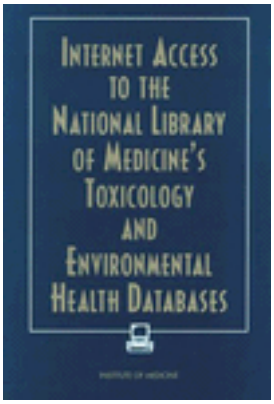

Internet Access to the National Library of Medicine's Toxicology and Environmental Health Databases

Catharyn T. Liverman, Carolyn E. Fulco, and Howard M. Kipen, Editors; Committee on Internet Access to the National Library of Medicine's Toxicology and Environmental Health Databases, Institute of Medicine

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Committee on Internet Access to the
National Library of Medicine's
Toxicology and Environmental Health Databases

Division of Health Promotion and Disease Prevention

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The serpent has been a symbol of long life, healing, and knowledge among almost all cultures and religions since the beginning of recorded history. The image adopted as a logotype by the Institute of Medicine is based on a relief carving from ancient Greece, now held by the Staatliche Museen in Berlin.

COMMITTEE ON INTERNET ACCESS TO THE NATIONAL LIBRARY OF MEDICINE'S TOXICOLOGY AND ENVIRONMENTAL HEALTH DATABASES

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This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the NRC's Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making the published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. We wish to thank the following individuals for their participation in the review of this report:

Bruce G. Buchanan, University of Pittsburgh;
Keith Burkhart, Milton S. Hershey Medical Center;
Terry Ann Jankowski, University of Washington;
Michael J. Kosnett, University of Colorado Health Sciences Center;
Trace Warner, Washington State Department of Health; and
M. Donald Whorton, M. Donald Whorton, M.D., Inc., Alameda, Calif.

While the individuals listed above have provided constructive comments and suggestions, it must be emphasized that responsibility for the final content of this report rests entirely with the authoring committee and the institution.

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Executive Summary

The growth of the Internet, its widespread use, and its availability as a platform for database searching has made it possible and practical for the National Library of Medicine (NLM) to provide Internet access for many of its 40-plus online databases. In 1997, the NLM decided to provide Internet access to its extensive portfolio of toxicology and environmental health databases available on the Toxicology Data Network (TOXNET). During the development phase of the TOXNET Web site, the NLM requested that the Institute of Medicine (IOM) conduct a study that would assess the usefulness and effectiveness of this new Web site (http://www.toxnet.nlm. nih.gov).

The IOM Committee on Internet Access to the NLM's Toxicology and Environmental Health Databases was formed in early 1998 and was charged with seeking input from health professionals on their assessment of the Web site and with providing recommendations on the refinements necessary to facilitate TOXNET database searches. The committee met twice in the course of the study and solicited input from a number of health professionals and other interested individuals on their experiences with searching the new interface. To more fully capture the search process and identify the barriers that individuals experienced, videotaping was used to record a small number of individual search sessions. In this way, the search process could be more carefully examined.

The committee's assessment of the current search interface found that improvements were needed to assist the user in all steps of the search process. Of particular importance are:

- improved assistance in selecting which of the TOXNET databases to search;

- clarification of the options for viewing the search results, including the use of the customized display option that narrows the display to specific content areas (e.g., animal toxicity studies, emergency medical treatment, human health effects); and
- improved mechanisms for providing "help" information (e.g., increased use of links to the help screens, development of a tutorial, and eventual use of context-sensitive help).

The committee found that the current search interface is too complex for the novice but does not offer the specificity and complexity needed by expert searchers. This disparity indicates the need for more than one search interface, and the committee recommends the development of three levels:

- Quick Search—This option would consist of a single input box for entering all search terms. Examples include the initial screens for Alta Vista and PubMed. Search results would be less refined but would allow for searching TOXNET information in a manner familiar to Web users.
- Step-by-Step Search—This interface would have detailed instructions to walk the searcher through each step of the search process and would be geared to the novice or infrequent searcher who wants to have substantive retrieval but is not familiar with the databases.
- Advanced Search—This interface would offer the complexity needed to equal the specificity and the power of the command line interface and could include a number of features such as simple and nested Boolean searching, truncation, field searching, phrase searching, and proximity searching.

Additionally, several other long-term enhancements should be considered to improve the quality and efficiency of the search process. These improvements include:

- development of cross-database searching capabilities,
- an online thesaurus and chemical dictionary,
- detailed search analysis screens, and
- extensive hypertext links within and among TOXNET records and between TOXNET records and MEDLINE and TOXLINE records.

To fully utilize the information contained in the TOXNET databases, it is critically important to integrate TOXNET with other NLM databases, particularly MEDLINE and TOXLINE. Because MEDLINE is a standard source of biomedical information for health professionals, any links (or other methods of) connecting a bibliographic citation to the relevant information in the TOXNET databases would greatly enhance the use of the TOXNET information and would provide an added service to MEDLINE searchers. It is hoped that the

NLM will utilize both existing technologies and those in development to integrate the TOXNET databases into the broader context of other NLM databases. This can be accomplished in the short term by adding links from PubMed and Internet Grateful Med to the TOXNET Web site. A more long-term goal would be to integrate links to TOXNET information directly into the bibliographic records of MEDLINE and TOXLINE. This system of links could be similar to those now available in PubMed between MEDLINE and the National Center for Biotechnology Information's ENTREZ databases.

Although a goal of the TOXNET Web site should be to minimize the training required to effectively search the databases, a certain amount of training will still be necessary, at least initially. Of particular importance are train-the-trainer sessions because participants can then further expand the capability by training others. The Toxicology Information Outreach Project, NLM's Regional Medical Libraries and the National Network of Libraries of Medicine, and Partners in Information Access for Public Health Professionals can all be utilized to enhance training efforts. In addition, the committee recommends that a Web-based tutorial be developed.

To maximize outreach efforts and raise awareness of the TOXNET Web site, it is important to take advantage of the many existing organizations, agencies, Web sites, and publications that reach the varied audiences for toxicology and environmental health information. Because environmental health concerns are frequently focused on local and regional issues, it is particularly important to reach regional, state, and local environmental health organizations. Outreach can take multiple forms including articles for newsletters, news columns, and journals; hypertext links from organization Web sites to TOXNET; brochures, news releases, and handouts; and presentations, seminars, and exhibits at conferences or meetings.

Reaching the numerous individuals and groups involved in environmental health issues poses a challenge when resources are limited. However, the Internet can go a long way in serving as a cost-effective mechanism for marketing the TOXNET Web site. Key hypertext links within the overall NLM Web site are crucial, including links to TOXNET from the homepages of NLM, Internet Grateful Med, and PubMed. Additionally, it is important to have links from other environmental health Web sites to TOXNET. Although adding a link to TOXNET is done at the discretion of the host site, the minimal time and cost involved in adding a link makes it quite feasible. The challenge is to contact the relevant organizations and acquaint them with the wealth of information available on the TOXNET Web site.

The committee believes that the TOXNET databases offer information of interest to a broad range of individuals and organizations, and it applauds the Specialized Information Services Division and NLM for expanding access to TOXNET through the development of an Internet Web site. The committee's recommendations for improving the Web site and raising awareness of this information resource are summarized in Table ES-1. The release of the TOXNET Web site offers an opportune occasion for raising awareness about

the TOXNET databases. The committee hopes that NLM will take advantage of this opportunity to broaden its outreach and training efforts. At the same time, it is hoped that the search interface will continue to evolve and that NLM will continue to integrate the TOXNET information into its overall Web site and its plans for the future.

TABLE ES-1 Summary of Opportunities for the TOXNET Web Site

Short-Term Opportunities

- Improved assistance in selecting which of the TOXNET databases to search
- Clarification of display, print, and e-mail options
- Improved mechanisms for providing help information
- Integration of TOXNET into the overall NLM Web site through links from PubMed and Internet Grateful Med

Long-Term Opportunities

- Three levels of search interfaces—Quick Search, Step-by-Step Search, and Advanced Search
- Further development of online help and tutorials
- Cross-database searching
- Addition of a thesaurus and chemical dictionary
- Detailed search analysis
- Extensive hypertext links within and among TOXNET records and between TOXNET records and MEDLINE and TOXLINE records

Training and Outreach Opportunities

- Utilize existing programs (e.g., Toxicology Information Outreach Project)
- Maximize outreach activities to raise awareness of the TOXNET Web site
- Utilize the Internet for outreach activities to reach national, regional, state, and local organizations and agencies

Introduction

The growth of the Internet, its widespread use, and its availability as a platform for database searching has made it possible and practical for the National Library of Medicine (NLM) to provide Internet access for many of its 40-plus online databases. Use of the World Wide Web to search the MEDLINE bibliographic database, through NLM's PubMed and Internet Grateful Med interfaces, has seen outstanding success as an access point for health professionals and for the general public.

One component of health information that continues to be at the forefront of health concerns for a wide range of scientists and health professionals, as well as the general public, is toxicology and environmental health information. To improve access to this kind of information, in early 1998, the NLM began developing an Internet Web site to provide access to the extensive portfolio of toxicology and environmental health databases located on NLM's Toxicology Data Network (TOXNET; Table 1.1). This Web site (www.toxnet.nlm.nih.gov) is the topic of this report.

STUDY BACKGROUND

NLM's work in toxicology and environmental health information dates from the mid-1960s with the establishment of the Toxicology Information Program, now the Toxicology and Environmental Health Information Program or TEHIP. In 1969, the National Academy of Sciences (NAS) began providing advice and oversight to the expanding toxicological information resources at NLM through the Toxicology Information Program Committee (TIPCOM). For over 25 years, the toxicologists, pharmacologists, chemists, and computer scientists on

TABLE 1-1 Overview of the TOXNET Databases

Database	Sponsoring Agencies	Factual or Bibliographic	Subject Content
CCRIS	NCI	Factual	Results of carcinogenicity, mutagenicity, tumor production, tumor inhibition studies
DART	NLM, NIEHS, FDA, EPA	Bibliographic	Literature on teratology and many aspects of reproductive toxicology
EMIC	NLM, EPA, NIEHS	Bibliographic	Literature since 1991 published on substances tested for genotoxic activity
EMICBACK	NLM, EPA, NIEHS	Bibliographic	Pre-1950 through 1991 literature on substances tested for genotoxic activity
ETICBACK	NLM	Bibliographic	Teratology literature from 1950–1989, continued by DART
GENE-TOX	EPA	Factual	Results from expert review of scientific literature on chemicals tested for mutagenicity
HSDB	NLM (previously ATSDR)	Factual	Peer-reviewed summaries of the toxicology of potentially hazardous substances
IRIS	EPA	Factual	EPA health risk and regulatory information, includes carcinogenic and noncarcinogenic risk assessment data
RTECS	NIOSH	Factual	Toxic effects including skin and eye irritation, carcinogenicity, mutagenicity, and reproductive consequences
TRI	EPA	Factual	Annual estimated releases of toxic chemicals to the environment

NOTE: ATSDR = Agency for Toxic Substances and Disease Registry; CCRIS = Chemical Carcinogenesis Research Information System; DART = Developmental and Reproductive Toxicology; EMIC = Environmental Mutagen Information Center; EMICBACK = EMIC Back File; EPA = Environmental Protection Agency; ETICBACK = Environmental Teratology Information Center Backfile; FDA = Food and Drug Administration; GENE-TOX = Genetic Toxicology Data Bank; HSDB = Hazardous Substances Data Bank; IRIS = Integrated Risk Information System; NCI = National Cancer Institute; NIEHS = National Institute of Environmental Health Sciences; NIOSH = National Institute for Occupational Safety and Health; RTECS = Registry of Toxic Effects of Chemical Substances; TRI = Toxic Chemical Release Inventory.

TIPCOM provided timely and relevant advice as NLM's toxicology and environmental health program grew. In 1995, NLM's focus turned toward examining the medical relevance of these databases and the needs of clinicians and other health professionals for this kind of information. NLM requested a study by the Institute of Medicine (IOM) on those issues, and the resulting report (IOM, 1997) addressed future directions for the NLM's Toxicology and Environmental Health Information Program to increase its utility and accessibility. Major issues addressed by that report were increasing access to and effective use of the TOXNET databases by health professionals.

In late 1997, NLM decided to make the TOXNET databases available via an Internet World Wide Web site. During the development phase, NLM requested that IOM conduct a study that would assess the usefulness and effectiveness of the new Web site. The IOM Committee on Internet Access to the NLM's Toxicology and Environmental Health Databases was formed in early 1998. The committee was charged with seeking input from health professionals on their assessment of the Web site and with providing recommendations on the refinements necessary to facilitate searches of the TOXNET Web site by health professionals, scientists, educators, and the general public. The committee consisted of eleven members with expertise in medical informatics, environmental health, family medicine, poison control, medical librarianship, health communication and education, toxicology, and pharmacology. The committee met twice in the course of the study, solicited input from a number of health professionals and other interested individuals, and invited individuals with different skill levels in database searching to conduct searches on TOXNET using the Web interface.

INPUT TO THE COMMITTEE

The committee sought the input of a number of individuals interested in the content of the TOXNET databases. Recognizing that input should be solicited from individuals covering a broad range of expertise, the committee decided to utilize the following list of potential users of toxicology and environmental health information (IOM, 1997):

- primary care professionals (e.g., physicians, nurses, nurse practitioners, and physician assistants) and pharmacists;
- specialists in occupational and environmental health (physicians, nurses, nurse practitioners, physician assistants, industrial hygienists, and safety officers);

• emergency medicine and poison control center personnel (e.g., emergency room health professionals, emergency medical technicians, clinical and medical toxicologists, and specialists in poison information);

• health science librarians and faculty at health professional schools (including medical, nursing, public health, pharmacy, and dental schools);

• environmental health researchers and scientists (including health physicists, epidemiologists, toxicologists, and forensic practitioners);

• patients, the general public, and community organizations (including local emergency planning committees, public librarians, educators, and advocacy and activist organizations); and

• health professionals in local public health departments or in state and federal agencies (e.g., policy advisors, health educators, and public clinic personnel).

The committee received input through videotaped search sessions, email responses, and by working through searches with colleagues and students. This input was structured to provide the committee with feedback and was not designed or conducted as a scientific study. The committee appreciates the input of the individuals (Appendix A) who searched the TOXNET databases through the new Web interface and provided comments on the problems they encountered in the search process as well as their thoughts on improving the search interface.

Videotaping was used to record a small number of individual search sessions to more fully capture the search process and identify the barriers that individuals experienced. In this way, the search process could be more carefully examined. Participants were invited by committee members and staff to participate in a 30- to 45-minute search session. In each session, the participants were first asked to fill out a short questionnaire to provide the committee with information on their occupation, use of toxicology and environmental health information, and extent of their prior Internet and TOXNET experience (Appendix B). The participants were then asked to search the TOXNET Web site to answer two predetermined questions:

- What is the potential for vinyl chloride to cause liver cancer in humans?
- What are the potential health effects of working as a dry cleaner?

In addition to searching for information to answer the two questions posed by the committee, most participants searched the TOXNET site for information on topics of their own interest. Their queries were frequently related to subjects that they were currently studying or to subjects they knew well and wanted to examine the nature and extent of information in TOXNET. Topics included pfiesteria, tobacco smoke, aspartame, estradiol, malathion, and calcium channel blockers.

The computer screen was videotaped during the searches through a VGA video converter (no audio was recorded), and participants were asked to talk through the search process with the IOM staff member present. After the searches were complete, participants were asked to answer questions about each phase of the search process, to describe barriers to searching, and to suggest opportunities to refine the Web site. Similar videotaping processes have been used in other studies as a means to analyze and record human/computer interactions (Kushniruk et al., 1996; Wang and Tenopir, 1998).

Individuals who agreed to provide input via e-mail were given the same series of questions and the Web site address and were asked to search the TOXNET databases and provide information on their search experiences.

In all 31 individuals provided email or videotaped input to the committee, 15 individuals participated in the videotaped search sessions, and 16 people provided e-mail responses. The participant group consisted of 5 occupational and environmental health professionals, 1 family medicine physician, 3 emergency medicine and poison control personnel, 7 librarians and information specialists, 5 environmental health scientists, 3 federal or state public health professionals, 4 health policy professionals, and 3 students. Participants included individuals who provided input through the workshop or responded to the questionnaire in the previous IOM study (1997) and other individuals who were familiar with the current study. When asked about their Internet expertise, 19 noted they were advanced Internet users, 10 rated themselves as having intermediate expertise, and two considered themselves as novices (having basic or minimal Internet expertise and experience). Sixteen of the individuals had previously searched at least one of the TOXNET databases. The search experiences and comments of the participants and the committee are described in Chapter 2.

Committee members also received input on the interface by asking students and colleagues to search the databases via the Web interface. Working through a search with a colleague or student and discussing the search experience was helpful to committee members as they performed searches themselves and assessed the search interface. The committee then discussed the input received along with their own search experiences.

OVERVIEW OF THE REPORT

This report presents the committee's assessment of the TOXNET Web site and provides the committee's recommendations. Chapter 2 summarizes the input received by the committee and the committee's assessment of the current Web site. In Chapter 3, the committee presents its recommendations for short- and long-term improvements to the TOXNET Web site, and Chapter 4 discusses recommendations for raising awareness of this valuable information resource. The committee hopes that its recommendations for refining the

TOXNET Web site will enhance its usefulness to health professionals, scientists, and interested members of the general public.

Assessment of the Current TOXNET Web Site

The 1997 IOM report on the utility of NLM's toxicology and environmental health databases identified access and navigation as key barriers. At that time, the databases were primarily available on a cost-per-search basis (costs depended on the amount of online time and the type of activity) that required registration for an NLM password and provisions for billing. Additionally, the primary method for searching was through a command line interface, which required knowledge of a complex search language and syntax (e.g., field names, print commands). To those who frequently use that interface to search the databases (this option is still available), the command line interface can be a powerful tool for search retrieval, but to infrequent or novice searchers, it is largely impenetrable. While pre-Internet Grateful Med offered an additional search option for most of the TOXNET databases—one with a more user-friendly interface—it required purchase and loading of the software.

The move to a free, Web-based interface represents a major leap forward in providing access to the TOXNET databases. The committee believes that this set of databases can provide valuable environmental health information to a wide range of users. The committee applauds NLM and particularly the staff of the Specialized Information Services Division (SIS) for their commitment to increasing accessibility to the TOXNET databases.

The committee understood, as they began their deliberations, that the Web site was a work in progress, would continue to undergo changes during the course of the study, and would continue to evolve once launched on the Internet for public access. For the majority of the time that the committee was testing the Web site and seeking input, the site only provided access to five of the factual databases on TOXNET (HSDB, CCRIS, IRIS, RTECS, and GENE-TOX). Search screens have been added more recently for the bibliographic databases—DART, EMIC, EMICBACK, and ETIC—as well as for the TRI data-

bases. As a result, the committee's assessment is primarily focused on the factual database search screen. However, a number of the recommendations may be generalized to the entire TOXNET Web site.

This chapter summarizes the search experiences of the committee and of the individuals who provided input to the committee (Chapter 1). Most individuals searching the TOXNET Web site experienced similar problems. Those problems are highlighted in this chapter's assessment of the current search interface and a number of refinements are noted.

SELECTING A DATABASE

One of the issues associated with the TOXNET system, no matter what the interface, has been the fact that it contains numerous specialized databases (e.g., DART and ETICBACK that focus on the teratology literature), some of which are familiar only to a focused user community. Therefore, the novice or infrequent user may have difficulty in determining which database to select to begin searching.

In most cases, searchers chose the default database, HSDB, as their initial selection. The committee agrees that HSDB should be the default database because it is has a wider range of information than the other factual TOXNET databases. Additional mechanisms are needed for informing the searcher about the content of each of the databases. While, the current help screens do an excellent job of explaining each database and providing the searcher with information on its purpose and structure, few searchers in the committee's experience took the time to read the help information (see later discussion). Options for improving assistance in database selection include:

- an opening screen with information on each database and guidance in selecting a database;
- a hypertext link to information about each database, integrating the help information into the search screen; or
- step-by-step screens that walk the user through the database selection process (see Chapter 3).

INPUTTING THE SEARCH STRATEGY

The current search form for the factual databases provides one box to enter chemical/other names (e.g., chemical name fragment or Registry Number) and one box to enter subject terms. The form then provides a list of LOOK FOR options for combining the subject terms and another list of options for displaying results.

There were mixed reactions to this search screen setup. Some searchers found it too complex, preferring one box to enter all search terms (e.g., Yahoo or PubMed). Other searchers wanted to be able to perform complex Boolean searching and would have preferred multiple boxes for entering chemical names and search terms (e.g., Internet Grateful Med). Thus, the committee concluded that the current search screen is too complex for simple searches but does not offer the specificity and complexity needed for advanced searching. This disparity indicates the need for several levels of search interfaces, from beginner to advanced, to meet each individual's search needs (see Chapter 3).

After entering chemical and/or related subject information, the next decision point in entering the search strategy is to choose how to combine the search terms. The current search interface has the following list of LOOK FOR options:

All subject terms within record (AND)
Any subject terms within record (OR)
Subject terms as phrase (NEAR)
Subject terms in same occurrence (SAME).

Searchers were unsure about what those choices meant. The options are not listed from broadest retrieval (OR) to narrowest retrieval (NEAR). Even individuals familiar with Boolean searching were not clear about the NEAR and SAME options and related concepts. Searchers would have preferred to enter phrases encased by quotations rather than use the term NEAR, which searches within six words. Additionally, because of the lack of understanding of the basic structure of the TOXNET database records (discussed below), searchers were not sure to what extent choosing the SAME option (same occurrence) would narrow their search. As in selecting a database, the help screens did offer examples and additional information. Those clearer explanations should be incorporated into the search screen either as hypertext links or as additional text on the search screen itself. The committee makes recommendations in Chapter 3 for varied levels of search screens that would assist in addressing and clarifying these issues.

DISPLAYING THE SEARCH RESULTS

One of the most difficult problems for searchers was in understanding the search results—both how to display the information on the screen and how to interpret the displayed information. Most users (e.g., health professionals and students) are more familiar with searching bibliographic databases, particularly MEDLINE, where searches on a chemical retrieve numerous citations. They were not familiar with the term "record" or with the structure of the TOXNET factual database records. Each record generally contains all the information in the database on the chemical organized into numerous fields. Searchers found it

helpful to have the search terms highlighted in the retrieved text. However, reading the search results on the screen required a great deal of horizontal scrolling on some computer monitors.

Other problems encountered relate to the five display or view options: chemical listing, exact term match (the default option), full record(s), customized display, or selectable list (all results). Searchers did not understand the differences among these options. The following three examples illustrate common problems.

For searchers who entered the term "vinyl chloride" in the chemical name field and kept the default display choice of "Exact term matches," the retrieval displayed the message "Your search found 1 record" with two lines of text (name and registry number) and the message "End of Results" (Box 2.1). This was disconcerting to many searchers who expected numerous "hits" or records. Additionally, many were unclear about why they only received two lines of text. Novice searchers felt that the two lines of text retrieved were the extent of the information on vinyl chloride in that database (largely because of the message, "end of results"). They then proceeded to choose another database in the hopes of retrieving additional information.

BOX 2.1

Your search found 1 record in Database: HSDB
Query: ((NAME) VINYL CHLORIDE)

Page 1

1 - HSDB
NAME OF SUBSTANCE VINYL CHLORIDE
CAS REGISTRY NUMBER 75-01-4

End of Results

A second problem presented itself to searchers who chose the display option, "Full record" and retrieved the first page of the record. They realized there were multiple pages that followed but would have preferred to know the extent of the record (how many pages or bytes) without paging through the entire record to determine its length. Further, most searchers were unfamiliar with the structure of the record. They were not sure, for example, where human toxicity information would be found or if the database contained that information. Searchers who confronted this problem would have preferred to have an outline

of the record or a hierarchical display of the major fields with hypertext links to sections of the search results.

The third, display-related issue came up with searchers who were sent to the middle of the record. These searchers frequently searched on both the chemical name and a subject term (e.g., vinyl chloride and liver cancer) and chose the display option "Exact term match." In HSDB, the retrieved information on that search begins in the vinyl chloride record in the field on storage conditions, followed by a field for emergency medical treatment information, and then information on clinical effects. The searchers found this information useful in answering the search question, but they were not sure about the context of the information or what other information was available in the record.

Searchers were pleased to find or be told about the "customized display" option; they felt that this option solved many of the problems described above because it provided an overview of the record content and presented them with useful options to narrow their search (e.g., human health effects, animal toxicity studies, emergency medical treatment). Changing the default display option to "customized display" or presenting an outline or hierarchy of the database record would be useful in familiarizing searchers with the content and structure of the database. "Customized display" is a valuable option that should be made more visible to the searcher as most searchers did not understand all that this option has to offer.

MODIFYING THE SEARCH

Once the initial search was performed and the searcher had assessed the results, there was frequently a need to modify the search. It was clear to searchers that they could either return to the search screen by way of the BACK button on the Web browser or by selecting the MODIFY SEARCH button in the left frame.

Several searchers wanted to work with only the subset of records they had previously retrieved to further narrow the search results. Currently, the search criteria can be modified, however, each search is run anew on the entire database. This problem is in part a function of the Internet and the difficulties involved in storing sets for each search that can then be combined or manipulated (Chu, 1998). Further refinements are needed to allow searchers to have increased specificity in modifying their search (e.g., PubMed's Advanced Search) and to work with stored sets of search results.

PRINTING OR DOWNLOADING THE SEARCH RESULTS

The final step of the search process involved saving the search results in hard copy or online. Printing the search results presented problems because

each page had to be viewed and printed individually. Searchers would have preferred the option to print specific fields or to print the entire search result. This is a problem of which the NLM staff is aware. However, it is difficult to address because it is largely a function of the database file structure. Having the capacity to print all or a specified part of the record would be optimal.

Searchers utilized the e-mail option once they found that it was available. However, because it is currently listed under the redisplay options, it was not readily apparent. It would be preferable to have more obvious buttons or links at the top and bottom of the screen for displaying, retrieving via email, or printing the search results. Additionally, a download option (save to disk) was requested by many searchers.

OTHER ISSUES

One of the advantages of the Web is that it facilitates feedback. Currently the TOXNET Web site offers searchers the opportunity to send an e-mail to TOXNET User Support to discuss problems, request assistance, or provide comments or suggestions. This feedback is important and can be supplemented on occasion by seeking searcher input on specific features of the TOXNET Web site.

The use of frames, a topic of ongoing discussion (Siegel, 1997), was an issue with a number of the searchers. The committee felt that frames did not add to the functionality of the TOXNET Web site. The left frame, containing options for modifying the search, new search, online help, and searches on other databases, currently remains relatively static once the search has begun. Depending on the computer monitor, the size of the right frame was limited and required constant horizontal scrolling to read the search results on screen.

If a design decision to retain the frames is made, then they should be used to enhance the site. Examples of possible frame uses include providing context-sensitive help (Chapter 3), listing the major sections of the database record (e.g., toxicity and biomedical effects, pharmacology), and providing links to jump to specific parts of the record. However, in the committee's view, the site would be better served by removing the frames and adding buttons and links as needed.

Other factors addressed by the searchers included positive experiences with the response time of the search and a few problems with connections to the Web site. The move of the TOXNET system in May, 1998 to a new hardware platform appears to the committee to have gone quite smoothly, and the new hardware system seems to have speeded up the search processing.

Improving the TOXNET Web Site

In addition to the short-term improvements to the TOXNET Web site discussed in Chapter 2, the committee focused on long-term goals for TOXNET. This chapter discusses the committee's recommendations for integrating TOXNET into the overall plan for NLM's databases on the Internet and then looks more specifically at the four major components of the TOXNET Web site: databases, search interface, educational components (i.e., help screens, online tutorials), and added enhancements to assist the user (e.g., thesaurus, links between databases). Beyond improving the Web site, the committee believes it is crucial for NLM to increase awareness of the TOXNET resources on the Internet, and this issue is discussed in Chapter 4.

INTEGRATING TOXNET INTO THE OVERALL NLM WEB SITE

To fully utilize the information contained in the TOXNET databases, it is critically important to integrate TOXNET with other NLM databases, particularly MEDLINE and TOXLINE. Since MEDLINE is a standard source of biomedical information for health professionals, any links (or other methods) connecting a bibliographic citation to the relevant information in the TOXNET databases would greatly enhance the use of the TOXNET information and would provide an added service to the MEDLINE searcher.

The incredible pace of change in technology makes it potentially imprudent to speculate about distant goals for the NLM Web site. However, the committee believes it is necessary to include the TOXNET databases in any long-term planning. One potential goal may be to provide a single entry point

for searching all of the NLM databases. Searchers would not be required to know the specifics of each database to determine which one would best answer their information queries; they would only need to become proficient in using one interface. The committee did not explore this option in depth but discussed it as a distant goal that may be reached after a number of transitional steps are completed.

In the near future, the committee urges NLM to utilize both existing technologies and those in development to integrate the TOXNET databases into the broader context of other NLM databases. This can be accomplished in the short term by adding links from PubMed and Internet Grateful Med to the TOXNET Web site. A more long-term goal would be to integrate links to TOXNET information directly into the bibliographic records of MEDLINE and TOXLINE. For example, MEDLINE abstracts on the health effects of vinyl chloride would have links to the factual information on the chemical in the TOXNET databases. Such a system of links could be similar to the extensive linkages between MEDLINE and the National Center for Biotechnology Information's ENTREZ* databases now available in PubMed. Additionally, future potential linkages could include links among the factual data in TOXNET, the bibliographic information in TOXLINE and MEDLINE, and chemical structure images, as well as the chemical identification files which include full records on the chemical synonyms (e.g., the ChemID database).

DATABASES

TOXNET is not a uniform set of databases because it has evolved, over time, from multiple sources and for a variety of purposes. This complexity is a challenge to the designers of the TOXNET Web site. They need to create an interface that masks differences and gives searchers both consistency and continuity in searching while allowing accessibility to the unique information in each database.

There are factors inherent in the structure of the TOXNET databases that currently limit the options for the Internet interface. One example is the display option. It would be preferable for the displayed results to state exactly how many pages are in the entire record and which page the display is currently on (e.g., "page 2 out of 6"). However, this change will require alterations to the database file structure and is considered a long-term goal.

*The National Center for Biotechnology Information's integrated database system, ENTREZ, allows retrieval of molecular biology data and bibliographic citations through the linkages of databases including PubMed, DNA sequences, protein sequences, genome and choromosome mapping data, and three-dimensional protein structures.

The committee is concerned in the long term with the subject coverage of the TOXNET system. Although the committee is aware that some of the TOXNET databases are also available through commercial vendors, the committee urges the relevant federal agencies to continue the availability of their databases through TOXNET. The free access available through the TOXNET Web site will provide numerous audiences (e.g., students, community organizations) with access to this information that may not otherwise be available. If databases, such as NIOSHTIC, become closed files and do not add new information, coverage of topics such as industrial hygiene and exposure assessment need to be expanded in HSDB and potentially in TOXLINE as well.

SEARCH INTERFACE

Chapter 2 noted a number of specific improvements to the current search interface. However, it is difficult to have a one-size-fits-all approach to database searching, and as expressed in the following quote, different types of search interfaces are needed to assist individuals with varying levels of expertise.

> The Great Law of Usability: A user with appropriate knowledge or expertise in the area of application but having no experience with the system should be able to use it effectively without assistance or instruction.
>
> The Lesser Law of Usability: The system should not substantially impede or interfere with efficient and sophisticated use by experienced users (Constantine and Lockwood, 1997).

NLM's staff has recognized this need and has indicated that plans for additional search interfaces are under consideration. The committee has discussed the varying audiences that could potentially use the TOXNET databases and recommends the development of three levels of search interfaces. The audiences served may vary in both the depth of knowledge of the subject and depth of expertise in database searching. The committee acknowledges that each Web search engine (e.g., PubMed, Yahoo, Alta Vista) utilizes a different combination of search features and urges NLM to examine the trade-offs of each feature. As noted earlier, an implicit criteria for selecting search features should be the aligning of the TOXNET interface with other NLM Internet search interfaces so that the searcher can easily search all NLM databases on the Internet.

Quick Search

The most basic interface would be a Simple Search or Quick Search option, which would consist of one input box for entering all search terms. Examples include the initial screens for Alta Vista and PubMed. This option could serve the needs of a number of different types of searchers, including new searchers

who want to initially explore the TOXNET databases and students or others who have a simple query. The Quick Search option should support simple Boolean searching. The subsequent screens that display the search results should provide simplified instructions and links to the other levels of search interfaces for more in-depth searches. This option would work best as a one-search that searches all of the TOXNET databases at one time. The committee envisioned the Quick Search as being directly displayed on the TOXNET homepage. The other two interfaces described below would be briefly described on the homepage with links to the search screens for each interface.

Step-by-Step Search

A second type of search interface would be the Step-by-Step Search, which would have detailed instructions to "walk" the searcher through each step of the search process. This search level would be geared to the novice or infrequent searcher who wants to have substantive retrieval but is not familiar with the databases. The first step of selecting the databases would clearly explain the strengths and limitations of each database, the types of information available, and the types of queries best answered by each database. At the next step of entering the search terms, the screens would explain all of the options for Boolean searching and narrowing the search strategy (such as through the use of the customized display option). Explanations would be provided for each of the different display, printing, and downloading options. Explanatory pages could be customized to each of the TOXNET databases to allow for the most precise searching possible. As the technological capabilities to handle natural language searching evolve, it will be important to add this component to the interface.

Advanced Search

The third level interface would be for the advanced search and would offer the complexity needed to equal the specificity and the power of the command line interface. In presentations to the committee regarding the Web site, NLM's staff indicated that future plans include an advanced search screen. This interface may be structured like the Internet Grateful Med interface, with multiple input boxes for complex searching, or like the PubMed Advanced Search option, with simple but powerful capabilities. Examples of search features to incorporate into this interface include:

- simple and nested Boolean searching;
- chemical name fragment searching;
- field searching;

- fuzzy searching to compensate for typing and spelling errors;
- range and ordering options for numeric and date fields;
- truncation, including wild card, left, and right truncation to allow for variations of a term, prefixes, suffixes, and characters within a word;
- phrase searching;
- proximity searching; and
- numeric operators.

EDUCATIONAL COMPONENTS

The use of the Internet opens up multiple opportunities for providing the educational information that searchers need. In the case of the TOXNET databases, two types of educational components are needed: those that provide further details on searching the TOXNET databases to allow searchers to improve their search skills and those that provide further information on the subject of toxicology and environmental health to allow searchers to better understand the information they are retrieving.

Online Help

Although there is a wealth of useful and relevant material in the current Online Help screens of the TOXNET Web site, it does not appear that they will be fully utilized in their current format. One barrier for using the help information on this Web site may be the term "Online Help." Searchers frequently did not click the Online Help button because they thought it would have information that would be useful only for trouble-shooting problems rather than for proactively assisting the searcher in planning and executing a search.

The most useful format for help information would be context-sensitive help that would provide detailed assistance on the specific problem encountered. This approach may be considered a long-term goal because it will require detailed programming. A short-term approach to solving this problem would be to integrate links to the help information directly into the search screens. For example, the phrase "Display Results As" or "Look For" could become a link to the help information on the display options or Boolean operators already available. Creative use of links to the help information is vital to assist searchers in navigating through the TOXNET search process.

Tutorials

The Specialized Information Services Division has invested in the development of Toxicology Tutor (http://sis.nlm.nih.gov/toxtutr1). This web-based tutorial offers an introductory college-level approach to the basic principles of

toxicology. The committee believes that this tutorial serves an important purpose and urges that it be maintained and updated.

Additionally, the committee believes that an investment should be made in a tutorial that will introduce the TOXNET databases and explain the steps needed to search the Web site. Although one of the goals of developing multiple levels of search interfaces, as described previously, is to assist the searcher at the time of the search process, a tutorial is frequently the best approach for providing additional search assistance and serving outreach purposes (Chapter 4). The

tutorial can serve as a ready-made demonstration tool for instructors, librarians, community leaders, and others who want to increase awareness of the TOXNET databases and the information that is available. Examples used in a search tutorial should feature realistic scenarios and demonstrate searching both by chemical name and by health effect.

Links

The committee believes that hypertext links on the TOXNET Web site to Web sites outside NLM should be used primarily to provide the searcher with access to other environmental health databases that are comparable to the TOXNET databases (e.g., the Agency for Toxic Substances and Disease Registry's HAZDAT [Hazardous Substance Release/Health Effects], the Environmental Protection Agency's Envirofacts, and the Environmental Defense Fund's Chemical Scorecard). Additionally, links to Web sites that provide educational information on environmental health issues should be considered and evaluated. Chapter 4 discusses links from other Web sites to TOXNET.

ADDED ENHANCEMENTS

Once a number of the short-term improvements to the TOXNET Web site are implemented, several enhancements should be considered to improve the quality and efficiency of the search process. As Internet capabilities and technologies improve, the committee hopes that the TOXNET databases will be included in all enhancements.

Cross-Database Searching in TOXNET

As described previously as a distant goal for all the NLM databases, it would be preferable for the user not to face the dilemma of choosing a database,

but, rather, have the capability to search all of the databases at once. This same goal of cross-database searching may be achieved first across the TOXNET system. Since the TOXNET databases contain the common field of the chemical Registry Number, it has been possible in the menu-searching mode to search several databases at once. It is important for cross-database searching to incorporate features to allow the searcher to eliminate duplicate records and to select only the records that are unique (e.g., choose those records in DART that are not in MEDLINE). Cross-database searching is under consideration by the NLM staff as a future step for the TOXNET Web site, and the committee urges efforts towards this goal.

Thesaurus and Chemical Dictionary

Inherent difficulties in searches involving chemical names include the complexity of chemical terms and the numerous synonyms involved. The committee encourages all attempts to utilize Internet technology to minimize these complexities. NLM's ChemID database links the Registry Number to the multiple synonyms for that chemical and will be a useful feature when incorporated into the TOXNET Web site. To enhance TOXNET searching to meet the needs of health professionals and others, it will be important to include as many common term and brand name synonyms as possible.

The committee urges the exploration of ways to utilize the UMLS (Unified Medical Language System) Metathesaurus for searching the TOXNET databases. This may involve expansion of the Metathesaurus to further include chemical and environmental health vocabularies. Since the TOXNET records do not contain MeSH (NLM Medical Subject Headings) terms, it is particularly important for the TOXNET searcher to be able to locate synonymous terms, identify hierarchical relationships among chemical terms, and see relationships among subject terms. Incorporation of the Metathesaurus in TOXNET, as currently available in Internet Grateful Med and PubMed, would be an eventual goal.

Search Analysis

A further enhancement to the TOXNET Web site would be a feature, similar to the PubMed and Internet Grateful Med Details Screens, that provides an analysis of the search conducted. Information is included on the number of hits or citations found for each query term, and details are given on how the system translated the search terms. An analysis may offer suggestions for expanding or narrowing the search results and may feature an option for weighting the various search terms and synonyms (i.e., allowing the searcher to specify that one term is more important than another) such as that available in Alta Vista's Refine option.

Hypertext Links Among Records

The use of hypertext links among MEDLINE, TOXLINE, TOXNET, and other records can provide the searcher with additional information and paths to pursue to locate related information without constructing a new search strategy. This use of linkages was discussed above as a way to integrate TOXNET into the overall NLM Web site. Linkages to consider include:

- links from the citations referenced in the TOXNET database records to the bibliographic records in MEDLINE or TOXLINE;
- links from MEDLINE or TOXLINE abstracts on specific chemicals to the TOXNET records on those chemicals;
- links among records for related chemicals; and
- links from MEDLINE, TOXLINE, or TOXNET records to related chemical dictionary records.

The committee believes that the use of the Internet as a platform for the TOXNET databases opens up numerous possibilities for enhancing their accessibility and utility. It is hoped that resources will be made available to the Specialized Information Services Division so that these opportunities can be explored and implemented. Further, as technology evolves, it is hoped that TOXNET will be integrated into plans for the overall NLM Web site and included in the use of new Internet technologies at the Library.

Raising Awareness: Training and Outreach

The TOXNET Web site offers information that is useful to a broad range of health professionals, researchers, community organizations, and other individuals and groups. Moving TOXNET from a fee-based, command-line system to free access and searching via the Internet greatly enhances accessibility of the information and offers the opportunity for expanding the audience. The committee hopes that NLM will take the opportunity presented by the new TOXNET Web site to raise awareness about this valuable information resource.

The goals for training overlap with the goals of an extended outreach program—to spread awareness of the TOXNET Web site and increase use of the information. To effectively increase training and outreach efforts for TOXNET, additional staff are needed by the Specialized Information Services Division.

TRAINING

Although a goal of the TOXNET Web site should be to minimize the training required to search the databases, a certain amount of training will still be necessary, at least initially. Of particular importance are train-the-trainer sessions because participants can then expand the capability to train others. The Toxicology Information Outreach Project, NLM's Regional Medical Libraries and the National Network of Libraries of Medicine, and Partners in Information Access for Public Health Professionals can all be utilized to enhance training efforts. In addition, the committee recommends a Web-based tutorial be developed.

Toxicology Information Outreach Project

The Division of Specialized Information Services began the Toxicology Information Outreach Project with Historically Black Colleges and Universities (HBCUs) in 1991. This project initially provided hardware, software, training, and access to the TOXNET databases at nine HBCUs. Since then, the project has expanded its training focus and, in joint training sessions with the Agency for Toxic Substances and Disease Registry (ATSDR), has provided training on toxicology and environmental health information resources for over 44 HBCUs. It is hoped that future plans for this outreach project will include sessions that inform instructors and students about the new TOXNET Web site and provide train-the-trainer sessions.

Regional Medical Libraries and the National Network of Libraries of Medicine

NLM works with and through an extensive regional and local medical library network. The eight Regional Medical Libraries (RMLs) and the over 4,500 medical libraries in the National Network of Libraries of Medicine (NNLM) provide an outstanding resource for outreach and training opportunities. Utilization of this network can be enhanced by training sessions for RML and NNLM librarians and by focused funding to RMLs that would provide resources for exhibiting the TOXNET Web site at regional and local environmental health meetings.

Partners in Information Access for Public Health Professionals

A cooperative project has been developed among NLM, the Association of State and Territorial Health Officials (ASTHO), the Centers for Disease Control and Prevention (CDC), the National Association of County and City Health Officials (NACCHO), and the National Network of Libraries of Medicine (NNLM) (Partners in Information Access, 1998). The goal of this project, Partners in Information Access for Public Health Professionals, is to provide public health professionals with access to the information resources they need. Specific activities to date have included regional training programs on public health information resources, development of distance learning materials, and development of a Web site and links among the sponsoring organizations. This partnership offers the opportunity to reach a group of health professionals who

work directly on environmental health issues. The committee believes that training on TOXNET is a natural fit with the mission of this partnership and hopes a number of activities and links will be developed and implemented.

Tutorials

As mentioned in Chapter 3, it is important to have a ready-made tutorial, available via the Internet, that can be utilized by teachers, librarians, individuals making presentations to community groups, and others. This tutorial could offer several scenarios focused on real-world environmental health issues and could demonstrate the types of information available in the TOXNET databases. Such a tutorial would make it easy for community groups, health professionals, and others to put together a presentation and would be a valuable tool in outreach and training efforts.

OUTREACH

To maximize outreach efforts and raise awareness of the TOXNET Web site, it is important to take advantage of the many existing organizations, agencies, Web sites, and publications that reach the varied audiences for toxicology and environmental health information. Because environmental health concerns are frequently focused on local and regional issues, it is particularly important to reach regional, state, and local environmental health organizations. Outreach can take multiple forms including articles for newsletters, news columns, and journals (including Internet journals); hypertext links from the organization's Web site to TOXNET; brochures, news releases, and handouts; and presentations, seminars, and exhibits at conferences or meetings.

Reaching the numerous individuals and groups involved in environmental health issues poses a challenge when resources are limited. However, the Internet can go a long way in serving as a cost-effective mechanism for marketing the TOXNET Web site. As mentioned in Chapter 3, key hypertext linkages within the overall NLM Web site are crucial, including links to TOXNET from the homepages of NLM, Internet Grateful Med, and PubMed. Additionally, it is important to have links from other environmental health Web sites to TOXNET. Although adding a link to TOXNET is done at the discretion of the host site, the minimal time and cost involved in adding a link makes it quite feasible. The challenge is to contact the relevant organizations and acquaint them with the wealth of information available on the TOXNET Web site. In addition to the following bulleted potential linkages, NLM should consider asking all Web sites that link to PubMed or Internet Grateful Med to add a link to the TOXNET Web site.

The committee did not make an exhaustive list of all of the organizations that should be contacted for outreach efforts, but it did start a list that can be

expanded. Outreach efforts can be targeted to reach each group as most appropriate, either via the Internet, printed materials, presentations, or exhibits. Organizations to involve in outreach efforts for TOXNET include:

- academic and public libraries (NLM has recently announced a pilot project with 37 public libraries across the United States to increase awareness of Internet health resources [http://www.nlm.nih.gov/news/press_releases/access.html]);
- high schools and universities;
- federal agencies involved directly in environmental and occupational health issues and specific programs within those agencies, such as the Environmental Protection Agency (EPA), Agency for Toxic Substances and Disease Registry (ATSDR), National Institute for Occupational Safety and Health (NIOSH), National Institute of Environmental Health Sciences (NIEHS), Occupational Safety and Health Administration (OSHA), and EPA's Environmental Justice Advisory Council and Advisory Subcommittees;
- state and local environmental and public health agencies, the Environmental Council of States;
- nonprofit organizations and networks (e.g., Environmental Defense Fund, National Wildlife Federation, League of Women Voters, Nature Conservancy, Right-to-Know Network, Sierra Club);
- industry and related organizations (e.g., Chemical Manufacturers Association, Pharmaceutical Research and Manufacturers of America); and
- professional associations (e.g., American Academy of Clinical Toxicology, American Academy of Pediatrics, American Association of Occupational Health Nurses, American Association of Poison Control Centers, American Bar Association, American College of Emergency Physicians, American College of Medical Toxicology, American College of Occupational and Environmental Medicine, American Industrial Hygiene Association, American Public Health Association, Association of Occupational and Environmental Clinics, Association of Teachers of Preventive Medicine, National Science Teachers Association, Society of Environmental Journalists).

CONCLUSION

The committee believes that the TOXNET databases offer a wealth of information to a broad range of individuals and organizations, and it applauds the Specialized Information Services Division and NLM for expanding access to TOXNET through the development of an Internet Web site. There are a number of short- and long-term changes to the TOXNET Web site that, if implemented, will increase the ease of searching the databases and will increase the searcher's efficiency in retrieving the information he or she requires.

Establishment of the TOXNET Web site offers an opportunity to raise awareness about the TOXNET databases. The committee hopes that NLM will take advantage of this opportunity to broaden its outreach and training efforts. At the same time, it is hoped that the search interface will continue to evolve and that NLM will continue to integrate the TOXNET information into its overall Web site and its plans for the future.

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APPENDIX A

Acknowledgments

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APPENDIX B

Search Questions

PRE-SEARCH QUESTIONS

1. **Please check the ONE category below that best describes you:**

___ Primary health care professional
___ Health professional specializing in occupational/environmental health
___ Emergency medicine or poison control specialist
___ Health sciences librarian
___ Environmental health researcher or scientist
___ Patient or community organization member
___ Local, state, or federal public health professional
___ Other (*please specify*)

2. **Your age _____**

3. **How would you describe your level of experience with the Internet?**

___ None/basic
___ Intermediate
___ Advanced

4. **Please indicate your online searching experience.**

___ No online searching
___ General World Wide Web search engines (e.g., Yahoo, Alta Vista)
___ MEDLINE primarily but occasionally other online databases
___ MEDLINE only
___ Numerous online databases

5. **If you use databases to locate toxicological and environmental health information, which ones do you use?** *Please check all that apply***.**

___ I haven't used databases to find toxicological/environmental health information
___ MEDLINE through Internet Grateful Med
___ MEDLINE through PubMed
___ MEDLINE through other sources
___ TOXLINE
___ NIOSHTIC
___ Poisindex/TOMES

TOXNET databases:
___ CCRIS
___ HSDB
___ GENETOX
___ IRIS
___ RTECS
___ Other (please specify)_____

6. **Please check the main ways you use toxicological/environmental health information**. *Please check all that apply.*
___ Patient care
___ Teaching/education
___ Clinical research
___ Policy decisions
___ Basic research
___ Risk analysis
___ Worker safety
___ Retrieve information for others (e.g., library searching)
___ Concerns about my family's health
___ Concerns about my health
___ Conditions in my workplace
___ Community/advocacy
___ School work
___ Conditions in my area/neighborhood
___ Other (*please specify*)_____

Search Scenarios

Please conduct searches of the new interface to answer questions 1 and 2 below. Also conduct a third search using a toxicology/environmental question of your own choosing. As you search, please explain to the IOM staff member what you are doing and note any problems you are experiencing or ideas you have on improving the search interface. Thanks!

1. What is the potential for vinyl chloride to cause liver cancer in humans?

2. What are the potential health effects of working as a dry cleaner?

3. Your choice: Please write down your search question.

POST-SEARCH QUESTIONS

1. The problems I experienced were (please be as specific as possible):

General Problem	Specific Details
__ Selecting a database	
__ Composing a search statement or search strategy	
__ Displaying the search results on the screen	
__ Modifying/rewording the search strategy	
__ Printing search results	
__ Evaluating the search results	
__ Other	