wiley Interscience and Ovid Technologies. Abstracts of the reviews are available free online from the Cochrane Collaboration at http://www.cochrane.org/reviews/. The CDSR is searched using either keywords or MeSH headings. As a full text database, the entire records are searchable. This is a mixed blessing, as keyword searches often bring up articles missed by subject heading searches, but they may also retrieve more irrelevant articles simply because they pick up every occurrence of the term(s) anywhere in the full-text of the documents.

Since CDSR is indexed by MEDLINE, the reviews can be found by conducting a topic search in MEDLINE, combined with a search on CDSR as a journal title.

Online textbooks

The content and structure of textbooks is familiar to any current or past student in the sciences. Online, these textbooks have tables of contents, chapters, page numbers, and indexes just like their print counterparts. Upon their initial publication, the online textbooks are identical to the print versions, but they have the advantage of being able to be updated far more frequently and economically. Vendors of online textbooks in the health sciences include Ovid Technologies, AccessMedicine, MDConsult and the (free) NCBI Bookshelf. These companies typically attempt to include a textbook representing most of the major medical specialty areas, thus enhancing their usefulness to busy clinicians and hospital staff. Usually only the most current edition of a textbook is available online.

The full-text of online textbooks is usually searchable. If the search is specific enough it can target a narrow topic, but quite often it will generate a long list of irrelevant hits due to incidental occurrences of the search terms. When available, searching within specific chapters or using the index can help to focus a search.

Clinical decision-support databases

In contrast to the seemingly anachronistic online textbooks, with their quaint tables of contents, indexes, and even page numbers, new formats for online information have emerged. These are clinical decision-making tools designed to provide health professionals with rapid, authoritative access to clinical information. Examples of these databases include Clin-eguide, DynaMed, eMedicine, FIRSTConsult, InfoRetriever, and UpToDate. Each of these competing resources fill a unique niche, some providing lengthy, evidence-based topic reviews, and others very brief summaries that can be accessed via handheld devices.

The information in these databases is more clinically oriented than textbooks. DynaMed records, for example, include fields for ICD-9/-10 Codes, Causes and Risk Factors, Complications and Associated Conditions, History, Physical, Diagnosis, Prognosis, Treatment, Prevention, Screening, References, and Patient Education information.

Clinical decision-support databases are updated on a quarterly, monthly, or weekly basis. These databases don't have editions as textbooks do. When a change is made in the database, the old information is not retained.

Researchers have estimated that healthcare professionals will spend no more than two minutes researching a clinical question,[8] so database developers have experimented with a variety of interfaces to make these databases operate more quickly. Each database is different and can change its interface without warning. Users should observe the display carefully for instructions on how to conduct a search, knowing that programmers are continuously making improvements.

The bibliographies of records in these databases are an excellent source of high quality references. References may link to journal articles through PubMed or to guidelines available from professional organizations or government bodies.

THE INTERNET

Some of the most heavily used literature databases were converted to electronic form on mainframe computers decades before the rise of the popular Internet. MEDLINE, for example, was searchable electronically through the MEDLARS system as far back as 1964.[9] Cancer.gov went online in 1982 as the National Cancer Institute's Physician Data Query (PDQ®) database.[10] Today, both of these databases are available free to the general public through the Internet. While some may think of the Internet as an alternative to databases of professional literature, in fact it merely serves as a conduit through which to access this and other types of information.

The difficulty with the Internet is that the high-quality, reliable, and authoritative information is so thoroughly intermixed with everything else that it is sometimes virtually impossible to find. It requires a sophisticated searcher and a refined skill set to effectively extract high-quality scholarly and professional documents. Using the popular Internet search engine Google as an example, some of these techniques will be examined.

Google

Google, also known as Google Web, is a database with unlimited scope. The authors of pages in Google range from experts in every field to charlatans deliberately promoting false information. The Google database consists of a copy of every page on the Internet that it has been able to access, now numbering in the billions. Each page becomes a record, with the words on the page sorted into fields, including page title, headings, links, and images.

Google rose to prominence among Internet search engines in part due to its innovative Page Rank system. The Page Rank for a Google record is based on how often other web pages cite the page and the rank of the citing pages. It is this feature that allows Google searches to produce more relevant results than other Internet search engines. Google's ability to outperform other search engines is also due to the approaches it uses to translate and execute search queries. Google is understandably reluctant to share the specifics of its search algorithm,[11] but generally speaking, it displays the results of a search in order of relevance and Page Rank, with the most relevant and highest-ranked pages displayed first. This presents a distinct drawback for scientists who are often looking for the most recent information. Since recent articles have not had the benefit of years of exposure that would allow other web pages to link to them, they are often not among the most highly ranked by Google, and therefore may not appear in the top pages of a Google search.

Google is a powerful search engine and an enormous database. Research has shown that, unfortunately, the larger a database is the harder it is to locate information in it, no matter how good the search engine or how expert the searcher.[12] However, there are several effective strategies that will maximize success when searching Google. One of the most useful is the use of quotation marks for phrase searching. If a search on a phrase produces records that don't use the words in the order expected, it may be placed in double quotation marks to ensure that Google will search exactly those words in exactly that order. Another strategy is to search on the most specific and unique terms possible.

Rather than searching on a specific topic directly, relevant results can often be found by searching for the name of the organization, society, or government body that would most likely provide the information. Access that organization's home page, and conduct an internal search. The strategy of searching for an organization rather than the exact topic can be very helpful because of Google's limitations. Google cannot transfer a search from its search box to the search box on another website. Although Google can see all of PubMed's records, for example, it can't search like PubMed, mapping to MeSH headings and combining terms in the way PubMed does. Nor can Google generate results from a dynamic database. The Centers for Disease Control and Prevention (http://www.cdc.gov), for example, links to many databases that will produce reports based on CDC statistics. Because these reports are generated dynamically, they only exist when someone requests them, so Google can't include them in its database.

Some well-known publicly available databases are not available through Google at all. Examples include the National Cancer Institute Clinical Trials Database, the US Patent and Trademark Database, and US Census Bureau data. The information in those databases is available through the Internet, but is not searchable by Google. Private, fee-based databases, such as CINAHL, EMBASE, Web of Science, most medical textbooks, and clinical decision support systems, are also not searchable through Google.

Google Scholar

Google attempts to address the needs of scientists and professionals through its Google Scholar database. Google Scholar includes journal articles, theses, books, meeting abstracts, and certain unique documents not found elsewhere. Unlike most licensed literature databases, Google has agreements with many publishers that grant it permission to search the full text of each article.

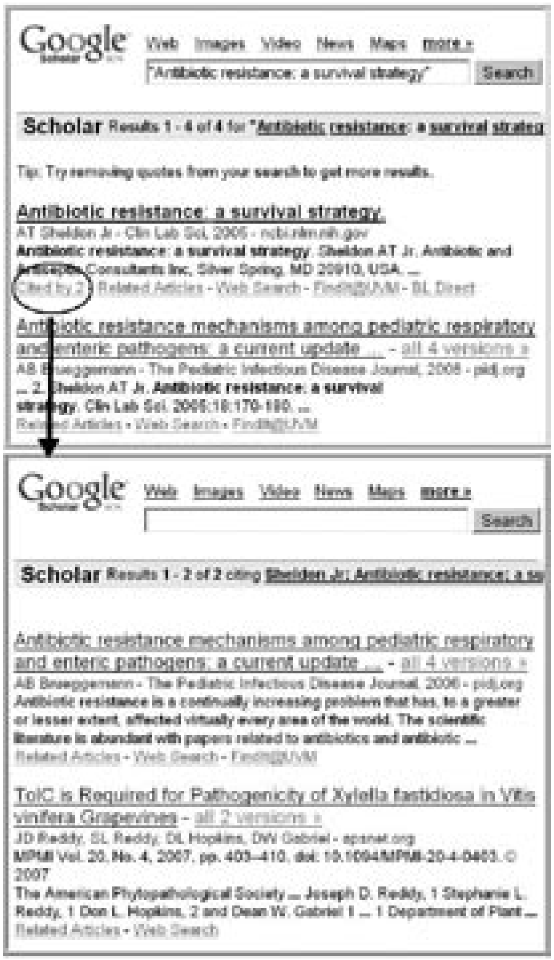
Like Google Web, Google Scholar displays the most relevant, highest ranked pages first, but Google Scholar uses cited references from bibliographies, not Page Rank, to determine rank. Publications that have been cited more frequently by other publications will be ranked higher. Again, this can impact the retrieval of recent articles. In order to address this problem, Google Scholar offers a Recent Articles link at the top of the results page. When this link is clicked, a drop-down box for publication date appears, allowing searchers to limit the search to a specified year, forward.

Google Scholar has several unique features that further distinguish it from its parent. When multiple versions of a given article exist in the database, it groups them together via a link attached to the original record. For example, there may be an official version of an article on the publisher's website, a link to the preprint of the article on the author's website, and a link to the PubMed record. By clicking on the All Versions link, Google automatically displays these records as a separate set.

Secondly, articles in Google Scholar that have been cited by other articles in Google Scholar indicate this connection through a "Cited By" link. Clicking on this link will produce a list of articles that cited the original article (Figure 1). Thus, Google Scholar provides a form of cited reference searching similar to that provided by Web of Science.

Finally, Google Scholar employs an undisclosed mechanism for finding related articles, using the Related Articles link found at the bottom of each record.

Figure 1. Google Scholar "Cited By" feature



Since Google Scholar includes articles that are not available free on the Internet, many records include a link to obtain a copy through other means. If the article is not available for free or through an institutional subscription, the publisher may offer the option to purchase the article outright. There may be a link through Library Search to WorldCat, a service that lists libraries that subscribe to the journal in question. Or, the BL Direct link offers the option to purchase a copy of the article through the British Library, although it is often more expensive than purchasing a copy directly from the publisher.

Google Scholar can be useful for cross-disciplinary searches. Topics in public health, healthcare administration, and education are not always well covered in databases like MEDLINE, EMBASE, and CINAHL. On the other hand, owing to the enormity of Google Scholar, if a topic is well-represented in a smaller, subject-specific database, a search of that database may be more productive.

USING THE LITERATURE IN CLINICAL LABORATORY PRACTICE

Suppose your laboratory is interested in exploring the various methods and protocols for screening for gestational diabetes (GDM), and you want to find what has been published to date on the topic. You begin by reviewing the basic facts of the disease, such as its clinical importance, incidence and prevalence, early detection, methodologies used for screening, current screening recommendations, and the effectiveness of treatment.

These background questions can best be addressed by literature that summarizes the current state of knowledge. From the array of clinical decision-making resources available, you choose UpToDate as a starting point. Searching on "gestational diabetes", you find the topic review entitled "Screening and diagnosis of gestational diabetes mellitus".[13] The article discusses the prevalence of the disease, possible adverse outcomes for mother and infant, and therapeutic outcomes. It summarizes guidelines for screening and diagnosis of gestational diabetes mellitus from the American Diabetes Association, the American College of Obstetricians and Gynecologists, the United States Preventive Services Task Force, the Canadian Task Force on Preventive Health Care and the Fourth International Workshop-Conference on Gestational Diabetes Mellitus. You note that these guidelines are not in complete agreement with one another. The review concludes with a summary and its own recommendations. The bibliography for this article includes 67 references, most with links to the MEDLINE abstract.

Having obtained the clinical background of the disease, you next seek laboratory-specific information from a current textbook or manual. MDConsult's book collection contains the 21st edition of *Henry's Clinical Diagnosis and Management by Laboratory Methods*,[14] wherein the chapter on carbohydrates offers a lengthy discussion on glucose measurements and GDM screening protocols, including references to the American Diabetes Association guidelines. Ovid Technologies provides access to *A Manual of Laboratory & Diagnostic Tests*,[15] which describes the test procedure, patient preparation and aftercare, and limitations of the test. While the recommendations included are not referenced, they do follow WHO guidelines. Conflicting guidelines are not mentioned.

Additional information may be sought from the websites of professional societies and organizations. A quick Google search leads you to the website of the American Association for Clinical Chemistry. This site lists a number of standards, including the 2002 *Guidelines and Recommendations for Laboratory Analysis in the Diagnosis and Management of Diabetes Mellitus*.[16] This guideline does acknowledge the controversy. The authors recommend following the American Diabetes Association guideline, but do not provide their rationale.

Realizing there is no consensus on issues surrounding screening for GDM,[17] you begin to wonder if there is another methodology for testing that might prove more effective than the traditional glucose tolerance test. You decide to search the journal literature indexed in MEDLINE, which covers much of clinical chemistry. You quickly access PubMed via your hospital library's website. Recalling that PubMed executes a simultaneous MeSH term and textword search, you enter the word string "gestational diabetes screening" into PubMed's search box. You limit your search to human studies, English language, and Core Clinical Journals. A quick scan of the results brings up a case-control study from 2007 describing the use of various serum markers for predicting gestational diabetes in the first and second trimesters of pregnancy.[18] You are intrigued, and decide to expand your search. Checking the MeSH headings assigned to this article, you re-run the search utilizing additional relevant terms. Also, you follow the Related Articles link for the most relevant results to bring up additional useful articles.

In an effort to search the literature thoroughly, you repeat the search in Ovid CINAHL, which indexes some publications not covered by MEDLINE. Searching on each concept separately, you generate separate sets of results for "diabetes mellitus, gestational", "glucose tolerance test", and "health screening". You also generate a set of articles indexed under the subject heading "diabetes mellitus, gestational" combined with the subheading "diagnosis". Finally you combine the

Figure 2. CINAHL search strategy

Figure 3. Web of Science Cited Reference Search

sets, using the Boolean AND and OR. To help eliminate duplicates from the previous PubMed search, you limit your final set to Allied Health Journals (Figure 2). From this set, you discover several unique hits to add to your collection.

Rounding out your search, you conduct a Cited Reference Search in Science Citation Index to see if any research has been published following up on the 2007 study (Figure 3). No references are brought up, probably because the study is so recent. Would Google Scholar have any unique hits? Since PubMed, CINAHL, and Web of Science only allow searches to match words in a limited number of fields such as the title, abstract, and subject headings, being able to search the full text of articles might be advantageous. Furthermore, Google Scholar may contain some forms of "grey" literature such as pre-prints and technical reports that are not generally included in the traditional databases. Clicking on the Recent Articles link and limiting to 2002 forward, you scan for any unique documents.

CONCLUSION

The research question on screening for gestational diabetes resulted in a search of eight different databases. Fortunately, most research topics in clinical laboratory science do not require such an exhaustive (and exhausting) search, However, when a comprehensive search is needed, you'll want to take advantage of all the resources at your disposal and draw on a variety of search techniques. By learning the characteristics of the various information resources available, cultivating the skills to search them competently, and knowing how to evaluate the quality of the studies you find, you'll be well on your way to becoming truly "information literate".

Clin Lab Sci encourages readers to respond with thoughts, questions, or comments regarding this article. Email responses to ic.ink@mchsi.com. In the subject line, please type "CLIN LAB SCI 21(1) FO O'MALLEY". Selected responses will appear in the Dialogue and Discussion section in a future issue. Responses may be edited for length and clarity. We look forward to hearing from you.

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