Haz-Map

A useful tool for SH&E professionals

By Jay A. Brown

Abstract: *Haz-Map, a decision-support relational database, was designed to help physicians and other safety and health professionals retrieve information about hazardous chemicals and occupational diseases. The database features a collection of key facts from industrial hygiene, epidemiology and other health sciences for the prevention of diseases in the workplace. Users can find information by browsing categories or querying the database. The free, open-access database is published on the National Library of Medicine website.*

IMAGINE TRYING TO FIND a food item, a can of tennis balls, a bookcase, a bathing suit, or a needle and thread in a big-box store that has no marked sections or categories. This is similar to the challenge faced by those looking for information about the health effects after an occupational exposure. The information is scattered among various books, journals, databases and websites—and generally it has not been summarized nor indexed for easy access.

Haz-Map is a decision-support computer application for occupational safety and health professionals. Its aim is to help them recognize and prevent diseases caused by chemical and biological agents in the workplace. Since its publication on the National Library of Medicine (NLM) website (http://hazmap.nlm.nih.gov) in 2002 as a free, open-access database, Haz-Map has also served the general public and is being used by the Department of Labor in the Energy Employees Occupational Illness Compensation Program (EEOICP) (DOL, 2007) .

The information in the database was comprehensively collected and indexed. It was designed to help users quickly drill down to the needed information. Users can find information about diseases or chemicals by text searching, browsing categories or querying the database. Queries make use of pick lists and drop-down lists to find chemicals (by adverse effect or process) and diseases (by symptom or job).

Origin & Purpose of Haz-Map

Haz-Map began in 1991 with about 700 chemicals from the NIOSH Pocket Guide (NIOSH, 2007a). The next addition was all agents—both chemical and biological—known to cause adverse effects (e.g., work-related asthma, contact dermatitis, toxic hepatitis). Throughout its development, the primary objective has been to accurately represent (or map) the current state of scientific knowledge about hazardous agents in the workplace.

The concept of an "intelligent database" was important in visualizing what this tool would become. This concept was introduced by Parsaye and Chignell (1993), who write, "Intelligent databases are databases that manage information in a natural way, making information easy to store, access and use" (p. 4). They also state:

> Early maps only showed a few well-known features like the "Pillars of Hercules" (the modern Straits of Gibraltar) or the island of Sicily. Once the map was outlined in terms of its major features, succeeding generations of mapmakers filled in the details, and the coastlines, mountains and river systems slowly became more precisely defined. Similarly, the concentric designer begins by sketching out the main features, based on the key constraints, and then successively elaborates these until the details are crystallized (p. 53).

Like a map, Haz-Map portrays details in the context of the whole domain of occupational toxicology and work-related diseases. Because of this concentric design, users can zoom in and out between the big picture and the details. For example, users can survey a list of all 225 diseases in the database or drill down to the 15 diseases in the category "chronic poisoning."

Information that is included or excluded in an intelligent database is defined by the purpose of the map. The purpose of Haz-Map is decision support for safety and health professionals. It is meant to provide easy access to key information.

The philosophy of decision-support software is to harness the computer as a tool for the natural intelligence of the human mind. The intention is not to replace the professional with artificial intelligence, rather it is to take advantage of a computer's capacity to store information and to make it as easy as possible to access that information.

Haz-Map contains no hidden algorithms. A query results in a list or an intersection of lists. For example, searching for all occupational diseases that have cough as a symptom will return one query result. Searching for all work-related diseases of carpenters will return another result. Putting the two criteria together in an "AND" search will yield all diseases associated with both carpenters and cough. While the sorting could be done manually, the computer does it instantly.

The goal of this database tool is to help users identify and prevent occupational diseases. All occupational diseases are preventable by reducing or eliminating hazardous exposures in the workplace. Early recognition of an occupational disease in one worker can lead to prevention of it in others.

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Use of Categories & Controlled Vocabulary in Haz-Map

All information in the database is classified into categories (Table 1. p. 26). The nine major categories of chemical and biological agents are subdivided into 106 minor categories. Diseases are divided into nine categories.

Haz-Map was built for queries and it uses a controlled vocabulary to systematically index the information it contains. To produce a controlled vocabulary for queries in a relational database, text-based information must be transformed into structured and unambiguous indexes. The names of chemicals, diseases, findings, jobs, industries and processes are all indexes.

Each chemical is flagged for the presence or absence of adverse effects, including:

- lung toxin (asthma, pneumonitis, chronic bronchitis, fibrosis, and cancer);
- neurotoxin (neuropathy, Parkinson's syndrome, CNS solvent syndrome);
- hematotoxin (methemoglobinemia and aplastic or hemolytic anemia);
- dermatotoxin (contact dermatitis, chloracne or skin burns);
- carcinogen (known, probable or possible);
- other tissue toxin (hepatotoxin, nephrotoxin and reproductive toxin);
- other poison (organophosphate, carbamate, organochlorine, uncoupler, chemical asphyxiant and simple asphyxiant).

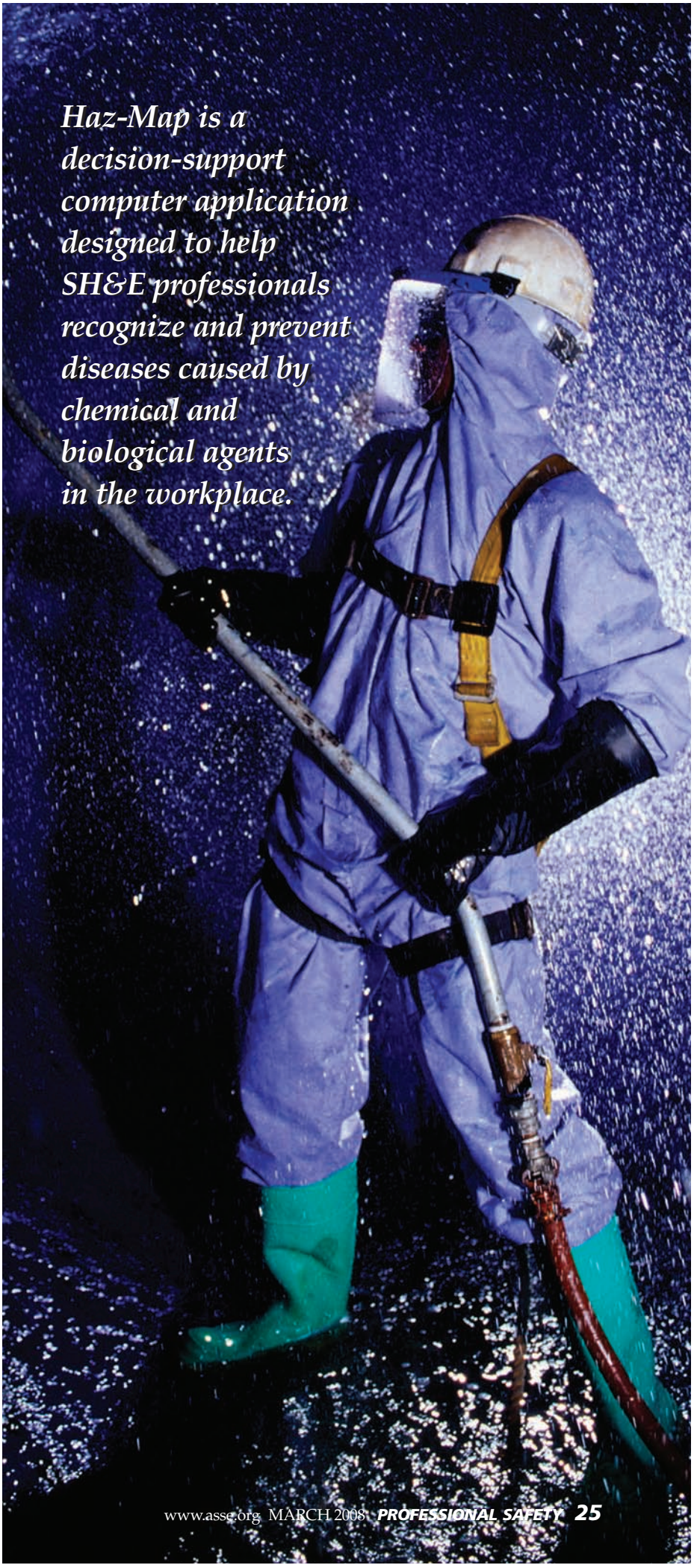
In addition to adverse effects, the agents table has fields to show all available information about properties, thresholds and exposure limits.

Database Structure & Relationships

The database currently contains 1,534 chemical and biological agents, 224 diseases, 122 findings (signs and symptoms), 277 jobs, 219 job tasks, 51 industrial processes, 624 industries and 26 nonoccupational activities. The relationships of the tables in the database are shown in Figure 1 (p. 26). Diseases, occupations and industries are defined and coded according to ICD-9 (U.S. Public Health Service and Health Care Financing Administration, 2007), the standard occupational classification system (Bureau of Labor Statistics, 2000) and North American Industrial Classification System (NAICS Association, 2002), respectively.

The two levels of information in Haz-Map are chemicals (the industrial hygiene perspective) and diseases (the epidemiologic perspective). For the 1,534 chemical and biological agents, information includes uses, adverse effects, associated industrial processes and threshold values useful for exposure assessment. For the 224 occupational diseases, information includes associated symptoms, high-risk job tasks, jobs and industries. A premium is placed on information that helps the user distinguish between significant and harmless exposures.

Notice in Figure 1 that bidirectional arrows indicate that users can find all chemicals linked to each



disease and all diseases linked to each chemical. Similarly, they can see all findings of a disease or all diseases with the finding.

Agents in the database are linked to industrial processes and nonoccupational activities. Linkage indicates the potential for exposure to the agent. As noted, each agent in the database is flagged for adverse effects including asthma, pneumonitis, neuropathy, anemia, hepatotoxicity and skin sensitization.

Agents are also linked to occupational diseases. Linkage between a chemical or biological agent and a disease indicates that sufficient exposure to the agent is associated with increased risk of developing the disease. For chronic diseases, linkage between an agent and a disease means that a causal relationship has been determined based on human case reports or epidemiological studies.

Carcinogens are linked only if they have been designated as known human carcinogens by the International Agency for Research in Cancer (IARC, 2007). Although the database includes the carcinogen designations of the American Conference of Governmental Industrial Hygienists (ACGIH) and the National Toxicology Program, the IARC designations are used to determine the linkage between specific chemicals and specific occupational cancers. In some cases, IARC does not list the target organs, but Haz-Map follows the interpretation published in *Cancer Epidemiology and Prevention* (Schottenfeld & Fraumeni, 2006). Linkage between acute diseases and chemicals is also, for the most part, based on reports of cases in humans.

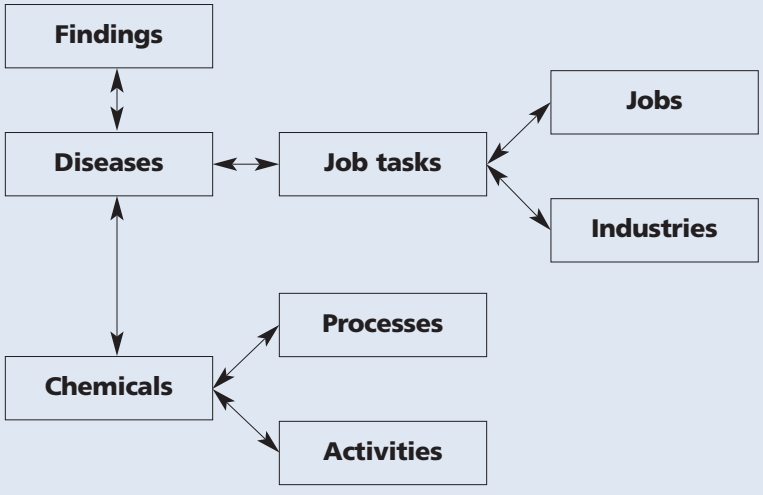
Table 1

Agent & Disease Categories

Agent major categories	Disease categories
Biological agents	Acute poison
Metals	Airway disease
Mineral dusts	Cancer, occupational
Nitrogen compounds	Chronic poison
Other chemicals	Hypersensitivity pneumonitis
Pesticides	Infection, occupational
Plastics and rubber	Interstitial lung disease
Solvents	Poisoning, heavy metal
Toxic gases and vapors	Skin disease

Figure 1

Two Levels of Information in Haz-Map: Diseases & Chemicals



Note. *A bidirectional arrow represents a many-to-many relationship between two tables. The "Chemicals" table is also referred to as the "Agents" table.*

Information Sources & Content

Information from occupational medicine textbooks, journal articles and electronic databases was classified and summarized to create the database. A bibliography including online resources is regularly updated at http://hazmap.nlm.nih.gov/hazref.html (NLM, 2007a). This page also shows the reference tags (highlighted in bold font) that are used throughout the database to reference the source material [e.g., Agency for Toxic Substances and Disease Registry (ATSDR) case studies] (ATSDR, 2007).

In addition, several databases were used heavily in the early developmental stages (ATSDR, 2006, 2007; NLM, 2007b; ACGIH, 2005; NIOSH, 1997b), as were occupational medicine textbooks (LaDou, 2007; Rom, 2007; Rosenstock, Cullen, Brodkin, et al., 2004; Sullivan & Krieger, 2001). Other databases have been used extensively in recent years (NIOSH, 2007; EPA, 2007; Extension Toxicology Network, 1996; U.S. Department of Transportation, 2004). References for infectious diseases included *Control of Communicable Diseases Manual* (Heymann, 2004).

Limitations of Haz-Map

Epidemiology is the study of the patterns of diseases in populations. It relies on scientific observational studies that reveal associations between diseases and risk factors. Industrial hygiene focuses on chemicals and their potential adverse effects in exposed humans. It is important to keep in mind the two levels of information in the database. The database was not designed to list every possible disease for each job.

For example, logging workers running chain saws are exposed to carbon monoxide and there is the potential for adverse effects. However, the job task "Operate internal combustion engine with inadequate ventilation" is not linked to logging workers because they work outdoors. In other words, a disease is linked to a job only if one of the high-risk job tasks of that disease is likely to be performed by workers doing that job.

It is also important to remember that Haz-Map is a map. A highway map of the U.S. is useful if it accurately shows the main roads between major cities. It would be less useful if had too much detail, showing

every small town, lake and dirt road. The goal is not to list every disease that could possibly be work-related, but to focus on established occupational diseases and their causes. From the point of view of epidemiology and occupational disease surveillance, what are the most common work-related diseases? For each occupational disease, which jobs have the highest risk? Within each job, what are the job tasks or conditions that put the workers at risk?

Updating the Database & Use by the Department of Labor

The content of Haz-Map is continuously revised, updated and expanded. At this time, it is published only by NLM (2007c). In 2002, the author performed an extensive review of the scientific literature from 1998 to 2002 using PubMed (NLM, 2007d) and NIOSHTIC (NIOSH, 1997b) to yield 696 abstracts and 216 full-text articles. The purpose of the review was to supplement information from occupational medicine textbooks and electronic databases. As a result of the review, some content was changed and hyperlinks to PubMed abstracts were added. Systematic reviews of key journals relating to occupational toxicology, industrial hygiene, epidemiology and occupational medicine will be made in the future.

In 2004, 88 new agents and 6 new diseases were added to the database. Many of the new agents were known causes of occupational contact dermatitis, a common work-related disease. In 2005, the revision focused on occupational infections. The 87 occupational infections were revised, and 18 "travel infections" were added. In 2006, 184 agents were added to the database, including 98 from NLM's (2007e) WISER database and 53 from the *2004 Emergency Response Guidebook* (U.S. DOT, 2004) to strengthen the database as a tool for emergency responders.

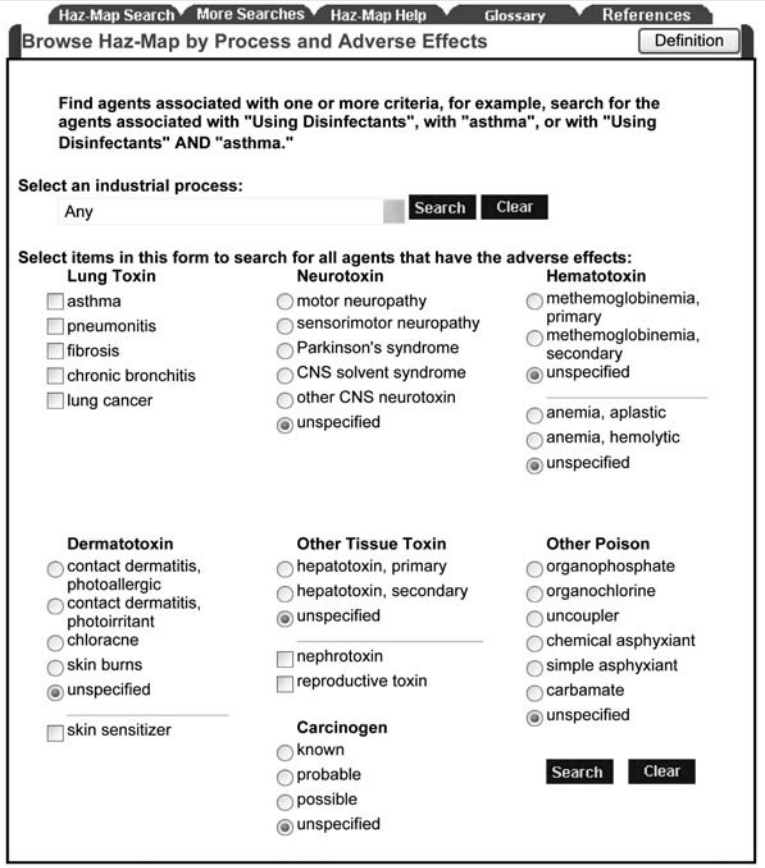
In April 2007, 94 chemical and biological agents —including 54 radioactive substances—were added. Two new diseases were added (bronchiolitis obliterans and pneumoconioses, other) and bronchitis, chronic, was revised and renamed pulmonary disease, chronic obstructive. The causes of asthma, occupational, and contact urticaria were revised based on the newest editions of reference texts (Bernstein, Chan-Yeung, Malo, et al., 2006; Kanerva, Elsner, Wahlberg, et al., 2004). Haz-Map currently has 258 chemical and biological agents linked to the disease occupational asthma; 107 agents linked to the disease contact urticaria; and 387 agents linked to the disease allergic contact dermatitis.

During the past 2 years, the agent-disease links from Haz-Map have been incorporated into the Department of Labor's Site Exposure Matrices (SEM) database, currently being used for the EEOICP. EEOICP provides financial and technical support to the continued development of the content of Haz-Map consistent with the way it has been developed in the past. New agents and their health effects are being added to the database based on chemicals used at Department of Energy sites where claimants worked.

Using this process, it is anticipated that approximately 200 chemicals and their related health effects will be incorporated into SEM each year. It is hoped that this coordinated effort will result in more accurate, comprehensive scientific knowledge which can serve as a stronger foundation for preventive and regulatory action.

Figure 2

Haz-Map: By Adverse Effects



Examples of How It Works

The home page for the Internet user interface is http://hazmap.nlm.nih.gov. At the top of the first page is a search box. By clicking the text search icon after typing a word, all text fields in all tables will be searched. Hazardous agents can be browsed by options such as by types of agents, by adverse effects and alphabetically; browse options for occupational diseases include by types of disease, by jobs and symptoms, and alphabetically.

Figure 2 shows what a user will see after selecting the "By Adverse Effects" hyperlink on the Haz-Map home page. What is not shown is the drop-down list of industrial processes that can also be used in a query. Try the following examples to practice using the web interface:

1) What chemicals are used as disinfectants?

2) Which disinfectants are known to cause occupational asthma?

3) Which chemicals could cause toxic pneumonitis?

4) Which diseases are linked to carpenters and cough?

5) What hazards are associated with welding?

6) What hazards are associated with metalworking fluids?

7) What is the biological exposure index (BEI) for cadmium?

8) What are the signs and symptoms of lead poisoning?

9) Which ketones are in the database?

10) After a spill of toluene in an enclosed space, what is the potential air concentration? Is this concentration above or below the odor threshold, TLV, IDLH, RD_{50} and LC_{50}?

Hints for Each Example

1) Click the "By Adverse Effects" hyperlink, then find "Using Disinfectants" in the drop-down list.

2) In addition, mark the check box for "asthma" on the adverse effects form.

3) Mark the check box for "pneumonitis" on the adverse effects form.

4) Click the hyperlink "By Jobs and Symptoms," find "carpenters" in the drop-down list and mark the "cough" check box.

5) Try a text search and a processes search for "weld." (To do processes searches, select the "more searches" tab.)

6) Try a text search for "metalworking."

7) Type "cadmium" in the search box and click the agent icon.

8) Type "lead" in the search box and click the disease icon.

9) Click the hyperlink "By Types of Agents," then the hyperlink "Solvents," then the hyperlink "Ketones."

10) Type "toluene," then click the "Agent" icon. Vapor pressure (VP) is a measure of a chemical's volatility at standard room temperature (68 °F). VP x 1300 = the saturated concentration in ppm of the chemical after a spill in a confined space (Sullivan & Krieger, 2001, p. 34). The definitions of odor threshold, TLV, IDLH, RD_{50} and LC_{50} are listed in the glossary, which can be accessed from the home page.

Conclusion

Haz-Map is an example of an intelligent database that stores information for easy retrieval and decision support, and it shows the usefulness of mapping a complex knowledge domain using interrelated tables and a controlled vocabulary. The author hopes to make the map more comprehensive and more accurate as more is learned about the adverse effects of chemicals in the workplace. ■

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