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Computer Support for Management Decision Making in Family Practice

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Computers have been used in clinical medicine for several decades,[1] but with the recent advent of microcomputers and the dramatic drop in storage and hardware costs, the dissemination of computer technology has accelerated dramatically. Research on the role of computer-assisted decision making dates back over 15 years, with most of the early development based on large multiterminal systems, usually hospital based. A shift to ambulatory practice has, however, occurred recently.[2] Some of these systems have been sufficiently simplified to be accommodated on the small, commonly available microcomputer.

Assuming that the primary role of microcomputers in office practice is to facilitate better financial and office management, the aim of this article is to illustrate some of the applications that might in the future be used to extend such an office system. All of the applications described below have already undergone a considerable amount of preliminary development and are certain to be available for office use within five years. In some of the more elaborate programs, the microcomputer may intermittently access a larger mainframe computer elsewhere, but most programs will be available on conventional office computers.

Preventive Health Care and Health Maintenance

Much improvement in patient care can be achieved using the information storage and retrieval capacity of the computer. Files can be maintained for well-child screening and developmental assessments, immunizations,[3] and age-appropriate examinations including regular breast examination, annual mammography, cervical cytology, and influenza and pneumococcal vaccination in the elderly and in populations at risk for respiratory tract disease. The management of chronic disease can be aided by regular surveillance programs based on simple short checklists completed by the patient to ensure that, for example, patients with hypothyroidism, hypertension, and diabetes are regularly reviewed. The word-processing capacity of the computer can be used to generate individualized recall letters to patients in much the same way as billing is handled at present. More complex management strategies can be targeted by calculating patients' risk scores—for breast cancer or heart disease, for example. Practice-based performance measures can be used to make colleagues more mindful of the level of preventive health care currently achieved and to identify overuse of certain investigative facilities in the practice. With the advent of preferred provider organizations and the constantly varying remuneration policies of third-party carriers, it is likely that computer-based practice management systems will be used to ensure that the investigations ordered for patients fall within the remuneration policy of their third-party payers.

All of these systems are likely to be available commercially in the next year or two but could easily be developed by individual physicians with an interest in these issues. Such systems call for relatively simple program writing that is well within the capacity of the languages currently available on microcomputer systems.

Computer-Based History-Taking Systems

The clinical history has attracted research interest for some years aimed at finding a possible role for the computer. Interest in computer-based history-taking systems peaked in the late 1970s, but the transfer of systems from research to prac-

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tice has been quite limited. There are two main types of computer-based history-taking systems. The first computer-based interrogation involved the routine collection of data such as past history and demographic and specific facts such as alcohol or smoking history.[4] These data are routinely collected in many clinics by questionnaire or in person by front-office staff. Moving this collection process to the computer is relatively simple and can form the basis of a simple system of prevention and health maintenance as discussed above.

Conventional history taking can be characterized as an interactive dialogue between the physician and the patient. The second type of computer-based history-taking system is usually characterized as being on line and interactive with the patient responding to the computer directly at a terminal.[5] History-taking systems of the interactive type have been advocated as (1) saving the clinicians time, (2) allowing for sensitive information (for example in gynecological histories) to be elicited using an approach that is less threatening to patients,[5] (3) providing a certain amount of uniformity in the data collected, and (4) yielding a printed record for the chart. The speed of display can be varied according to the reaction time or the age of the patient.[6] Such systems are well accepted by 82 percent of patients, particularly those who are male, older, and less well educated, especially manual workers.[7,8]

Clinical usefulness has been a much more complex problem to evaluate. In general, the reaction of medical staff is not nearly so clear-cut as that of patients. There seems to be an initial enthusiastic response by clinicians, but eventually the limitations of the technique become irritating,[7] probably because the physician, when dealing with a patient, is following his or her own particular hypotheses and strategies.[9] The sequence in which the physician selects data is related to the need to confirm or refute such hypotheses. Data from automated history systems tend to disrupt this flow by following a preset, although flexible, interactive strategy. The routine interrogation of patients for basic clinical and demographic data seems likely to be transferred to computer systems, but the more elaborate interactive type of computer history taking is likely to have limited application[10] unless interactive history-taking systems can be tailored to the conventions and cognitive styles of the individual clinicians; that is, the computer must become an extension of the individual clinician's decision-making style.

Computer Diagnosis Systems

A source of a great deal of interest since the late 1960s, many computer diagnosis systems exist for the diagnosis of a wide range of biomedical diseases. These systems are usually based on probabilistic, Bayesian assumptions about the decision-making process. They are hampered largely by a very limited understanding of the clinical decision-making process itself.[9] Computer systems can certainly calculate diagnoses based on previously completed surveys of the disease being considered.[11] They can even select investigations, taking account of the cost of investigations and dramatically reducing the cost of making a diagnosis.[12] However, such systems bear a very superficial resemblance to the decision-making processes of the experienced clinician. Systems that are based purely on probabilities neglect the whole question of clinical goals and utilities. The questions clinicians ask and the tests they order are based on priorities pursued to maximize the benefit to patient and to minimize the cost of achieving that benefit. These costs include not only financial costs but also the physician's and the patient's time, a physician's finite reserve of empathy and dedication, and the value that society places on improving the quality of life or length of life of individual patients.[11] Because of this fundamental role of goals and values in clinical decision making, any attempt to evaluate a computer-based diagnosis system quickly reaches into the area of clinical ethics and the ethical aspects of policy making. These reasons are among the most important why computer diagnosis systems have had remarkably little impact on routine practice.[13]

Consultation and Expert Systems

Given the failure of computer diagnosis systems to make any significant impact on clinic practice, the trend in research on clinical decision support systems has been in the direction of consultation systems and more recently toward so-called expert systems.

These systems provide relevant clinical knowledge structured in such a way as to make it as accessible as possible for aiding and informing clinical decisions.

Among the earliest areas of application of consultation systems were the management of acid-base disorders and the prescription of digoxin. Bleich[13] developed a computer-based consultation program for the management of acid-base disorders in 1969, the earliest clinical application of computer-based consultation in medicine. His program is widely available on commercial time-sharing systems at a cost of about $2 per consultation, taking about 7 minutes to enter the data and to receive the feedback, and will no doubt be available on microcomputers soon. References to appropriate medical literature are provided at the end of a consultation. The program combines standard calculations in the area of acid-base chemistry with a great deal of branching logic and numerous logical decision rules. Based on the view of an acknowledged expert in this area of clinical management, the program represents the best current opinion about the physiology and management of acid-base disorders.

Several other broadly similar acid-base management programs[14,15] have been used. A similar approach to blood gas management has been described,[16-18] and digoxin dosage planning has been approached in a broadly similar way.[19,20] The first part of such dosage planning programs asks for basic patient-specific data such as body weight, age, and results of standard indices of renal function. The next part of the program asks for the type and previous dosages of the drug to calculate existing distributions of the drug in the patient's body, taking into account the different potencies and metabolic pathways of the four main drugs in the digoxin group currently used. Finally, the program computes and prints a dosage regimen that is compatible with the clinical goals already laid down by the clinician in the first part of the program. The clinician can specify a blood drug level he wishes to attain and the length of time over which he wishes to achieve this level. Systems such as this have reduced drug overdosage from 12 to 35 percent.[20]

The potential of the computer as an "electronic textbook" and "aide-mémoire" is enormous. Information on drug interactions, rare syndromes, and possible etiologies of symptom clusters will be easily accessible. However, when faced with clinically difficult problems, the clinician may wish to call on the expertise of colleagues in his own discipline or, where appropriate, colleagues in other clinical disciplines. Here the advice is more clearly tailored to a specific problem and the features of an individual case.

A number of different systems of *expert consultation* have been developed. Shortliffe et al[21] developed one of the earliest systems to use the concepts and software from the artificial intelligence laboratory to develop a program representing the knowledge of an expert in microbiology so as to provide advice to physicians concerning the choice of appropriate antimicrobial therapy for infections. The system uses about 100 decision rules and has the great advantage of providing background explanations to the user about its advice. The system is called MYCIN and has been shown to function similarly to infectious disease experts when selecting therapy for cases of bacteremia and meningitis. However, a demonstration of its acceptability to physicians is still under review.[13]

The aim of expert systems is to encode and store in routine form the judgmental knowledge of experts.[22] At Rutgers University an expert-management program for glaucoma has been developed based on an anatomical and physiological understanding of glaucoma (similar to the biochemically oriented systems described above) combined with the specific advice of expert ophthalmologists.[23] However, the most comprehensive and most clinically applicable expert system so far produced is that developed at the University of Pittsburgh by Dr. Jack D. Myers, who over the past 12 years has developed the program Internist-1,[24] which is based on his personal clinical experience as a consulting general internist. The program contains information and management strategies covering about 600 diseases. Internist-1 embodies two major components: a knowledge base and diagnostic algorithms. The knowledge base represents 15 person-years of work. The assumptions the clinician consulting the program wishes to make in dealing with actual cases are incorporated into the program's decision rules. The program interrogates the physician about his views in a particular case and then organizes these views into a data base for guidance in similar cases in the future. A recent study evaluated the performance of this system in diagnosing clinicopathological cases from *The New England Journal of Medicine*.[25] It made the correct diagnosis in 65 to 75 percent of these cases.

Such expert systems are still in the early experimental stage. Successful systems are unlikely to be available until much more is known about the medical reasoning of physicians and (1) how to use the computer to interpret written or spoken natural language, (2) how to acquire or present the knowledge obtained from collaborating experts, (3) how to incorporate and use time relationships that are so important in many disease processes, and (4) how to represent "inexact reasoning," as much of the reasoning of successful and experienced physicians does not fall neatly into the logic of available programs.[24]

Expert systems are the focus of increasing interest in Europe. At a recent international conference on decision making in family medicine,[26] several general practitioners in Britain reported considerable support for such systems for facilitating their office practice. One family physician[27] has been recording the decision rules he uses in managing his patients in his own urban family practice and now has an extensive library of these decision rules and related clinical knowledge that he normally uses in managing his practice. The aim of this experimental system is to develop a computer-based clinical support system for use in family practice,[28] where the course and etiology of commonly encountered diseases are distinctly different from subspecialty practices.

It is interesting that in the United Kingdom, where physicians are salaried, interest in such expert systems is lively, but in the United States such systems are perceived by many clinicians as a threat to fee-for-service medicine. These perceptions may parallel the contrasting attitudes of Japanese automobile workers (whose lifetime employment is guaranteed) welcoming robots onto the production line, whereas automobile workers in Detroit see robots and intelligent computer systems as a threat to their livelihood. There is the real possibility that the inevitable development of consultation and expert computer systems in subspecialty practice and primary care may lead to some of the activities of clinicians being replaced by intelligent computer systems fed by paramedical personnel.

It seems inevitable that physicians will be attracted by the availability of elaborate consultation systems readily accessible on their office desks and that the systems currently available in subspecialty practice will lead to parallel developments of systems for family practice. These systems are likely to be primed with policies of preferred provider organizations and health maintenance organizations so as to minimize costs and maximize the quality of care. However, the danger will always exist that such expertise captured in computer systems may threaten the very clinical expertise that is the cornerstone of the physician's professional identity. The only reliable protection against such developments is likely to be the nurturing of a close, continuing personal relationship with patients and a dedication to provide the uniquely human care that most patients need and value.

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