Addiction Medicine
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Expert Systems in Treating Substance Abuse

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Computer programs can assist humans in solving complex problems that cannot be solved by traditional computational techniques using mathematic formulas. These programs, or "expert systems," are commonly used in finance, engineering, and computer design. Although not routinely used in medicine at present, medical expert systems have been developed to assist physicians in solving many kinds of medical problems that traditionally require consultation from a physician specialist. No expert systems are available specifically for drug abuse treatment, but at least one is under development. Where access to a physician specialist in substance abuse is not available for consultation, this expert system will extend specialized substance abuse treatment expertise to nonspecialists. Medical expert systems are a developing technologic tool that can assist physicians in practicing better medicine.

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An "expert system" is a specialized computer program that assists humans in solving difficult problems. Unlike a computer program that solves complex problems using mathematic equations, expert systems solve problems that cannot be reduced to precise mathematic formulas. In its problem-solving approach, an expert system emulates that of a human expert in some limited domain, such as an area of expertise. Like the human expert, an expert system processes information by applying general rules, sometimes called heuristics, to arrive at a recommended solution to a problem.

Expert systems have been developed to solve problems in finance, oil exploration, computer design, and medicine. Table 1 lists some of the medical expert systems that are available.

As in other areas of medicine, many problems in substance abuse treatment lend themselves to the expert system approach; however, no expert systems have been developed specifically to assist physicians in substance abuse treatment.

With grant support from the National Institute on Drug Abuse, we are developing an expert system to assist physicians in the detoxification process for patients who are withdrawing from drugs of abuse. This expert system, called DETOX, can be run by physicians on microcomputers to aid them in planning detoxification schedules. The development of this system was inspired by the following incident:

The patient, a 35-year-old woman admitted to an inpatient chemical dependence treatment program, had been ingesting 6 to 10 tablets of Fiorinal with Codeine* per day for 4 years before admission. The admitting physician wrote detoxification orders for the codeine but did not write sedative-hypnotic detoxification orders because he did not know that each Fiorinal tablet contains 50 mg of butalbital. As a result, the patient had a barbiturate withdrawal seizure on the second hospital day.

*Fiorinal with Codeine is a combination product containing codeine phosphate, butalbital, caffeine, and aspirin.

This case example illustrates one reason why an expert system for detoxification would be useful. No physician can possibly know the ingredients of all prescription medications. Improperly treated during withdrawal, a patient who is physically dependent on sedative-hypnotic agents may have major motor seizures or psychosis with abrupt withdrawal. Uncontrolled withdrawal from alcohol and some other sedative-hypnotics can be fatal. Yet, many prescription and street drugs contain sedative-hypnotics. Because an expert system can supply more information than any physician can possibly recall and can check that all pertinent information is considered, it can assist a physician in identifying medications containing sedative-hypnotics or street drugs and to arrive at the best clinical decision regarding detoxification.

Drug users are often treated by primary care physicians who do not specialize in treating drug abuse. Where a physician specialist in substance abuse cannot be readily consulted, expert systems provide a means of extending specialized expertise to nonspecialist physicians. Making detoxification more efficient can shorten inpatient treatment and lower the cost of treatment, an important consideration in an era of medical cost containment.

Expert Systems Versus Decision Support Systems

Expert systems are an extension of more traditional programs that physicians may use for decision support. A decision support system provides information. An example that might be familiar to many physicians is PDR (Medical Economics Company, Inc, Oradell, NJ), a microcomputer program that gives electronic access to drug interactions and side effects. The program is essentially an electronic *Physicians Desk Reference.* The program is a good example of a decision support program.

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An expert system also gives access to information, but it does more; it gives access to knowledge—relationships between facts and desired goals. This distinction between knowledge and information is crucial to understanding what expert systems offer that decision support systems do not. If a person wished to know the number of cities in the United States with populations greater than 10 million, he or she might consult an almanac, a source of facts or information. On the other hand, to determine the best route to drive from Los Angeles to New York City, a person would probably refer to a road map, a source of knowledge for solving specific kinds of problems. In this case the problems would be finding the best route from point A to point B, where "best" might mean shortest, quickest, most scenic, safest, or some combination.

A decision support system could scan a data base containing records of cities in the United States and their populations and count the number of cities with populations greater than 10 million. But an expert system would be needed to determine the best route from Los Angeles to New York City under specified constraints. From a functional standpoint, decision support systems state facts, whereas expert systems form opinions based on expert knowledge.

Expert systems, of course, also require access to information. In this sense, they are extensions of decision support systems. They contain knowledge as well, which can be in two forms: declarative and procedural. Declarative knowledge is in the form of associations between entities used in the reasoning process and their various properties. Procedural knowledge is in the form of step-by-step methods for determining a given piece of information.

The use of an expert system has many advantages, even for a domain expert (Table 2).

TABLE 1.—*Examples of Medical Expert Systems*

Expert System	*Knowledge Domain*	*Source*
DXplain	Medical diagnosis	Barnett et al, 1987[1]
INTERNIST-1	Internal medicine	Miller et al, 1982[2]
MYCIN	Infectious diseases	Shortliffe, 1976[3]
CASNET	Glaucoma diagnosis	Kulikowski and Weiss, 1982[4]
ABEL	Acid-base and electrolyte disorders	Patil and Senyk, 1988[5]
ONCOCIN	Treatment of cancer	Shortliffe et al, 1984[6]

TABLE 2.—*Advantages of Using Medical Expert Systems*

Make available the combined expertise of leading experts in the field
Factual and procedural knowledge is always available and consistently applied
All the relevant facts are used in formulating the medication treatment plan
The steps in the problem-solving process are documented
Some of the patient record-keeping is automated
Nonexperts can achieve high levels of problem-solving performance
The human expert can have more time to devote to difficult clinical problems

The Development of DETOX

In developing an expert system, a "knowledge engineer" collaborates with a domain expert to elicit the declarative and procedural knowledge that can be represented in a computer program language. In the case of our expert system, we used case histories to elicit the knowledge from the domain expert (D.R.W.). Using a think-aloud technique, the knowledge engineer (R.F.H.) requested that the domain expert actually plan a detoxification process from hypothetical case material. The domain expert described his reasoning verbally while he was working on the problem. The knowledge engineer analyzed notes or tape transcripts of the interview using the methods of protocol analysis to uncover the concepts, facts, conjectures, and relationships used by the domain expert. Once the reasoning for a set of cases was established, the knowledge engineer modeled this reasoning by coding the knowledge employed into the program's knowledge base. The domain expert then reviewed the performance of the system and critiqued its behavior. The knowledge engineer made necessary modifications until the domain expert was satisfied that the system faithfully represented his reasoning. At this point, more cases were considered, and the process began another iteration.

TABLE 3.—*Physician Detoxification Options in the DETOX Program*

Drug Class	*Withdrawal Protocols Available*	*Comments*
Alcohol	Intermediate- and long-acting benzodiazepines	...
Beer, wine, liquors	Carbamazepine	
	Phenobarbital (available when alcohol is combined with other sedative-hypnotics)	
Amphetamine and cocaine	...	No specific withdrawal medication is recommended
Barbiturates	Phenobarbital	Taper of short-acting benzodiazepines is not recommended
Secobarbital (Seconal)	Butabarbital	
Pentobarbital (Nembutal)	Taper of barbiturate	
Benzodiazepines	Phenobarbital	Withdrawal from long-term, low-dose benzodiazepine use is supported
Alprazolam (Xanax)	Carbamazepine	
Clonazepam (Klonopin)	Taper of benzodiazepine	
Diazepam (Valium)	...	
Opiates	Clonidine HCl	Clonidine tablets and transdermal patches, alone or in combination
Heroin	Methadone HCl	
Oxycodone HCl	...	
Other sedative-hypnotics	Phenobarbital	...
Meprobamate	...	
Glutethimide	...	

HCl=hydrochloride

The case material covered both typical and atypical examples. A sufficient number of cases was reviewed to sample the entire domain, including its full range of task difficulty.

The process of writing detoxification schedules is divided into stages: acquiring the patient history, acquiring the drug history, acquiring the physician's medication preferences to be used in the detoxification, generating the detoxification orders, and printing out the results.

The patient's history consists of the standard information, such as age, weight, sex, blood pressure, temperature, allergies, and medical complications, that is obtained from every patient. A physician enters the information into the computer in response to prompts provided by the computer program. The user may recall this information later to make corrections.

The second stage is the acquisition of the patient's drug history. Four data bases are available to assist in this process. One data base references drug information by generic name, a second references trade names, a third cross-references street nomenclature for drugs and the generic names, and a fourth consists of information on alcohol-containing beverages. With these four data bases, the physician identifies the various substances that the patient typically uses.

For each substance identified, the physician is presented with a series of windows requesting information about the amount of drug consumed, the duration of drug use, and the daily time distribution of the total amount consumed.

When the physician is attempting to identify a substance by its street name, a window prompting the user for a purity estimate appears. Additional information on the street value of drugs is provided to assist the physician in converting dollar amounts to milligram amounts.

The third stage of the system is the generation of the detoxification plan. The physician is presented with a list of reasonable withdrawal substitutes based on a patient's drug history. The physician selects from the list, and the expert system produces the detoxification schedule, which is computed from the starting date provided by the physician. The detoxification schedule indicates the daily medication, dosage, and dispensing instructions.

As shown in Table 3, an expert system offers physicians several clinically acceptable withdrawal protocols. There are three such protocols for sedative-hypnotic withdrawal: the phenobarbital substitutions and withdrawal, substituting a sedative other than phenobarbital, and the gradual withdrawal of the drug of abuse. The physician may choose the protocol he or she prefers. The DETOX program also offers carbamazepine substitution for alcohol detoxification. For opiate withdrawal, there are protocols for using clonidine hydrochloride or methadone hydrochloride.

To support its recommendation and allow the physician to review the process, the expert system program also produces a summary of the calculations it did to arrive at its recommendations for detoxification. Finally, a natural language summary of the case is generated that incorporates information from the patient history and the drug history.

Our expert system has been tested by the domain expert. In more than 30 case histories tested, the expert has judged the program's recommendations to be safe and within the range of good medical practice.

The program will next be tested in actual clinical situations to see how physicians can best use the system. The expected benefits of an expert system are access to the combined expertise of leading experts in detoxification, accessibility to the current knowledge about detoxification, a consistent application of all clinically relevant information to a detoxification plan, documentation of the information and calculations used to derive the detoxification plan, and a reduction of paperwork.

The Future of Expert Systems in Medicine

Expert systems are not commonly used today in medicine, and it will probably be many years before their use becomes standard medical practice.

Before the invention of the computed tomographic scanner, no one would have predicted that computers would become indispensable to the practice of medicine. Now, computerized scanning of patients is routine medicine, and a failure to use such technology when indicated would constitute malpractice in some situations.

Expert systems are a beginning in applying another form of technology to assist physicians in managing the problems of treating substance abuse. Many more applications will no doubt be developed. In time, their use will become routine, perhaps even obligatory, in some types of clinical management problems.

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