Computer Technology in Medical Education and Assessment

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COMPUTER TECHNOLOGY IN MEDICAL EDUCATION AND ASSESSMENT

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BACKGROUND REPORT

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PREFACE

This report reviews the state-of-the-art of the use of computer technology in medical education and assessment. It both describes the technologies and strategies for computer-based education and assessment, the current state of medical education and assessment activities, and computer applications in medicine. It also provides examples of systems for the development and dissemination of computer-based educational materials. A summary and analysis of such computer uses are also presented. Although the focus of the report is on physician education and assessment, the implications of the activities described are applicable to other health professions.

The Federal Government's role in computer-based education and assessment has been primarily in the research and development phases. However, the medical areas in which such computer-based methods have been applied have been of long-standing interest to the U.S. Congress. Such areas include health professions education, monitoring and evaluating physician services through Professional Standards Review Organizations (PSROs), and efforts to contain the costs of such federally financed programs as Medicare and Medicaid. In all of these areas the use of computer technology is becoming the rule rather than the exception.

This report examines these computer applications in various stages of the life-long process of medical education from entry into medical school through active practice. It therefore provides an overview that may be of value to two audiences: policymakers at the Federal, State, and local levels, and those in the public and private sectors who are directly involved in the use of computer technology in medical education and assessment.

The study was conducted by the OTA Health Group staff with assistance from an advisory panel and contractors. The report was also reviewed by the OTA Health Advisory Committee. This report is a synthesis and does not necessarily represent the views of any of the individuals involved in its preparation.

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ACRONYMS

AAFP – American Academy of Family Physicians
ABIM – American Board of Internal Medicine
ABMS – American Board of Medical Specialties
ACEP – American College of Emergency Physicians
AMA – American Medical Association
CAI computer-assisted instruction
CAIREN - Computer Assisted Instruction Regional Education Network
CASE – Computer-Assisted Simulation of the Clinical Patient Encounter
CAT – computer-assisted testing
CATS – Computer-Assisted Teaching Systems Consortium
CBE – computer-based education
CMI computer-managed instruction
COSTAR - Computer-Stored Ambulatory Record System
CPMP – Computerized Patient Management Problems
CPHA – Commission on Professional and Hospital Activities
CQE – Comprehensive Qualifying Exam
FLEX – Federal Licensing Examination
GME – graduate medical education
HEN – Health Education Network
HEW – Department of Health, Education, and Welfare
ISP – independent study program
JCAH – Joint Committee on Accreditation of Hospitals
MCAT – Medical College Admissions Test (MCAT)
MCC – Milliken Communications Corporation
MCE – Medical Care Evaluation (MCE)
MERIT – Model for Evaluation and Recertification Through Individualized Testing
MGH – Massachusetts General Hospital
MMIS – Medicaid Management Information System
NBME – National Board of Medical Examiners
NRMP – National Residency Matching Program
OSU – Ohio State University
OTA – Office of Technology Assessment
PACE – Physician Ambulatory Care Evaluation
PAS Professional Activities Study
PLATO - Programed Logic Automated Teaching Operation
PMIS – PSRO Management Information System
PMP – patient management problem
PSRO – Professional Standards Review Organization
QAM – quality assurance monitor
RAMS – Retrospective Analysis of Medical Services (RAMS)
SOPHIE – Sophisticated Instructional Environment
S/UR – Surveillance and Utilization Review
TES – tutorial evaluation studies
TICCIT – Time-Shared Interactive Computer-Controlled Information Television
UNDDS – Uniform Hospital Discharge Data Set
UPRO – Utah Professional Review Organization

Chapter 1

SUMMARY AND ANALYSIS

1 •

SUMMARY AND ANALYSIS

INTRODUCTION

In the past quarter century, dramatic reductions in the size and costs of computers have increased their availability and led to their application in most aspects of our lives. Projections regarding their prevalence and use in the 1980's indicate that most stores, offices, and hospitals, and many homes will have them. During this same period, advances in medicine have led to a virtual information explosion, making the contemporary medical care system more complex, more information-dependent, and more technology-oriented. Computers, as perhaps one of the most pervasive of the present technologies, can contribute to the increasing complexity of medicine, as well as assist efforts to more effectively understand, employ, and manage the information and array of technologies used in health care. Already, they have become integral elements in public health and biomedical research (e. g., statistical analysis, experimental modeling); medical education (e. g., electronic access to learning resources); patient care (e. g., on-line physiological monitoring); and enhanced information management (e. g., medical information systems).

This report focuses on the use of computers in medical education and assessment. * More precisely, the report examines the methods by which students or practitioners interact with teaching and testing materials contained in a computer. Such methods are generally called computer-based education (CBE).

It is now recognized that medical education includes not only the formal education of physicians in undergraduate and graduate (residency) medical training, but also the more informal education accompanying active patient care. This new recognition that medical education is a life-long process is evidenced by two developments:

First, continuing medical education for physicians, initially implemented on a voluntary basis, is now a requirement for reregistration by many State medical licensing boards and for recertification by some specialty boards.

Second, improvements in the quality of medical care are clearly related to continuing medical education. Criteria used in evaluating the quality of care are usually grouped according to structure, process, and outcome measures. Structural measures include both the availability of resources (e.g., facilities, equipment, and health care personnel) and the qualitative aspects of medical care personnel (e.g., extent of educational background and board certification). Process measures assess the appropriateness of the medical care that has been provided. Outcome measures reflect the effect of medical interventions on patient health status. These three ways of measuring the quality of medical care reinforce the relationships between the formal education process and the more informal life-long learning process that must accompany patient care.

*Assessment is defined to include both formal and informal methods of evaluation and testing.

ORGANIZATION OF THE REPORT

This report examines the application of computer technology in medical education and assessment. Computer technology and its uses and capabilities in general education and assessment strategies are described in chapter 2, followed by a description of the process of medical education and assessment in chapter 3. Case examples of the application of computer technologies in specific areas of the medical education continuum are then presented in chapter 4. The institutionalization of computers in medicine is documented in chapter 5 through summary descriptions of the development, dissemination, and use of computer-based education and assessment materials.

In the following sections of this first chapter, the implications of computer technology developments and uses in medical education and assessment are summarized. Further discussion of the conclusions drawn in this chapter are provided in the body of each chapter.

CONCLUSIONS

Computers can be compared to other medical aids upon which the physician has come to depend. In many cases, computers have replaced other, less reliable technologies. Computer technology can: 1) assist in, and help manage, educational activities; 2) assist in, and help manage, assessment activities; 3) assist in diagnostic, prognostic, and therapeutic processes in patient care; and 4) help manage large amounts of data for a variety of purposes. Computers save time, improve efficiency and skills, and provide unique learning opportunities.

Due to their ability to store, process, and retrieve information almost instantaneously, computers can be used in ways that make comparisons with the capabilities of other methods difficult or impossible. Such unique uses include individualization, simulation, inquiry, interpretation, and data management.

Computers permit a wide range of learning responses in tutorial sessions and can respond to individual learner backgrounds and needs. Computers enable students to pace their progress through a curriculum. The independent study programs in the basic medical sciences are examples of computer uses in medical education that take advantage of these capabilities to create a flexible curriculum.

Computers are capable of storing and rapidly searching and processing huge volumes of data. This capability permits *simulations* of some aspects of the patient-physician encounter. Computers, however, cannot assess the quality of the physical examination conducted by the physician; they can only present the findings of such examinations. “Body language” cues that may be apparent in a live physician-patient interaction also cannot be duplicated by a computer because it uses electronically printed words as the predominant communications device. However, simulations can provide student exposure to specific diseases or clinical situations that are rarely encountered, as well as familiarize the user with the many variations by which even common diseases can be manifested. Simulations also can be used in examinations and tests to overcome some of the subjectivity inherent in other techniques (e.g., essay questions, oral exams, clinical rounds, and student “treatment” of patient actors). Finally, as in teaching, simulations permit uniform nationwide testing of aspects of the patient-physician encounter that previously were not effectively or economically measured.

Methods for *inquiry* and *interpretation* of data have been influenced dramatically by the computer. The huge amount of data stored in computers obviates much of the physician's need to retain detailed facts; and, much of the deductive reasoning process that takes place in diagnosing and treating patients can be done with more consistent, comprehensive, and instantaneous recall and application.

> The computer's information-handling capabilities allow it to serve as a reliable extension of the physician's memory and expander of the physician's information and synthesized knowledge resources. Computers have been used to facilitate decisions through organization of patient data, improved classification of patients, decision analysis in clinical settings, and simulation of expert clinical reasoning. Computer programs are more successful in narrow, constrained, single arenas of medicine with much underlying pathophysiologic understanding and where decisions are based largely on hard laboratory data. New models of synthetic reasoning that simulate expert clinical behavior show promise of supporting complicated decisions concerning problems of multiple disease (Schoolman and Bernstein, 1978).

The use of computers as "consultants" for specific diseases or problems, or for a particular specialty, illustrates these capacities.

Finally, computers have a unique role in the *management* of large volumes of data for reimbursing health services; reviewing utilization; and planning, monitoring, and evaluating medical care services. Computer systems are, or can become, integral components of both intra-institutional medical information systems and interinstitutional health data systems.

Medical information system are defined as computer-based systems that receive data describing patients; create and maintain computerized medical records based on these data; and make the data available for the following uses: 1) patient care, 2) administrative and business management, 3) medical care service monitoring and evaluation, 4) epidemiologic and clinical research, and 5) medical care resource planning. No existing medical information system yet provides data for all the purposes enumerated.

Health data systems collect data from a variety of medical care institutions. Although health data and medical information systems are not now coordinated, these uses of data cannot realistically be separated. Both systems should be highly integrated, interactive subsystems of the health care system. A well-designed computer system should facilitate and enhance data and other information flow among the various users and between types of information systems.

The use of computers in education and assessment inevitably will be linked to their uses in medical information systems. Such linkage will allow, if not force, the formation of new relationships between segments of the medical education and assessment continuum through the accumulation of large data bases on student characteristics and performance, on physician and institutional performance in patient care, and on patient outcomes following treatment. These data bases could serve as the thread of continuity between portions of the continuum. They could provide more objective and quantitative feedback mechanisms from active practice to education and assessment.

Currently, the best measures of competence in learning do not necessarily predict good performance in practice. Patient care assessments depend largely on comparison with peers using standards (processes that should be followed) or empirically determined norms (the average care provided). Computer technology could be used to improve the linkage between medical education and patient care through the provision and maintenance of more specific and objective data bases for diseases and treatments. In addition

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to providing better data for generation of standards, computer data bases could allow better comparison of present standards and norms of care with actual patient outcomes. These data bases also could permit the development of computer consultant systems. Feedback from medical information and health data systems could provide continuous updating of the data bases.

Such data bases could be linked to education and assessment systems for improvements in both areas. Early in the medical education and assessment continuum, the emphasis is on the accumulation, retention, and application of knowledge on which decisionmaking in future practice will be based. This general medical education is quite different from the specialized training that follows undergraduate medical education. Furthermore, there is an inherent problem in deciding what aspects of clinical practice should be emphasized in the general medical education curriculum. Computerized data bases could help to highlight areas of knowledge and skills that need further emphasis. They could dynamically link medical education to ongoing patient care. The development of computer course work for learning and testing calls for specificity in defining objectives and in correlating the knowledge and skills to be acquired with the objectives. Techniques for accomplishing such specificity could help improve the quality of information collected in medical information systems.

This report emphasizes the positive aspects of the application of computer technology. It is beyond the scope of this report to delve into the myriad of sociopolitical issues in both the use of computers per se and in the medical education and assessment system. Regarding the former, the issues relate primarily to control and access to electronically stored data; such issues are not unique to the particular application of computer technology in medicine. Another OTA report is exploring these issues. *

One major sociopolitical issue in the medical education and assessment system that deserves note, however, is the issue of governance. Medicine, as for other professions with specialized knowledge, is regulated by licensing boards that are dominated or controlled by the profession. Increasing specialization may lead to changes in the role of licensing boards, which issue general licenses to all physicians under their jurisdiction, and in the role of specialty boards, which, although voluntarily joined, convey prestige and economic advantages to their members. If the general medical license is modified to reflect the increasing specialization of medicine, questions will arise on how such licenses will be determined and regulated.

IMPLICATIONS

The use of computer technology in medical education and assessment activities will significantly alter these two processes. A number of potential changes are presented and discussed below:

1. The use of computer technologies to retrieve knowledge and assist in problem-solving will substantially obviate the present need for accumulation and retention of facts by individual physicians. This may require changes in the medical curricula.

*"Assessment of the Societal Impacts of National Information Systems, " an OTA study currently in progress.

Electronically stored knowledge is more accurate, consistent, and rapidly retrieved than the knowledge contained in the physician's memory. Computers will become more prevalent and indispensable as tools to aid in diagnosis and other decisionmaking because of their enhanced memory capabilities. Medical admissions and testing processes will need to adjust to this change. Since the use of computers will be unavoidable, and since students and practitioners will need to learn how to use them, courses in computer operations will need to be incorporated into the medical school and graduate curricula. Such education is the key to realizing the long-term benefits of computers in the practice of medicine.

Medicine, however, is not based solely on statistical probabilities; consequently, computers will act more as aids to, rather than as substitutes for, physician decisionmaking.

2. The improved understanding of disease and health that will occur with the use of computers will, in turn, change the method and content of physician education.

The computer's ability to perform statistical correlations between patient characteristics, diseases, treatments, and results will contribute significantly to the medical knowledge base. This knowledge base can be improved and expanded as more data are gathered. New data can be incorporated into the educational and patient care process, leading to changes in medical school curricula and the practicing physician's repertoire of supportive services.

3. The accumulation of large data bases on student characteristics and performance, on physician and institutional performance in patient care, and on patient status will enhance efforts to measure, validate, and improve the quality of medical care and medical education.

The ability to evaluate the quality of medical care has been inhibited by a lack of understanding about the relationships between both specific structural and process measures and patient outcomes. Although correlation between structural measures (e.g., whether a physician is board certified) and patient outcomes may always be tenuous, systematic correlations between the processs of medical care and patient outcome measures may be possible. As a result of the computer's ability to provide new knowledge for diagnostic, prognostic, and therapeutic purposes, computerized data systems will enhance our current ability to distinguish between medical interventions that make a difference in patient outcomes and those that do not.

The use of computers as aids in defining and monitoring quality of care is limited by the quality of the data base. The use of computerized data bases may raise the problem of prematurely legitimizing current diagnostic and therapeutic procedures. If too rigidly applied, norms and standards may impose too much conformity on the practice of medicine, promote the perception of individuals as disease entities, and interfere with the identification of new syndromes.

4. Computer-based education will allow individualized medical education, perhaps in different settings. Independent study curricula will provide new opportunities for students with academic weaknesses or allow students to alter the pace of their education.

Computer-based education in undergraduate medical education has been demonstrated to be a workable substitute for substantial portions of the traditional lecture/discussion curriculum. Computer-managed and computer-assisted independent study is feasible for large numbers of preclinical students. Such independent study programs enable students to control the rate of their progression through the rather intense medical school curriculum. Students with strong academic credentials, as well as those with academic deficiencies, benefit from the inherent flexibility of independent study. Students who choose computer-based independent studies perform comparably to 1ecture/discussion students on standardized exams. Student attitudes toward independent study are favorable.

A more student-centered and directed form of education could promote more creativity and lead to changes in the way a physician practices. A physician's ability to assess his/her own strengths and weaknesses is an important component of his/her functioning capabilities.

Developments in computer technologies may lead to student training in divergent settings without great variations in the quality of education. Electronic networking and the proper combinations of computer simulations and real experience are already being used to meet the continuing education requirements of practicing physicians.

5. The use of computers in medical education will change the role of the faculty member.

Faculty will spend less time disseminating information in traditional settings. Rather, they will spend more time orchestrating the learning process and tutoring individuals and small groups. Faculty also will spend more time developing courseware.

6. The evaluation of a student's problem-solving abilities will be improved through the use of simulations.

The use of simulations can avoid some of the subjectivity inherent in testing methods such as essay questions, oral exams, clinical rounds, and the use of patient actors. Simulations can also provide experience with "patients" who have rare or seasonal diseases. The computer, however, cannot replace subjective assessments that may be essential for determining physician competence.

The use of computer simulations for credentialing in Canada has demonstrated that simulations are effective means of measuring portions of the problem-solving components of clinical competence. Physician reaction to these exams generally has been positive. Initial findings from two U.S. experiments using computers in credentialing are similar.

7. Continuing medical education will become more individualized and directed toward remedying identified deficiencies in physician performance.

The continuing education needs of each physician will be more clearly identified because of the ability to individualize assessments of physician competence. If trends toward required continuing education continue, physicians may be asked to select a given number of educational experiences that specifically address their deficiencies. Furthermore, awarding continuing education credit may be linked to evidence of mastery of the continuing education materials.

Computer-based education not only can provide immediate feedback on performance in continuing education but also can generate and maintain records on the type and amount of continuing education credit received.

Data on the types of patients and diseases treated by the physician and on the quality of treatment rendered (e. g., professional standards review data) can also be maintained. Coordination and synthesis of this data in developing tests make the test more individualized by reflecting specific practice patterns and areas of potential concern in each physician's practice. As in undergraduate and graduate medical education, computer networking can make educational materials available in divergent settings (e. g., home, hospital, or office), without significant variations in quality.

8. Testing and other assessments of physician performance also will become more individualized.

General tests that are administered to all persons under a particular authority (e. g., medical schools, licensing boards, specialty boards) are used as a means of determining the attainment of a particular level of achievement. These tests, however, do not necessarily y measure the level of competence needed in patient care because of the increasing specialization in the practice of medicine. Computers will assist in the development and administration of tests that more accurately reflect the kinds of situations that the physician faces in his/her practice. By complementing the use of norms and standards, computer simulations will permit a more precise identification of deficient performance.

9. Individualized testing will accelerate the trend toward testing competence in a limited area.

The general licenses issued by State medical licensing boards do not limit the scope of a physician's practice. However, informal, de facto constraints exist, such as physician choice in limiting his/her practice to a specific area of medicine. Various institutional constraints, such as hospital privileges, also act to limit practice. Consequently, broad licenses to practice hardly exist in fact.

Specialty certification limits assessment to a specific specialty field. Activities are already underway to reflect the increasing specialization of medical care, The proposed comprehensive qualifying examination (CQE) would assess the preparedness of the medical school graduate to enter advanced training. If medical licensing boards eventually issue a license limited to the supervised setting of graduate medical education, questions will be raised regarding limiting the subsequent license to practice in an unsupervised setting to a physician's specialty area.

Individualized testing will make it easier to test competence in more depth and in particular areas of knowledge, such as in specific specialties. The computer-based examinations being developed by the American Board of Internal Medicine represent one approach to individualized testing in specialty areas.

10. Testing in limited areas of practice will raise questions regarding the issuance of limited licenses to practice and the governing of the licensure process.

State licensing boards, which now administer or accept common tests applicable to all medical school graduates, would have to administer different types of tests to the various specialists. If specialty board certification is accepted in lieu of State medical board tests, specialty certification would attain comparable legal status to licensure. If this occurs, the appropriateness of specialty self-regulation and determination of standards will be questioned.

11. Fundamental questions will arise regarding the changing role of medical licensing boards.

Standard setting, as in the acceptance of board certification in lieu of a licensing exam, could be separated from professional regulation; the responsibilities for professional regulation could remain with the licensing boards. A variation of this approach already exists in the acceptance of the National Board of Medical Examiners (NBME) test results by individual State licensing boards; regulation, however, continues to be a responsibility of the licensing boards.

Licensing boards already have shifted away from standard setting, which has been largely delegated to NBME in the formulation of both the Federal Licensing Examination (FLEX) and the NBME exam, toward regulatory activities. If the boards are to continue in this direction, then more systematic relationships could be formed with the various quality assurance programs now in place or being developed. For example, statistical deviations from accepted standards or norms could identify physicians that should be investigated further by the board.

12. The application of computer technology in the education and assessment of other health professionals **and** in the education of patients deserves exploration.

Although this study focuses on physician education and assessment, the conclusions and implications are directly applicable to the training and evaluation of other health professionals. Nurses and allied health professionals could benefit from individualized education in much the same way as physicians.

The development of individualized education and simulations for patient use (e.g., living with a colostomy, care and feeding of the newborn) linked with trends toward home and personal computing could enhance patient involvement in and responsibility for their own care.

13. The development of integrated data systems in health will raise complex technical, political, and social questions as to control of and access to such data.

Incompatible hardware and software, rapid obsolescence of hardware, security needs, and the configuration of computer networks and their communication systems will affect the use, coordination, and sharing of integrated data systems. Traditional organizational differences in objectives (e.g., education, testing, patient care, cost containment, and fraud detection) will also affect coordination and shared use. Storage of personal data in electronic data banks, control of access to data, and centralization of data bases may create threats, real or imagined, to individual privacy.

Many questions will arise around issues such as access to information and the creation of an information elite. Specifically, as the general public becomes more literate in computer capabilities and uses, issues will be raised about the types of information and decisionmaking that can be handled only by physicians.

Chapter 2

COMPUTER TECHNOLOGY IN EDUCATION AND ASSESSMENT

2.

COMPUTER TECHNOLOGY IN EDUCATION AND ASSESSMENT

This chapter presents an overview of computer technology and its uses in education and assessment. First, the definition and context of such computer uses are discussed, followed by a description of the types of educational computer systems that have evolved.

THE TECHNOLOGY

Description

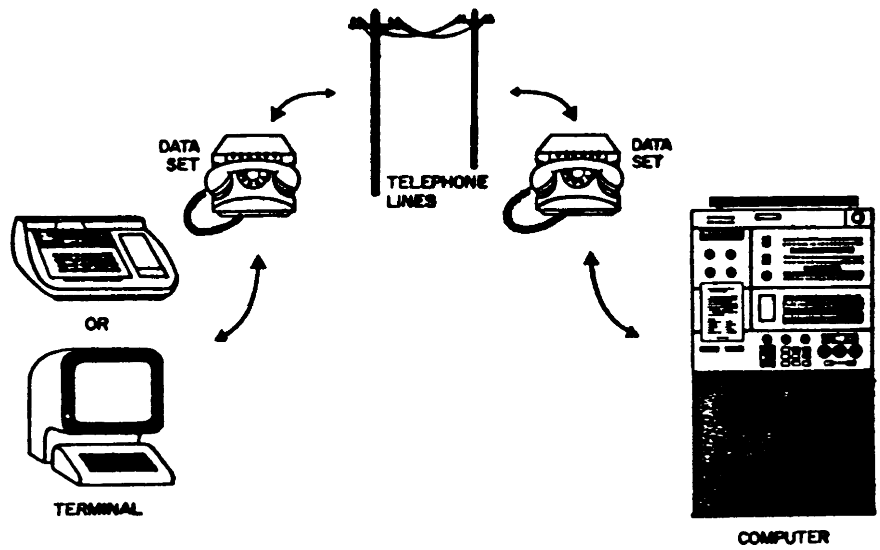
The use of computers in education and assessment, often called computer-based education (CBE), involves a process by which an individual uses a typewriter-like device, a *terminal,* to communicate 'with a computer. Information is transmitted into and out of the computer through the terminal by means of a typed page or a special television screen. Other forms of communication with the computer (e. g., voice) are available only on a limited basis in very restricted settings. The terminal is connected by a *communication link,* such as a cable, microwave, or telephone, to a computer that may be distantly located. The computer receives, stores, retrieves, processes, and outputs data. The terminal, computer, and the communication links are called *hardware.*

An educator or evaluator uses a simplified computer programing language, called an *authoring language,* to translate learning materials into *programs* that direct the activities of the computer hardware. Computer programs are generally labeled *software;* the subsets of programs that serve as the instructional materials are given the specific name *courseware.* Records of individual performance and additional education and assessment programs are stored in the computer or in storage hardware such as tapes and disks; storage hardware are called *auxiliary memories.* Taken together, hardware and software comprise a system that allows the user to interact with educational or evaluative materials stored inside the computer.

Figure 1 portrays a sample interactive hardware configuration. The terminal and a small computer may be combined with sufficient auxiliary memory to create a self-contained system, or they may be part of a larger system tied by a communication link to a distant computer. Figures 2 and 3 portray sample interactive computer systems in the medical education and assessment context.

The most suitable configuration of hardware and software for CBE depends on the desired features of the instruction or assessment program. The choice of systems is influenced primarily by the availability of equipment at an institution or by the desire to use specific courseware. Alternative systems vary, for example, in speed, reliability, ease of programing, ease of use, operating costs, initial costs, capabilities, availability of courseware, and number of simultaneous users permitted by the equipment. Differences in equipment and in software make courseware transfer from one institution to another less

Figure 1.—Sample Interactive Computer Configuration



SOURCE. The Ohio State University College of Medicine

than a routine activity. Smaller machines require a lower capital investment and have lower operating costs, but they generally can accommodate fewer simultaneous users and may have limited capabilities. Larger machines require a higher capital investment and are more expensive to operate, but they provide more capabilities and permit larger numbers of simultaneous users.

There is no consensus on explicit definitions of the descriptors "small" and "large;" rather, these are subjective terms. However, three general categories of computers that reflect these terms are commonly used: microprocessors, minicomputers, and large-scale computers. These three categories are described briefly below.

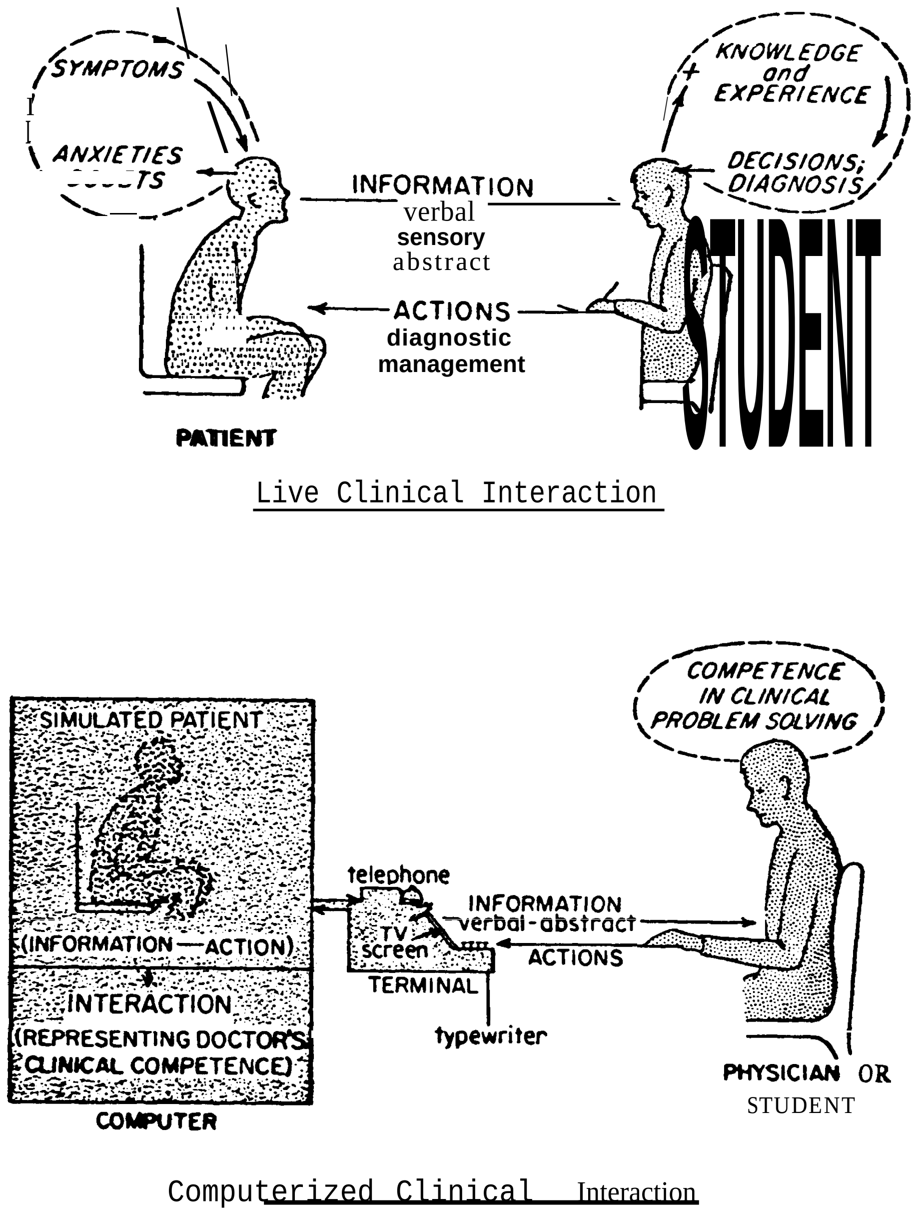
Microprocessors are the smallest of computers. They can be used as stand-alone machines that have a terminal "built-in" and, therefore, require no communication links. They also can be used as sophisticated terminals that are linked to a larger computer. They generally serve only one user at a time and have limited storage and processing capabilities. Their greatest advantage is low cost; their greatest disadvantage is the paucity of existing courseware suitable for use on a microprocessor.

Minicomputers are the middle category of computers. They have more software and courseware because they are generally easier to program than microprocessors. They can execute instructional programs that are almost as complex as those in large-scale computers. Minicomputers, however, cannot serve as many simultaneous users as the larger machines and are more costly than microprocessors.

Large-scale computers are the most costly and powerful computers. A typical large-scale system can support hundreds of simultaneous users and the most complex software and courseware. Clusters of terminals linked to the large system can be used for specialized training or other functions.

From the standpoint of user access, computers are generally categorized in the following four ways: single user systems; small-scale, time-sharing systems; large-scale, time-sharing systems; and networking,

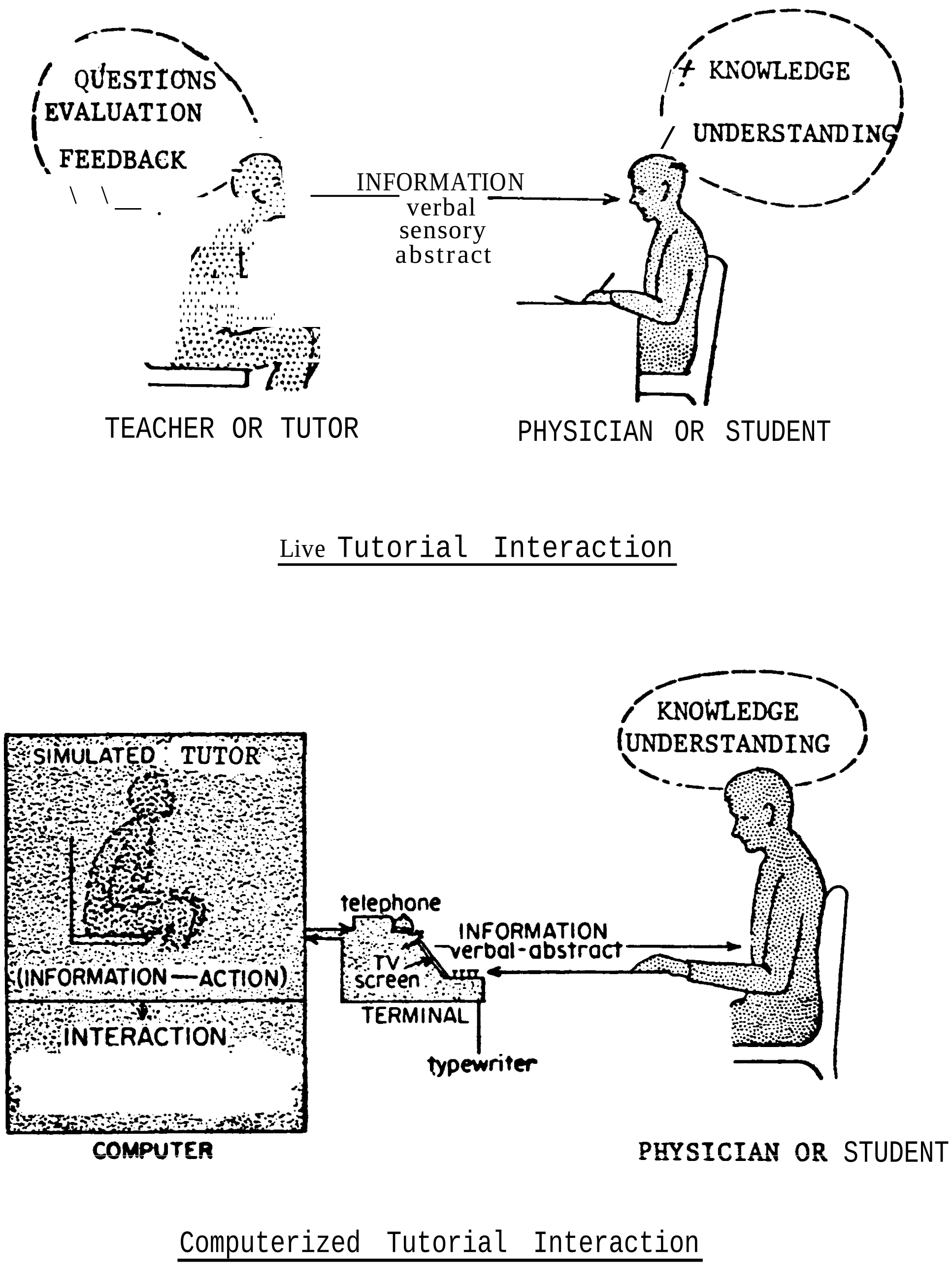
Figure 2.2.—Sample Interactive Computerized System in Which the Computer Simulates the Patient



Adapted from figures 1 and 2, p xiii, Toward the *Measurement of Competence in Medicine,* **John R. Senior, 1976**

Single user systems exist in the grey *zone* between the "home/hobby" computer market and the less sophisticated segment of the "office" computer market. In this category, the terminal and a microprocessor or minicomputer are combined with sufficient auxiliary memory to create a self-contained system that does not require linkage to a larger computer. Since the auxiliary memory is usually a flexible diskette that has limited storage capacity, a rather small number of programs or courses can be used at any one time; the complexity of such programs and courses also may be restricted by storage limita-

Figure 3.—Sample Interactive Computerized System in Which the Computer Acts as the Teacher/Tutor



Adapted from figures 1 and 2, p xiii, *Toward the Measurement of Competence m Medlcme,* **John R Senior, 1976**

tions. The lack of standardization in the manufacture of small computers increases the difficulties of transferring courseware from one type of single user system to another type. Several computer languages are available, including special purpose educational languages (Gerhold and Kheriaty, 1978). The initial cost for such systems is usually less than $10,000. * The costs for hardware operation and maintenance also are low. The degree of user control is high; computer professionals usually are not required to program or maintain the system.

Small-scale, time-sharing systems include microprocessor- or minicomputer-based machines that support from 1 to 16 simultaneous users (Tidball, 1978 b). No clear distinctions exist between this category of use and the previous one except in the number of users able to interact simultaneously with the computer. Because of these systems' larger auxiliary memory capabilities, it is possible for many programs and courses to be continuously and simultaneously available for use. These systems are flexible, require relatively low initial costs, and include central program libraries. Programing and maintenance for such systems generally require special expertise. Initial costs for these systems range from $10,000 to $100,000. The cost of additional terminals is highly variable, ranging from $1,000 to over $10,000 apiece, depending on the degree of independent "intelligence" desired by the user.

Large-scale, time-sharing systems are, for the most part, dedicated only partially to education and assessment because the full capacity of the minicomputer or large-scale computer is not required for such uses. In a hospital, for example, excess computing capacity may be used to support the medical information and hospital payroll systems. The initial costs for these systems range from $100,000 to over $1 million, although the costs for one terminal's use of the system are typically less than $600 per year (Ohio State University, 1977).

However, some large-scale, time-sharing systems are used exclusively for one purpose, such as education and assessment. Thus, their hardware, courseware, and communication links are used optimally for one activity (Hunter et al., 1975; Trends in Computer-Assisted Instruction, 1978). This optimization can result in operating efficiencies and reduced costs in systems that are extensively used. The costs of such systems are still relatively high because efforts have, and continue to be, directed at developing greater capabilities, not at reducing costs. For example, highly sophisticated graphics, touch panels, microfiche, voice recognition, and audio response capabilities increase costs. As mentioned earlier, a typical large-scale system can support hundreds of simultaneous users and may provide sophisticated instruction for large training programs.

IBM offers systems that include education and assessment programs as only part of their design. Examples of systems designed exclusively for education are time-shared interactive computer-controlled information television (TICCIT) and programed logic for automated teaching operation (PLATO). Both TICCIT and PLATO have had extensive funding support from the Federal Government. PLATO was started in 1959 at the University of Illinois (Seidel and Rubin, 1975) and continues to be developed by that institution. The TICCIT system began with a small amount of internal funding at the MITRE Corporation in 1968 (Nuthmann, 1978) and is being developed currently at Brigham Young University. In 1972, the National Science Foundation added millions of dollars of support for completing and field-testing both systems (Stetten, 1972). Results of evaluations of the implementation of both systems have been mixed. Development of additional courseware and more experience in privately supported use are required before conclusions can be reached regarding the efficacy and costs of these systems.

PLATO is now being marketed commercially by Control Data Corporation, and TICCIT, by Hazeltine Corporation. The purchase price of TICCIT is approximately

*All figures in this chapter, unless indicated, reflect only computer hardware costs. Communication links, software, and courseware are all additional costs.

$750,000 for 128 terminals (approximately $6,000 per terminal); PLATO costs $6,000 to $20,000 per terminal, depending on the size of the computer supporting the system and the number of terminals connected. A limited number of each system has been sold to date.

Networking, the final category of use, involves computer-based learning materials, developed at one site, that are shared with other institutions through a network of interfacing computers and leased telephone lines. The networking approach can be significantly cheaper since it does not generally require as many support staff at the user site nor faculty expertise to develop CBE materials. Other advantages in joining a network include access either to a central computer with a large library of tested courses, or to multiple computers with libraries of courses; economies of scale; the availability of technical and educational network specialists for particular computer applications that an individual institution or user could not afford; wider exposure, and hence, better quality of courseware; greatly reduced capital investments; expenditures only for computer services used; and opportunities for communication with a community of users. The network user has access to a library of existing CBE courses, written in different computer languages by one or more authors, without the costs of conversion, installation, and maintenance of all software. The major disadvantages to networking are the lack of control over computer resources and courseware and the continuing costs for long-distance communications access to the host computer(s).

The development of distributed networks will further opportunities for use of both single user and time-sharing systems and minimize the disadvantages of networking. In a distributed network, an entire computer program can be "down-loaded" from a small-or large-scale, time-sharing system to a single user system. It can be used by the single user system without connection to the network until an updated version is desired, user data need to be transferred, or other functions are desired that require linkage to the program library or host computer(s).

Trends

Several trends are evident in the future of computers that will affect the availability and costs of CBE:

The number of computers will continue to rise. The number of computers in the United States has risen from 1 in 1944, to 12 in 1950, to 6,000 in 1960, and to 50,000 general purpose computers in 1975. These figures do not include the almost unquantifiable number of microprocessors that are in use. Added to the 40,000 computers in use around the world, the total value of all computers exceeds $35 billion (Molnar, 1975). The percentage of the U.S. gross national product spent on computer usage will increase from 2.1 percent in 1979 to 8.3 percent in 1985; per capita expenditures for computing will rise from $101 to $670 in the same period (Nyborg et al., 1977). It is estimated that by 1980 every hospital with 200 or more beds will have a computer, and most homes and private offices will have access to a computer of some type (Collen, 1974).

The costs of computing will continue to decrease dramatically. The most important impetus for the dramatic reductions in the costs of computing is improved performance of electronic circuitry, which can now move electronic impulses from one circuit to the next in one-trillionth of a second (Branscomb, 1979). Silicon and integrated-circuit technology provides the basis for these advances, although new technologies, such as liquid helium, are in development and may result in further advances. Such circuits are packed closely together to enhance speed of transfer; they also account for the continued reduction in the size of computers.

The size of computers will continue to decrease dramatically. The computing power of a machine that filled a large room 25 years ago is now contained in a machine that can be held in one's hand. "An individual integrated circuit on a chip perhaps a one-quarter-inch square now can embrace more electronic elements than the most complete piece of electronic equipment that could be built in 1950" (Noyce, 1977). The microprocessors or personal computers of today, which cost as little as $300 to $500, have larger computing capacities than those of the first computers, are 20 times faster, and are much more reliable. Some predict that personal computers the size of an average dictionary will be available within the next 5 to 7 years at less than the cost of one of today's handheld calculators. These future devices will have more computational power than all but the largest of today's machines (U.S. Congress, 1978).

Input and output terminals or mechanisms will become increasingly sophisticated. Typewriter-like terminals, touch panels, and light pen technologies now are used for learner input in interactive educational computing. Printed pages or visual screens are the most commonly used means for the computer to output its messages. Currently, terminals can incorporate slides, soundtracks, microfiche, and similar technologies in the learner-computer dialog. In some cases, these auxiliary technologies are user-controlled and in others, they are computer-controlled. Voice recognition for input and voice synthesis for output are in early stages of use. Research is being conducted to explore the use of thought waves or electronic brain impulses to interact with the computer (Fields, 1979).

Costs of software and courseware development will continue to rise. In light of all the hardware advances and the decreases in their costs, the development of software and courseware that take advantage of the capabilities of the machine represents the most serious future problem regarding the use of computers. Currently, costs for courseware design and development are much more expensive than hardware costs. The gap between hardware and software costs will continue to widen as labor costs increase and hardware costs decrease.

Author time required to create truly sophisticated CBE materials cannot be underestimated. Table 1 shows the increasing time requirements for courseware development as the complexity of the courseware increases from simple linear tutorial questions to linear tutorials with a variety of feedback options, to linear tutorials with branching within questions, to linear tutorials with branching between questions, to fully individ-

Table 1—Computer-Based Education Course Development

	Instructional Programmer						
Type of CBE	Initial author effort	Author interaction	Coding and debugging	Author review and revision	Additional review	Course documentary	Total develop. time
Linear.	25	5	10	10	5	5	50
Linear with options.	30	5	10	15	5	5	70
Linear/within question branching	**40**	10	**30**	**20**	**5**	10	115
Linear/between question branching	80	**30**	**50**	**40**	**10**	15	215
Individualized	100		100	**50**	40	20	330
Simulations.	3-1o	(4-6:)'	72-124	2-1o	7-14	5-6	94-1 70"

NOTE: Average development times in hours for 1 hour of terminal Interact Ion or one case
"Time for generation of a case—this time is somewhat less due to an automatic authoring aid
SOURCE: The Ohio State University, College of Medicine, 1976.

ualized tutorial development, and to simulations. Times for courseware development and maintenance range from 50 to over 300 hours; costs range from $1,000 to $15,000 per hour of courseware developed (Ohio State University, 1976).

Communication costs will continue to be high. Costs per hour of use depend on the usable life of the course, the computer and communications hardware configuration, the volume of use, and the degree of support services provided. Communication costs account for over 50 percent of hourly costs in most networks (Forman et al., 1978). Other costs, such as those for user services, user training, billing, research, and development, must also be considered. When all cost components are included, expenditures per student hour for CBE systems use vary greatly. One national network charges from $4 to $15 per hour (Tidball, 1978a).

Personal computing will rapidly accelerate, posing new opportunities and problems. The lower costs and smaller sizes of computers have led to their widespread use for hobby and entertainment purposes. In the near future, the use of microprocessors for personal needs will be as commonplace as the use of handheld calculators. Individuals, families, schools, and businesses all will have terminals containing powerful microprocessors that can be used for a wide variety of functions, including education and assessment. The development and availability of software and courseware will not keep pace with the increasing availability of hardware. Creativity and careful planning will be necessary to fully realize the capabilities offered by the linkage of emerging technologies, such as video discs, with microprocessor technologies. Microprocessor-based computer systems serve not only as stand-alone systems but also as linked systems. Microprocessor systems can be linked to "view data" systems such as the British Post Office System; this system offers stock market status information, consumer reports, bibliographic indexes, electronic financial transactions, and mail-order catalogs (Institute of the Future, 1979). Home- and office-based education (especially continuing education) will be available as a result of linking microprocessor systems with extensive data bases.

COMPUTER-BASED EDUCATION

Methods

Specifying the knowledge to be obtained, the skills to be learned, and the standards of acceptable performance is a prerequisite of any education and assessment system. Educators refer to the specification of measurable knowledge and skills as behavioral objectives. Ideally, then, instruction should be designed to teach objectives; tests should be developed to measure attainment of objectives; and administrative mechanisms should be developed to monitor, record, and manage activities in the educational process. CBE methods are similarly divided into three categories to reflect the three components of the educational process: computer-assisted instruction, computer-assisted testing, and computer-managed instruction.

Computer-assisted instruction (CAI) involves the computer in the presentation of instructional material. The computer is combined with other media, such as lectures, films, and labs, in the instructional process and is used ideally for those aspects of the teaching/learning process that can benefit most from CAI capabilities.

Computer-assisted testing (CAT) can be *on-line,* when the test is generated by the computer and administered at a terminal connected to a computer, or *off-line,* when the test is administered manually by paper and pencil. The computer can support testing in any of the following ways: (a) store and retrieve banks of test items, allowing for efficient generation of numerous alternate tests; (b) administer tests; (c) score and print results of tests; (d) maintain testing records for purposes of test validation and/or student diagnosis and prescription; and (e) catalog and reference instructional materials relating to specified knowledge and skills.

Test items can be selected for presentation according to either a set of rules, statistically determined prior to testing, or the individual's responses to items in the current testing situation. Both testing mechanisms take less time to complete than traditional tests, prevent redundancy in test items, provide consistency and standardization for the entire target audience, provide equivalent alternative versions of tests, and allow for more precise measurement of achievement and ability. Learners are not retested on previously mastered knowledge and, hence, receive only those test items that are necessary. The reliability and validity of the tailored tests are comparable to those of traditional tests containing twice as many items (Weiss, 1976; Be jar et al., 1976; Patience, 1977), and immediate information regarding the correctness of the response given after each item can alleviate test anxiety (Weiss, 1976). Automatic maintenance and availability of performance records assist in test validations and in the recognition of gaps in learner knowledge; such gaps may be overlooked in conventional testing because an adequate overall grade may mask important specific deficiencies (Kimberlin, 1973). Generally, the response of test-takers to all types of computer-assisted and tailored testing is positive.

Computer-managed instruction (CMI) manages the learning process by assessing the student's level of skill and knowledge through testing, by maintaining records of student progress through a course or within individual sections of a course, and by prescribing the next step a student should take in his/her studies (Seidel and Stolorow, 1975). CMI can route a student forward to the next section or back to remedial sections, give tests, and direct the learner to written materials, faculty consultation, or CAI courses. CMI can coordinate both the computerized and noncomputerized portions of the entire instructional process.

Strategies

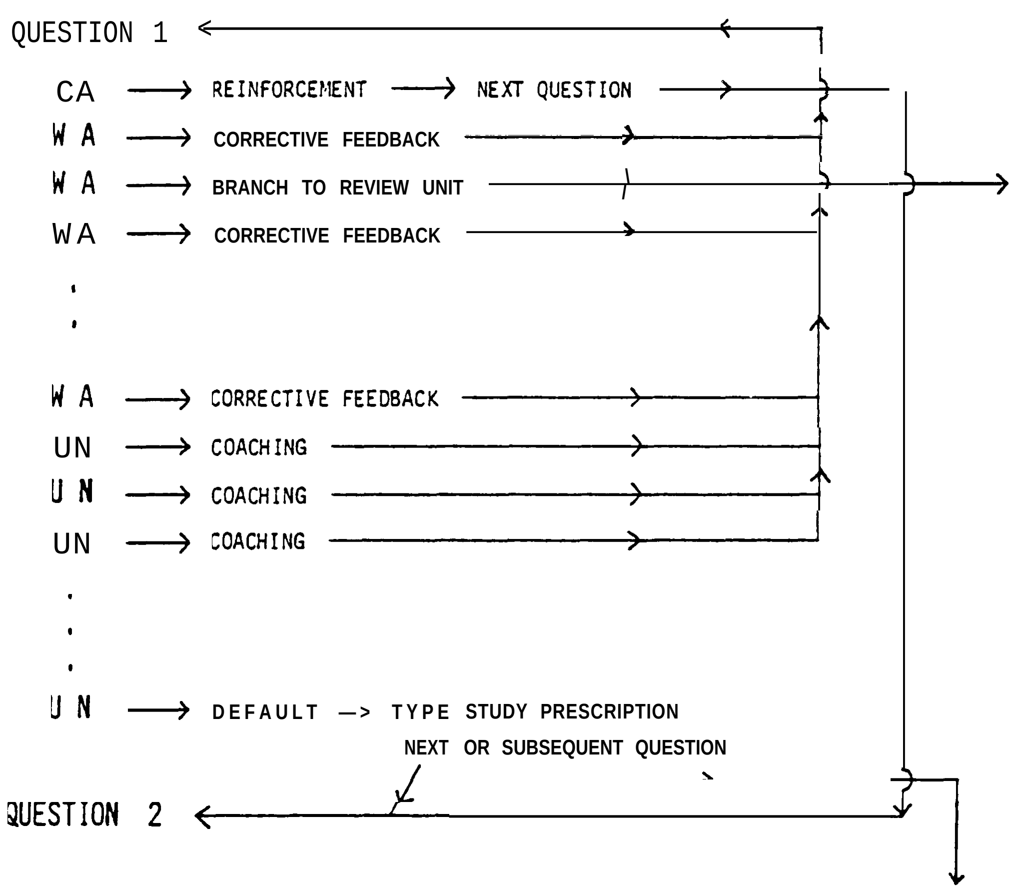
CBE employs a variety of educational approaches or strategies, including drill and practice, tutorials, simulations and games, and inquiry. These strategies have been used for both individual and group-oriented education. The use of CBE by groups is relatively new (Bergin et al., 1978a & b).

Drill and practice exercises require the user to complete a series of exercises, for example, balancing equations in acid-base calculations, that relate to a particular area of knowledge. The computer can use random number generators or complex algorithms to create an almost endless set of exercises of any given difficulty level that are specifically tailored to the needs of the individual learner.

Tutorials are instructional situations in which the learner interacts with computer programs that model a teacher, Such tutorials are designed to meet the individual needs of each student by allowing "instructors" to be continuously present and, therefore, responsive to specific learner needs. Student feedback, remediation, as well as testing and recordkeeping, can be accomplished by a computer instead of by a human instructor. Tutorial programs allow problem solving, question answering, and other similar capabilities. "Intelligent tutors" that are built into these systems offer the student hints, track student errors, and present alternatives to identify overlooked or misunderstood information. A schematic drawing of a tutorial CBE item is shown in figure 4.

51-541 0 - 79 - 3

Figure 4.—Schematic of a Tutorial Computer-Based Education Question



KEY: CA = CORRECT ANSWER
WA = WRONG ANSWER
UN = UNANTICIPATED RESPONSE

Simulation and games are instructional strategies that allow participation in a situation closely resembling an actual experience. The sophistication of the computer allows for generation and use of simulation rules and enables complex simulated decisionmaking by the student in accordance with these rules. Simulations permit students to perform "dangerous" and "critical" tasks. They also telescope real-world time, abstract essential task elements from a potentially confusing total environment, and expose the user to a wider variety of environmental variations. For example, flight simulators have been used in aviation since 1939. Real flight accommodates only 6 practice landings per hour; flight simulations allow 30, and can be conducted despite airport traffic, unfavorable weather, and initial pilot inexperience without risk to personnel or equipment (Orlansky and

String, 1977). Through 1981, the total Department of Defense investment for flight simulators will approach $2 billion (Allen, 1976). Aircraft control, submarine control, navigation, automobile control, medical diagnosis and treatment, business management, population and ecology studies, and dozens of other complex situations also have been simulated for the purposes of training and testing both individuals and groups. The skills developed through simulations transfer well to on-the-job performance (Puig, 1976).

Since the 1950's, there have been efforts to construct computer programs that simulate human thought processes through *artificial* intelligence. Research groups at Bolt, Baranek, and Newman; Stanford University; and the Massachusetts Institute of Technology have developed programs to teach logic, symbolic integration, and automatic critiquing of student achievement. Using artificial intelligence, the computer program itself tries to simulate a human tutor (Papert, 1975; Brown et al., 1977). Recent work in this area includes the "sophisticated instructional environment" (SOPHIE), which is being used by the Navy to teach electronic troubleshooting. This program creates a "reactive" situation in which the student learns by experimenting with his/her own ideas (Brown, 1975). Currently, the major source of financial support for artificial intelligence development is the Department of Defense, although small projects have been funded by the National Institute for Education and the National Science Foundation (U.S. Congress, 1978).

Computerized games create a cooperative or competitive environment in which the student interacts with real or artificial participants to achieve specified goals. Simulation and games are often used together as instructional tools for teaching problem-solving skills. In electronic troubleshooting, for example, partners can introduce faults into a simulated machine and the "winner" both diagnoses his/her problem and provides a solution first. Data requested from the computer by either player may be helpful to both.

Inquiry permits the learner or user to address questions to the computer. To process the questions and provide answers, the computer uses key words and stored responses. For example, the computer could be queried as to contra-indications for drugs or serve as a "consultant" for the diagnosis and management of patient problems. This use differs from artificial intelligence because queries are compared to specific answers rather than being interpreted according to a general rule or algorithm.

Funding

During the past 20 years, CBE development and testing have been supported by Federal, State, and local governments; educational institutions; private foundations; the military; large industrial firms; the computer industry; and, to a lesser extent, the publishing industry (Tennyson, 1977). Table 2 shows the results of a 1974 study of expenditures by developers for CBE programs in all subject areas.

More recent data on funding for health-related CBE projects between 1968 and 1978 show three primary funding sources: the Federal Government, private medical foundations, and medical boards. Their combined support totaled over $9 million (Association of American Medical Colleges, 1979). Among the Federal agencies, the National Center for Health Services Research, the National Library of Medicine, and the Bureau of Health Manpower provided over $5.4 million. Almost .50 percent of these Federal funds went for direct support to medical school programs that were developing, using, or evaluating CBE; over 35 percent was directed to improve the cost-effectiveness of computers in

Table 2.—A Sample Spread of Computer-Based Education Funding and Development Sources as of 1974

Categories of developers	Percent of CBE programs developed as of 1974*
National Science Foundation.	300/o
Colleges and universities	29
Military ., ...	10
U.S. Office of Education	9
Private sector	9
Public schools	8
National Institutes of Health , ...	1.8
Other Federal agencies.	1.8
Other—foundation	
State agencies	
Community colleges	1.4
Professional societies.	
Total, ...	1000/0

"IS somewhat Inflated since It Includes learnlng *about* computers (e g , computer science and programming) as well as learning wlth computersd (e g , CBE)
SOURCE Human Resources Research Organizatlon, 1974

cost-effectiveness of computers in health education; and the remainder was dedicated to projects designed to educate physicians in the use of computers.

Among private medical foundations, the National Fund for Medical Education, the Robert Wood Johnson Foundation, the Kellogg Foundation, and the Merck Foundation have expended over $2 million on a wide variety of CBE projects. Medical boards, such as the National Board of Medical Examiners, the American Board of Internal Medicine, and the American College of Physicians, jointly spent almost $2 million in the development of CBE materials for the assessment of physician competence.

Federal funding levels for CBE research and development have decreased in recent years (U.S. Congress 1978). This reduction is due partially to the inability of CBE researchers to document initial claims of large cost decreases and proficiency increases in education and training as a result of CBE use. In many situations where CBE proved useful, State, local, or private support was used to replace Federal money (Montgomery County Public Schools, Ohio State University, etc.).

Limitations and Capabilities

Computer-based education is most frequently applied to test knowledge and skills in areas in which correct responses do not involve an affective component, such as attitudes or preferences. In situations where an evaluator must observe the performance of certain skills (e. g., surgery), assessment by computer is ineffective, if not impossible. Additionally, required individual and organizational changes often inhibit effective CBE introduction, diffusion, and utilization (Casburgue, 1978). Despite these and other limitations, CBE can be an improvement over more conventional educational and evaluative methods. Table 3 summarizes the results of 32 studies that are recent and representative samples of the many CBE evaluation studies. The findings of these studies are summarized below.

Savings in learner time to complete a course of study were shown in the great majority of the studies, with as much as 50-percent savings in training and testing time. The reorganization of instruction to an objectives-based form, a prerequisite for CBE use, can itself cause significant learner timesaving.

Table 3.—Thirty-two Studies of Computerized Simulations and Testing

	Source	Time saved	Cost saved	Greater efficiency	Improved skills	Provision of training not previously available
S	Abernathy and McBride, 1978 . . . . •	+	+	+	+	+
S	Allen, 1976	+	+	+	+	+
T	Bejar et al., 1977	+	0	+	+	+
s	Bentz, 1975	+	–	+	+	+
s	Brown et al., 1977	+	0	+	+	+
s	Brown, 1977. ....., ...	+	0	+	+	+
T	Brown and Weiss, 1977	+	+	+	+	+
s	Buchanan, 1978	+	+	+	+	+
s	Ellis, 1978	+		+	–	+
s	Gregory, 1975.......,..	+		+	+	+
T	Guerra et al. 1977. . .	+	0	+	+	+
T	Hansen et al.,1974.	+	+	+	+	+
s	Johnson, 1976..	0	0	0	+	+
T	Lippey and Partos, 1976.	+	0	+	0	+
T	McLain and Wessels,1975. . .	+	0	+	+	+
s	Misselt and Call-Himwich, 1978 . . .	–	–	–	–	–
s	Mockovak et al.,1974, ...	+		+	+	(conventional – superior)
s	Orlansky and String, 1977	+	+	+	+	+
s	Puig,1976					
	Tanks	0	+	0	0	–
	Aircraft carrier.	+	0	+	+	+
	Weapons trainer. ., ...	+	+	+	+	–
	Airtraffic controller	+	0	+	+	–
	Automobile	0	+	+	+	–
	Airborne Ecosystem.	+	+	–	+	–
s	Roberts, 1977	+	+	+	+	+
T	Sealy,1975.	+	0	+	0	+
T	Vale, 1977	+	+	+	+	+
s	Willey,1975					
	Dartmouth	+	0	+	+	+
	Ohio State	+		+	–	+
	University of Wisconsin. .	0	–	+	+	+
	University of Illinois	+	0	+	+	+
	University of Michigan ...,	+	+	+	+	+
	Totals.	+ = 27	13	~8	26	**25**
		– = 1	7	2	3	**7**
		0 = 4	12	2	3	**0**

Key **S = simulation**
T = testing
+ = positive results
– = no slgnificant difference
O = no results

SOURCE Human Resources Research Organization 1978

Cost savings findings were mixed. These findings reinforce the need for further studies in this area. One such study could examine linking particular educational needs with the use of different media. For example, instructor provision of tutorial sessions for three or four students may be more cost-effective than CBE sessions of the same material largely because of the high developmental cost-to-use ratio for CBE. If there is a need for frequent repetition of the sessions over an extended period of time, however, CBE may be more cost-effective. Examples of cost savings are evident in the computer-based simulations of the University of Michigan's Psychology Department; these simulations are carried out at one-half the cost per student hour ($7 versus $14) of live experimentation (Willey, 1975). IBM also realized cost savings from CBE use. IBM's Field Engineering

Division has used CBE since 1964. As a consequence, the number of their education centers decreased from 17 to 3, and the costs of training were reduced by 60 percent (Long, 1978).

Greater efficiency in learner functioning was demonstrated in the majority of these studies. Learners showed greater achievement per unit of time spent because they could proceed at their own pace, receive continuous feedback on their individual performance, take tests at appropriate points, and discuss materials presented with their peers. Tests could be tailored to precisely assess the individual's performance, not only by giving a score, but also by identifying any gaps in knowledge. Since clerical chores of grading and remediation are part of most CBE programs, the efficient use of instructor time also increased.

Improved skills were shown in 80 percent of the studies in such diverse areas as flying and flight maintenance, merchant marine and submarine operations, personal interviewing, business forecasting, and on-the-job performance of telephone servicepersons (Puig, 1976; Roberts, 1977).

Provision of training not previously available was characteristic of the large majority of the studies analyzed. Simulation for training purposes is a prime example of this uniqueness: simulation can provide practice of many kinds that only years of experience could previously have provided. For example, weather, traffic, time, maintenance, and fuel costs make training of airline pilots or tanker captains in real craft impractical (Puig, 1976); and financial, political, and physical phenomena cannot be adjusted for training purposes.

Chapter 3

MEDICAL EDUCATION AND ASSESSMENT

3.

MEDICAL EDUCATION AND ASSESSMENT

INTRODUCTION

Although a clear demarcation exists between the formal education process of physicians in undergraduate and graduate (residency) education and the more informal learning process accompanying active patient care, it is now commonly recognized that medical education is a *continuum* spanning both processes. This recognition has been manifested in two ways.

First, continuing medical education for physicians, initially implemented on a voluntary basis, now is a formal requirement for reregistration by many State medical licensing boards and for recertification by some specialty boards.

Second, in evaluating the quality of care provided by physicians, criteria are usually grouped according to *structure, process,* or *outcome* measures. *Structural* measures refer to the availability of resources, including facilities, equipment, and the numbers and types of different health care personnel. Structural measures also include qualitative aspects of the personnel providing medical care, such as the extent of educational background and board certification in a specialty area. *Process* measures usually assess whether or not diagnosis and/or therapy have been appropriately conducted according to norms or standards, or the medical profession's *average care* or *judgment of what that* care *should be. Outcome* measures reflect the end results of medical interventions and relate to the condition of the patient.

Outcome measures could tell us more precisely when and how medical care can help patients. However, knowledge is still rudimentary concerning the relationship between medical interventions and specific health outcomes. Ideally, structure, process, and outcome measures could be related. Specific medical interventions (process) could be correlated with improvements in health status (outcome). This correlation would then be used to modify the learning process (structure): the content of education would be improved by learning from experiences in the actual practice of medicine.

Medical education and assessment as continuous processes are most observable in the formal and informal education and assessment activities (continuing education requirements, recertification, peer review systems) that have appeared in clinical practice. The continuity is also reflected in the trend to revise present educational and assessment strategies to more accurately reflect the explosion of medical knowledge and the fact that physicians practice in specialized areas of medicine. The amount of knowledge that is needed to address all types of medical problems is too large for any physician to consistently retain, recall, and apply. Physicians now need to know more-about every specialty of medicine, yet knowledge and medical capabilities are expanding across all specialties. The medical information explosion also results in changes in the content and methods of medical education and in the use of medical knowledge.

Changes are occurring in medical licensure as a result of this reformulation of educational and assessment strategies. The content areas to be tested are changing, and the types of medical care that individual physicians are authorized to provide also may change. Such changes would lead to a modification in the role of State licensing boards and possible involvement of the medical specialty boards in the licensing of physicians.

The continuity of medical education and assessment activities is graphically summarized in figure 5.

UNDERGRADUATE MEDICAL EDUCATION

Admissions

Medical school is the common denominator for all types of physicians. Students are selected from a pool of applicants on the basis of generally uniform criteria, modified by the desire and need for diversity. Schools seek diversity in their student bodies voluntarily, as a result of judicial actions, and/or as a condition of Federal and State financial support. Geographic origins and minority/disadvantaged applicants, for example, are now factors in the admissions process.

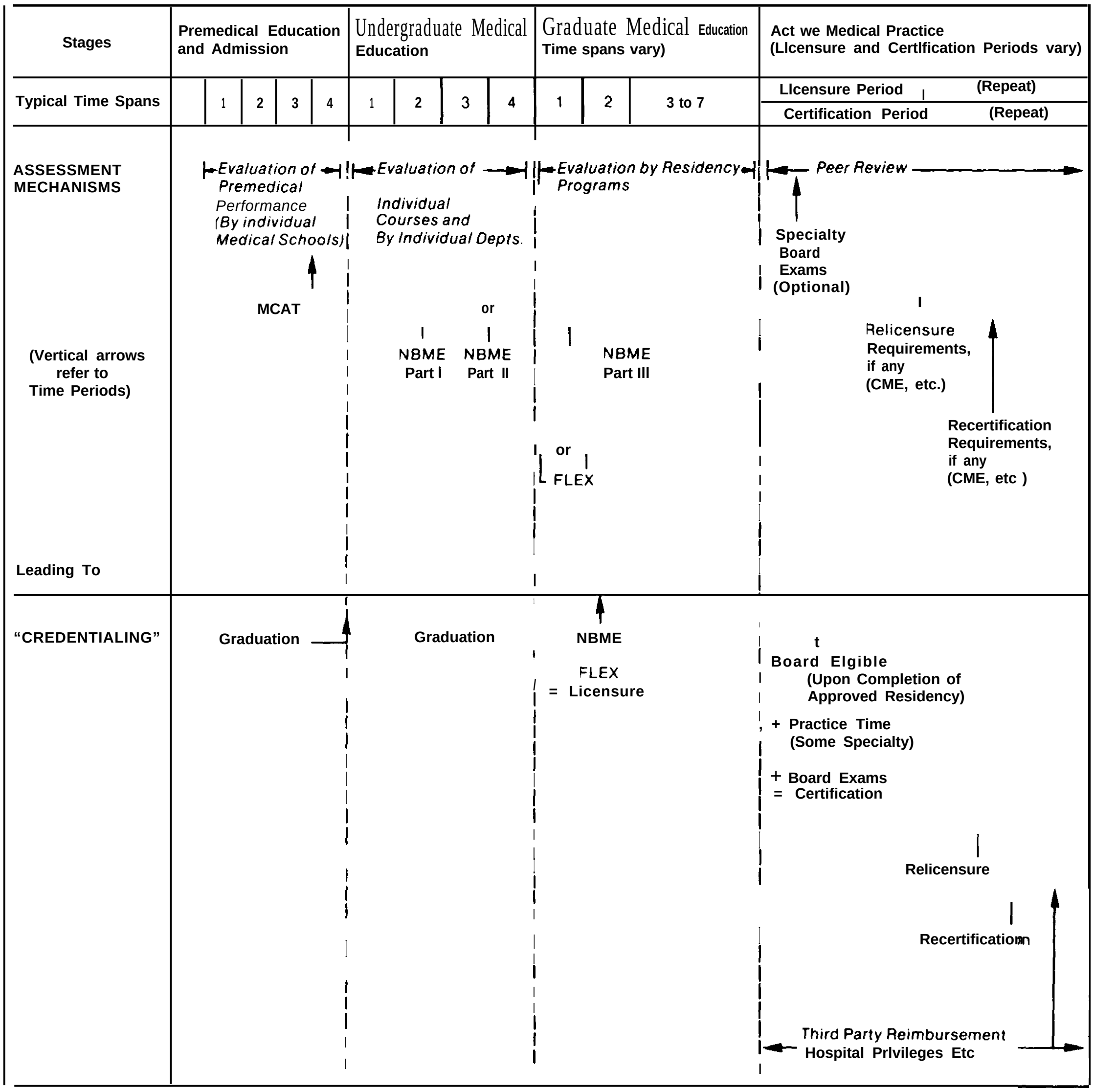
The geographic origin of a student is seen not only as a factor in student body diversity, but also as an important determinant of practice location. Consequently, attempts to influence the future geographic distribution of practicing physicians may be reflected in medical school admissions criteria. Such criteria are intended to improve access to medical services.

Favoring minority/economically disadvantaged applicants in the admissions process also addresses access questions, but of two different types. Access to medical services is one; students selected on the basis of these criteria are assumed to have a greater rate of practice in the types of communities from which they come. The primary consideration, however, is access *into* the medical profession by the disadvantaged.

Factors entering into the decisions of medical school admission committees include: 1) Medical College Admissions Test (MCAT) results; 2) the applicant's academic background and overall grade point average, difficulty of courses taken, and performance in related courses such as biology, chemistry, physics, and mathematics; 3) biographical data, including applicant's State of residence, ethnic background, and participation in nonacademic activities such as student government; 4) recommendations and reports from the applicant's premedical health profession advisor; 5) information and impressions from the personal interview, which is intended to allow the applicant to demonstrate communication and personal interaction abilities, and includes questions regarding the applicant's plans for career and location, as well as motivation for the study of medicine; and 6) results of other assessment instruments such as Miller Analogies, Myers-Briggs personality assessments, and any special knowledge tests used by selected medical schools.

Each school's admissions committee has its own particular needs and methods of judging the relative importance of each of the above criteria in choosing among applicants. The mix of criteria used depends largely on a school's previous experience with accepted applicants. In addition, most State-supported medical schools favor resident applicants by limiting the admission of nonresident students to 10 to 15 percent of the entering class (Association of American Medical Colleges, 1978a).

Figure 5.—The Medical Education and Assessment Continuum



In 1977-78, there were 15,493 first year positions available in U.S. medical schools. There were 40,569 applicants competing for admission, of which 15,977 (39.4 percent) were accepted for first or later year positions (Gordon, 1978). Table 4 summarizes trends and projections in the numbers of medical schools, graduates, and physicians in practice between 1960 and 1990.

Table 4.—Number of Medical Schools, Graduates, and Physicians in Practice, Selected Years

Year	Number of schools[a]	Number of graduates[a]	Number of physicians M.D.	Number of physicians D.O.
1960	85	7,081	247,300	12,000
1970	101	8,367	311,200	12,000
1975	114	12,714	364,500	14,100
1980 (projected)	122-124	16,086	426,300	17,700
1990 (projected)	—	18,318	564,200	29,800

[a]M.D. schools and graduates only

SOURCES "Medical Education in the United States, 1977 -1978," JAMA 2402822 (December 1978). Bureau of Health Manpower, Health Resources Administration, DHEW, 1978

Curriculum

The majority of U.S. medical schools conduct traditional 4-year undergraduate medical education programs. Approximately 6 percent of the schools have programs in which the student can receive the M.D. degree in 3 years (34 to 36 months) (Association of American Medical Colleges, 1978b). In this setting, the student takes coursework essentially on a 12-month basis. Although there are slight reductions in the total hours of some courses, the basic content of these courses is similar to the courses in traditional 4-year programs. Some schools accept students into a special program immediately following graduation from high school. Assuming normal academic progress, the students graduate approximately 6 years later. Other schools accept highly qualified students after the junior year in undergraduate college and award the M.D. degree 4 years later, for a total of 7 years.

The general 4-year program of undergraduate medical education is divided into two major portions—the basic medical sciences and clinical sciences. The basic sciences generally span the first two academic years of the program and include anatomy, biochemistry, physiology, microbiology, pathology, and pharmacology. These disciplines may be taught either independently as separate disciplines, or together as separate aspects of particular human organ systems, such as the cardiovascular system or the central nervous system. In either case, the material is taught via a mix of lectures, laboratory exercises, and discussion and/or correlative sessions. When the curriculum is taught by the separate disciplines, the usual sequence is anatomy, biochemistry, and physiology in the first academic year; microbiology, pathology, and pharmacology are taught in the second academic year. In interdisciplinary curricula, where the disciplines are taught together within particular human organ systems, there is no given sequence of courses arranged according to discipline. Other types of nontraditional curricula are offered in which the student is permitted to study and progress through the curriculum at his/her own pace.

A variety of educational support services are employed in the medical school program. Although the primary form of presenting didactic information is the lecture, other associated learning resources include audiovisual aids, case study materials, and computer-assisted instruction (CAI). Sixty percent of U.S. medical schools incorporate CAI into the curriculum. CAI is generally in the form of independent units of instruction that are available to the student upon his/her request (Association of American Medical Colleges, 1977).

Attempts to introduce early patient encounters during the two basic science years as a means of demonstrating the relationship between the basic sciences and patient care are increasing. Through these programs, there are opportunities to use the knowledge learned and to expose students to problem-solving and patient diagnosis exercises.

In the transition from the basic science to clinical science years, learning through formal lectures decreases while learning through working with patients increases. The transition to clinical medicine is aided by the development of physical diagnosis, history taking, and physical examination skills and by introductory courses in the various major clinical specialties.

There are generally six clinical areas in which the student is required to serve: family medicine, internal medicine, obstetrics and gynecology, pediatrics, surgery, and psychiatry. Students serve a period of 8 to 12 weeks in each of these six clinical areas. During each clerkship, students learn via lecture, discussion, and considerable interaction with clinical faculty on their rounds in the hospital or clinic. Students conduct physical examinations, take patient histories, and participate in the formulation of treatment plans and requests for laboratory analyses. As the student progresses through a particular clerkship, he/she is required to assume an increasing share of responsibility for patient diagnosis and treatment under the supervision of the clinical faculty and house staff. The student is evaluated in each clinical clerkship by the faculty member(s) supervising the clerkship and by house staff.

Following the required rotations, which usually occur during the entire third year of medical school, the student may select certain specialty areas according to interest and career choice. Fourth year electives can be either a mixture of basic science areas and clinical specialties or totally clinical electives. The student interested in medical research, for example, might choose to take additional basic science coursework as well as clinical electives. Regardless of the particular choices, the student spends the majority of the fourth and last year of medical school in his/her chosen area.

Assessment of Student Performance

The purpose of evaluation in undergraduate education is to assure that students achieve the educational objectives of the medical school and thereby qualify for the academic degree. The extent of a student's knowledge is assessed through objective tests that are administered throughout the student's medical school career. Student acquisition and use of clinical judgment skills are assessed primarily through the use of evaluation forms in the clerkship phase of medical education.

Within the basic sciences, objective examinations are both written and practical. They are designed essentially to assess the acquisition of knowledge and understanding of concepts within each discipline of the basic medical sciences. Faculty use their own tests and simulations as well as more widely used and standardized ones. The National Board of Medical Examiners (NBME) provides standardized tests for intramural use by medical school departments and faculty for student assessment. Based on the student's performance on locally developed examinations, he/she either advances in the program or is required to take remedial and/or tutorial instruction. The particular pass/fail criteria are a matter of the individual department's policy, Students often take the comprehensive examinations administered nationally by NBME at the end of the basic science portion of medical school (NBME Part I). Approximately three-fourths of all medical schools also require students to take Part I, and some schools also require Part II (Association of American Medical Colleges, 1978b). The extent to which medical schools require passing performance on this exam varies. Some schools require a passing score on *each* discipline section; others, an overall passing score. Some require the student only to take the exam. The degree to which the NBME Part I scores contribute to the student's evaluation varies considerably among schools.

In addition to these methods of evaluation, many programs offer opportunities for self-evaluation. Often these self-evaluation methods utilize computer-simulated situations and computerized sets of test items and test situations. The availability of these facilities allows students to continuously assess their performance and progress.

The methods of assessing student performance in the clinical sciences are quite different from the basic sciences. The clinical evaluation contains a high degree of subjectivity and, although a standard institutional form may be used, often the clinical sciences are designed to determine the student's ability to integrate and synthesize the basic science information in clinical settings. Written, oral, and practical evaluations occur in each of the clinical rotations; and emphasis is placed on the student's ability to interact with patients, conduct physical examinations, take patient histories, make accurate diagnoses, and properly adapt basic science knowledge to the diagnosis and treatment of patients.

The assessment of student performance and preparedness during the course of undergraduate medical education is only one of the purposes of the assessment activity in medical school. A second and equally important purpose is to determine the adequacy and effectiveness of the curriculum itself. In most medical schools there exists an Office of Medical Education Research and Development that develops the internal mechanism for continuous student and curriculum assessment within the medical school.

GRADUATE MEDICAL EDUCATION

Graduate medical education (GME) is a period of training that leads to qualification in a specialty. Medical students begin interviewing for graduate medical education positions (residencies) in the spring, summer, and fall between their junior and senior years. Students usually apply through the National Residency Matching Program (NRMP) for first-year appointments by the end of December of their senior year. Residency appointments are released in the spring.

Although based on different criteria, the same type of assessment that occurs in the medical school application process also occurs in the residency application process. Program directors review the applicant's academic performance in undergraduate medical education, recommendations of the faculty (particularly clinical faculty), and, if applicable, performance on Parts I and II of the NBME test. The results of the program director's interview with the applicant, if conducted, are also considered. Finally, the graduate program director's past experience with graduates of specific medical schools enters into the consideration.

The first year of GME is designated as the first year of an approved residency program. Beginning in July 1975, the term *internship* has not been used in approved graduate training programs (American Medical Association, 1977a). Although an integral part of the approved residency is a specialty, the first year is designated as either a categorical or a flexible first year. Such categorization reflects the fact that the first-year residency program is not necessarily limited to one specialty. One type of categorical first-year residency limits the program's content to the specialty field of the sponsoring programs. A second type may include two *or* more specialty fields as determined by a sponsored program. A flexible first year is sponsored by two or more approved residencies and is jointly planned and supervised by the directors of such residency programs.

Following the first year of GME, additional periods of education are required to satisfy qualifications for specialty board certification. The years of required training for each specialty are summarized in figure 6.

During residency, the assessment of professional attitudes, self-discipline, communication skills, and various aspects of clinical judgment is accomplished chiefly through the subjective evaluations of the attending physicians and program directors. A number of specialty boards are now encouraging and introducing evaluative techniques for use during the residency training period. These in-training examinations assist the resident and the program directors to identify the resident's strengths and weaknesses in diagnostic techniques, medical procedures, and basic scientific knowledge in the specialty area.

LICENSURE AND SPECIALTY CERTIFICATION

Licensure

States and U.S. territorial jurisdictions (the District of Columbia, Puerto Rico, the Virgin Islands, and Guam) have the authority to license physicians. A physician must be licensed in each State or territory in order to practice there, although licensure reciprocity exists between most of them. Each jurisdiction establishes, through laws and regulations, the requirements for eligibility to take the licensing exam.

There are two primary examination pathways for licensure in the United States: 1) Parts 1, 11, and III of the NBME exam, and 2) the Federation Licensing Examination (FLEX). FLEX is constructed by the Federation of State Medical Boards and produced through NBME. It is the examination administered by individual State medical licensing boards. For foreign physicians, some States accept a Canadian license; others accept specialty board certification.

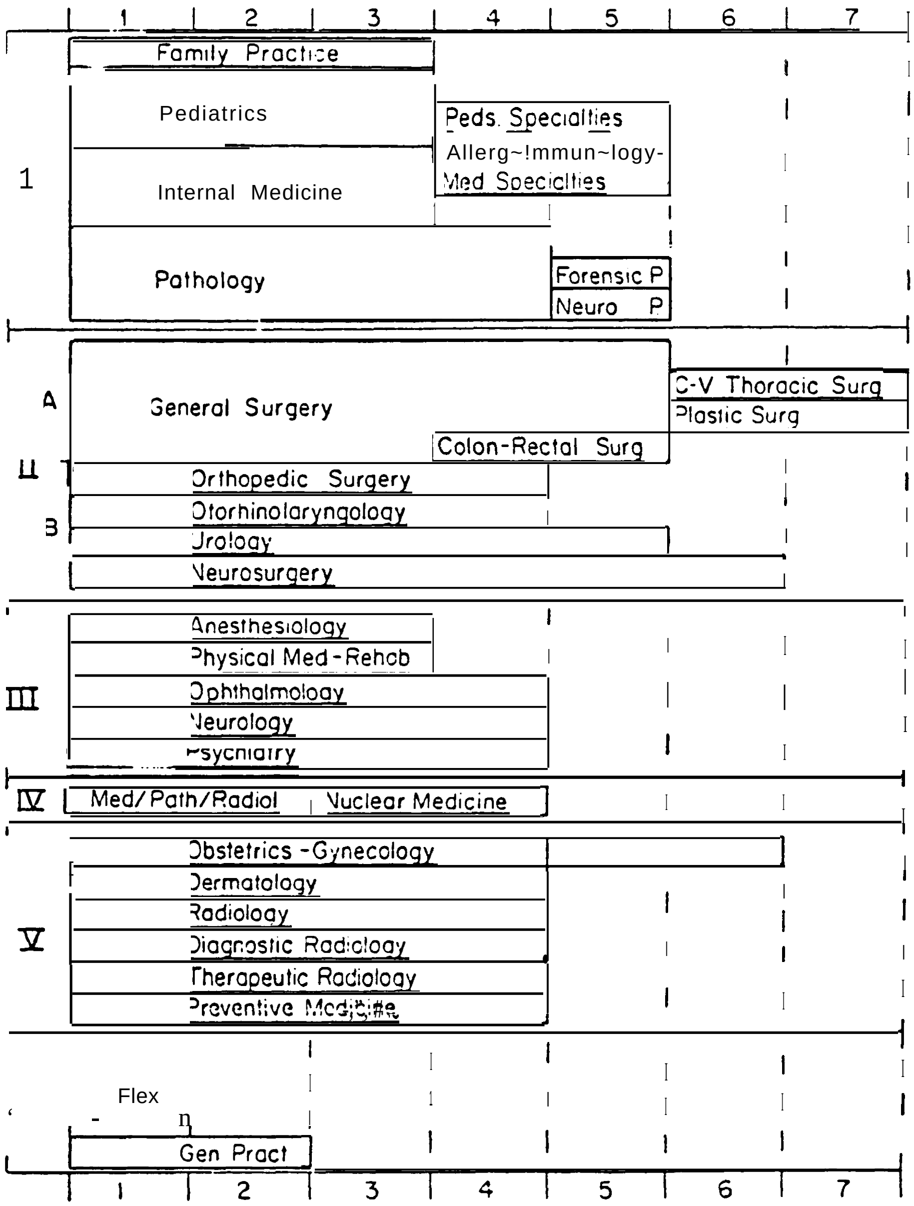
The NBME examination is composed of three parts. Part I, usually taken upon completion of the basic medical sciences, assesses the student's grasp of knowledge and concepts within the basic sciences. It is a comprehensive, 2-day examination consisting of approximately 1,000 multiple choice questions equally distributed among the disciplines of anatomy, behavioral sciences, biochemistry, microbiology, pathology, pharmacology, and physiology.

Part 11, taken either during the third or fourth year of medical school, is designed to measure knowledge and comprehension of the clinical sciences. Approximately 900 multiple choice test items are administered over a 2-day period. Questions are derived equally from internal medicine, obstetrics and gynecology, pediatrics, preventive medicine and public health, surgery, and psychiatry.

Part III, usually taken during the first year of graduate medical education, focuses on problem-solving abilities. The exam utilizes programed testing in the form of patient management problems as well as multiple choice questions, many of which require interpretation and analysis of illustrations, graphs, and tables of data.

Since the sequence of the NBME exam begins during undergraduate medical education, the majority of students successfully completing Parts I and II will use the NBME as their method of achieving licensure. Approximately 80 percent of U.S. medical school

Figure 6.—Years of Graduate Medical Education



SOURCE: Graettinger, 1977

graduates achieve initial licensure by successfully completing Parts I, II, and 111 of the NBME exam (American Medical Association, 1977b). The percentage of graduates achieving licensure through the NBME exam is influenced by the fact that a number of schools require their students to take and pass Parts I and/or II of the NBME exam as a part of their intramural evaluation system. However, the student always has the option to choose between the two certifying methods, regardless of whether or not parts of the NBME exam were taken in medical school.

If the physician does not take the NBME tract, he/she is required to take FLEX. Candidates usually take FLEX during the first year of graduate education. The examination is composed of three parts that must be taken at one time in 3 successive days. FLEX also differs from the NBME exam in its method of scoring; less emphasis is placed on the basic sciences. Although FLEX, at any one administration, is the same for all States, and all boards require a minimum weighted average score of 75, there are interstate variations on the acceptable minimum scores for individual subject areas. Thus, although the reported scores are uniform, there is some variance among licensing jurisdictions regarding acceptable passing scores (Merchant, 1978).

The composition of FLEX is derived from test items within those developed and validated by NBME. Questions are selected by committees, the members of which represent various State medical licensing boards. The 3 days of tests are similar to Parts I, II, and III of the NBME exam. The first day covers the basic medical sciences, the second day covers the clinical sciences, and the third day covers clinical problem-solving.

FLEX is the main route to licensure for foreign medical graduates; 78 percent of candidates taking FLEX in 1977 were foreign medical graduates (Merchant, 1978).

None of the State boards require a relicensing examination. However, as of December 1978, 23 States and Puerto Rico had enacted legislation or written regulations requiring continuing medical education (CME) for reregistration of the license to practice medicine. These States are identified in table 5. In the other States, relicensure remains a pro forma process accomplished by paying a renewal fee.

Specialty Certification

The successful completion of a residency program, and, in a number of specialties, additional practice, qualify the physician for specialty board certification. Specialty board certification is not legally required. Rather, it is a voluntary process designed to indicate the type of specialized medical expertise a physician possesses beyond the general ability to practice medicine. The physician who has completed a residency program and received a license to practice is legally qualified to practice in that respective specialty without passing a certification exam. However, a physican will not be considered board certified.

The requirements necessary to achieve specialty certification are determined by the boards themselves. The 22 specialty boards and several other organizations are members of the American Board of Medical Specialties (ABMS). Among its functions, ABMS establishes standards, policies, and procedures for assuring the continued competence of physicians (Amercian Board of Medical Specialties, 1977). The recognized plans and educational standards for graduate training in each of the specialties are published annually in the Directory of Accredited Residencies (American Medical Association, 1977a).

The certifying exam for specialty board certification is developed by each of the 22 specialty boards. A number of specialty boards are receiving assistance and guidance

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Table 5.—Jurisdictions With Authority to Require Continuing Medical Education for Reregistration of the License to Practice Medicine

State	Requirement in effect
Alaska	No
Arizona	Yes
Arkansas	No
California	Yes
Colorado	Yes
Hawaii	Yes
Illinois	Yes
Iowa	No
Kansas	Yes
Kentucky	No
Maryland	Yes
Massachusetts	Yes
Michigan	Yes
Minnesota	Yes
Nebraska	No
New Hampshire	Yes
New Mexico	Yes
Ohio	Yes
Pennsylvania	Yes
Puerto Rico	No
Rhode Island	Yes
Utah	Yes
Washington	Yes
Wisconsin	Yes

SOURCE" "Medical Education In the United States, 1977.1978,"JAMA 240:2850(December1978)

from NBME in the development and validation of their exams. The certifying exam for most specialty boards consists of oral and written tests. The written exam assesses basic scientific knowledge pertinent to the specialty. The examination of skills necessary to apply basic knowledge to the management of clinical problems is assessed chiefly through the oral exam. Skills, such as the ability to obtain and interpret information required for the proper diagnosis, the proper selection of therapy, and general patient management, are also assessed by the oral exam. Using standard techniques to specify and assess cornpetence in specialty training becomes increasingly difficult, however, as the sophistication ofatient care and management techniques increases.

All 22 medical specialty boards have established policies to provide recertification. Seventeen boards have established dates on which recertification will begin; six boards have already administered their first exam. Five boards have made recertification mandatory. Table 6 summarizes these developments.

Emerging Developments

As a result of a report of the Committee on Goals and Priorities of NBME (National Board of Medical Examiners, 1973), the methods of assessing the readiness of a medical school graduate to enter GME has received considerable attention. NBME is presently under contract to the Bureau of Health Manpower, Department of Health, Education, and Welfare (HEW), to develop and validate methodologies for an examination, the Comprehensive Qualifying Examination (CQE), to be administered Prior to graduate medical education (National Board of Medical Examiners, 1979). NBME is developing a rating scale and a behavioral checklist for the exam and methods for assessing skills in sequential diagnostic problem-solving.

Table 6.— Implementation of Recertification by the Specialty Boards

Board	Implementation date	Mandatory requirement
Allergy and immunology	1 0/77	No
Anesthesiology	1984	No
Colon and rectal surgery	1985	Yes
Dermatology	1985	No
Family practice	10/76	Yes
Internal medicine	10/74	No
Neurological surgery	None	—
Nuclear medicine	None	—
Obstetric-gynecology	12/77	No
Ophthalmology	1983	No
Orthopedic surgery	None	—
Otolaryngology	1980	No
Pathology	1983-84	Yes
Pediatrics	1/80	No
Physical medicine and rehabilitation	1978	No
Plastic surgery	1978	No
Preventive medicine	None	—
Psychiatry and neurology	None	—
Radiology	1980	No
Surgery	1986	Yes
Thoracic surgery	1986	Yes
Urology	1980	No

SOURCE "Medical Education in the Unlted States, 1977.1978," ./AMA 24O: 2850(December. 1978)

CQE could provide an assessment of the medical school graduate's readiness for graduate training; such assessments are not conducted currently. In addition, CQE could be offered to all those entering graduate training for specialization: graduates of U.S. and foreign medical schools.

This new examination may lead to: l) a limited license to practice upon attainment of specialty status, and 2) intermingling of licensure by State medical licensing boards with specialty certification by the independent specialty boards. First, the graduate trainee would concentrate on a specialized area of medicine. If CQE is eventually acceptedly State medical licensing boards as a license to practice in the supervised setting, then the subsequent license to practice in the unsupervised setting may also be limited to the physician's specialty area. Second, all physicians who presently wish to practice must successfully pass the State licensing exam or other recognized tests. Those who qualify through specialty certification might not be required to be examined by the State if they successfully pass their specialty board certification exams (Merchant, 1978; Evans, 1978). Widespread adoption by State medical licensing boards of specialty certification, in lieu of the licensing exam, would further link the governance powers now vested in public agencies, the State medical licensing boards, with the powers of private organizetions, the specialty boards.

CLINICAL PRACTICE

The process of assessing a physician's performance during practice is different from the one used during formal training. Some elements of the process are the same; for example, continuing education requirements and recertification exams are similar to learning and testing in the physician's formal training years. However, the practicing physician also is subject to the requirements of various programs designed to measure, evaluate, monitor, and/or improve medical services. Many of these programs are commonly known as "quality assurance" programs because of these objectives. There are generally two major categories of such programs. Programs may be designed primarily to assess and improve the quality of medical care by *retrospective* analyses of physicians' treatment of patients. These programs rely on the analysis and interpretation of data about the medical care process and are designed to evaluate care already delivered. Other programs are designed to provide guidance to the physician during diagnosis and treatment. Such programs are commonly referred to as concurrent programs. Both retrospective and concurrent programs frequently have two distinct goals: 1) intervention in the medical care process in order to improve the quality of care rendered, and 2) reduced costs of medical care through reduction of inappropriate and/or excessive medical services.

Some quality assurance programs are federally mandated, such as the Professional Standards Review Organization (PSRO) program; others are privately sponsored. The PSRO program has established a major system of hospital quality assurance through concurrent review and medical care evaluation studies; efforts are now underway to identify variations in medical services through the development and analysis of provider and patient profiles. Recently enacted legislation established State government units to identify and detect cases of fraud and abuse in the Medicaid Program. A standardized data processing system, the Medicaid Management Information System (MMIS), has been installed in several States and is scheduled for full-scale national implementation. The Joint Committee on Accreditation of Hospitals (JCAH) promotes its own recommended hospital quality assurance programs and has recently entered the area of ambulatory care. Insurance companies have increasingly turned to review of claims data to isolate cases of flagrant abuse. Descriptions of a number of these review systems follow.

Hospital discharge abstract processing systems use data abstracted from hospital records by hospital medical records personnel. Abstract forms designed by a processing service include, at the minimum, the Uniform Hospital Discharge Data Set (UHDDS). The processor prepares a number of reports, such as the disease and operations index. Most abstract forms have been modified to include PSRO data elements to accommodate PSRO requirements for concurrent review information. Hospital discharge abstract processing systems are intended both to assist the institution in meeting the requirements imposed by JCAH and to provide the information for the hospital medical staff's various committees, such as the Utilization Review, Tissue, Tumor, and Infection Committees. Peer review and quality assurance activities are performed retrospectively. Reports derived from the abstracted data can be used by the physician committees to examine institutional and physician care patterns more clearly.

Private health insurance companies, which serve as intermediaries for Federal health insurance programs and PSROs, use a variety of methods for processing claims data for quality and utilization review. One such method, employed by Blue Shield of California, utilizes the electronic data system's retrospective analysis of medical services (RAMS) programs (E.D.S. Federal Corporation, 1978). Data submitted on the claims form for services are used for this retrospective analysis as well as for payment of claims. Systems are designed to analyze the relationships among patients, medical problems, providers, and procedures used to assess the appropriateness of care (quality and utilization). This assessment is performed by employing predefine criteria to evaluate problem and treatment interactions (proper treatment for specific problems) and to report any deviations for further study. The treatment model concept (analysis of problems versus treatment procedures) allows evaluation of the health care services delivered for a specific problem (diagnosis) by comparing the services actually rendered with the ideal or expected patterns of care. The established peer group norm concept is used as a supplement to the treatment model approach. Treatment analysis profiles are developed using previously defined models and community norms to evaluate a provider's practice by diagnostic categories. Patterns of care failing these explicit criteria are noted as exceptions for further study and review. Summary profiles that report percent of deviation from the group norm and any deviation based on high and low parameters, which the user may select, are available for review. These profiles are used to indicate the necessity of further, more detailed review of patients and their providers. The computer, with its capability to store large data bases, allows comparison of criteria, establishment of practice norms, and production of practice pattern profiles.

The Commission on Professional and Hospital Activities (CPHA), a nonprofit organization based in Michigan, began to provide discharge abstract services as early as 1955 and has developed a data base consisting of approximately 150 million patient records from 2,200 U.S. and Canadian hospitals. The Commission has developed average lengths of stay for selected diagnoses or groups of diagnoses; these serve a useful function in admissions certification and concurrent review activities in the PSRO program. In addition to the Professional Activities Study (PAS), CPHA offers the Quality Assurance Monitor (QAM) from which three quarterly reports are prepared: 1) priority for investigation, 2) monitor profile, and 3) audit trail listings. These reports can be used by the various medical care committees to assist their review activities.

The computerized MMIS (U.S. Department of Health, Education, and Welfare, 1973) is a collection of subsystems designed by HEW's Health Care Financing Administration to assist States in the management of their Medicaid programs. Fifteen States are currently operating certified MMISs; 11 are expected to have their systems certified; and 23 are developing, or have partially implemented, MMIS.

One of the MMIS modules is the Surveillance and Utilization Review module (S/UR). The S/UR module is designed to: 1) produce a prescreen set of profiles that have been compared to the average pattern of care as defined by the State, 2) limit production of profiles to those providers showing aberrant behavior, 3) perform postpayment utilization review, and 4) offer options in the individual State's approach to utilization review. S/UR is a retrospective review mechanism for care that has already been provided and reimbursed. S/UR operates by using an edited paid claims tape to: 1) accumulate totals (for example, total number of providers in class group and total number of office visits); 2) select data items; 3) produce averages and standard deviation reports; 4) produce exception control limits reports; 5) produce exception summaries; 6) print exception provider profiles; and 7) produce, for hospitals, treatment analyses that relate the care provided to diagnosis and age group categories.

S/UR was designed to be a statistical reporting system, using means and standard deviations instead of norms. It is a flexible system because it can modify exception control limits through tables instead of through computer program changes.

PSROs were federally mandated and organized primarily to determine the medical necessity and appropriateness of care in Medicare, Medicaid, and Maternal and Child Health. PSROs are required to develop standards based on the care normally provided within the PSRO region. Major functions of the review process include admissions certification, continued stay review, retrospective review, and Medical Care Evaluation (MCE) studies (Goran et al., 1975). Determination of the necessity and appropriateness of medical services required developing criteria and standards for various types of diagnoses referenced to various patient characteristics, such as age and sex. Average length of stay based on these parameters has been calculated by the Commission on Professional Hospital Activity, but this data base does not include data from all hospitals in the country. AUTOGRP, an interactive computer system, provides the means by which each institution can more clearly investigate its own case mix characteristics, and to further define its criteria for length of stay (Mills, et al., 1976).

Admissions certification requires assessment of the status of the patient by a review coordinator to determine whether the diagnosis is appropriate for treatment at the health facility; the coordinator also determines whether admissions criteria for that diagnosis are met. If the review coordinator questions that admission, the case is referred to a physician advisor, who decides whether or not the admission should be certified. If the admission is appropriate, the coordinator determines the average length of stay for that particular diagnosis by age and sex, and indicates that a review of the case will be necessary within a prescribed number of days.

Review after admission is termed continued stay review. The coordinator reviews the patient's chart to determine when the patient may be discharged and whether the discharge falls within the prescribed length of stay. If the length of stay needs to be extended, the coordinator may either approve an extended length of stay or refer the case to the physician advisor. If inappropriate admission or stay occurs, the patient and the admitting or attending physician are notified that the stay may not be certified for payment.

Retrospective review is also performed by PSROs through profiling. Patient, practitioner, and institutional profiles are developed and reviewed to sharpen the length of stay indicators and to identify potential problems.

Finally, the PSRO's MCE studies focus on specific administrative and clinical problems and, after appropriate action has been taken, determine whether or not the problem has been solved.

Computers are principally used in the PSRO program both to schedule admissions certification and concurrent review activities and to evaluate the patterns of care. Computerized data bases that provide length of stay indicators and norms and standards are also used in order to properly certify the appropriate length of stay for a particular case. Computer applications in review functions include profiling and, to some extent, MCE studies. The computer is particularly useful in aggregating data elements for profiling because it is able to handle a wide variety and number of cases, and it can perform statistical analyses to obtain new dimensions of the information in a variety of displays. The computer is used in MCE studies to process data that focus on the individual problems being studied and to monitor the impact of efforts to solve these problems (Martin, 1978).

The PSRO Management Information System (PMIS) (USDHEW, 1975) is a system originally designed for use by the Health Standards and Quality Bureau, HEW, to process data required from each PSRO. These data are used to monitor and evaluate the performance of PSRO. By aggregating data from the various PSROs, it is possible to cluster them to allow self-evaluation. In addition, PMIS aggregates data regarding length of stay and other indicators of the medical appropriateness and necessity of admissions and hospital use. An inventory of selected MCE study designs and outcomes is also maintained and forwarded to the PSROs to assist them in conducting these studies.

PSRO projects may also cover ambulatory care. The physician ambulatory care evaluation (PACE) program (Nelson et al., 1976), operated by the Utah Professional Review Organization (UPRO), is a physician-directed professional review effort that utilizes both claims data and an advanced automated system for building histories of ambulatory patients and screening them for compliance with clinical guidelines. Both quality and utilization issues are addressed. Where patterns of variation from peer expectations are observed, intervention is directed toward improving patient care. The approach involves educational contacts with physicians rather than immediate punitive action. Denial of payment is only employed when other methods fail.

The New Mexico Professional Standards Review Organization's Revised Medicaid Ambulatory Care Review System (Health Care Management Systems, Inc., 1976) contains both a prepayment and a retrospective review system component based on claims that have been processed by the fiscal intermediary for claims payment. A small sample of New Mexico providers is reviewed before payment as a result of previous analyses of their practice patterns that have indicated substantial deviations from standard patterns. All other providers are reviewed retrospectively at least twice a year if their claims volume justified such a review. Both prepayment and retrospective review employ criteria developed by physician committees, and claims data are subject to these guidelines. Physicians failing the retrospective guideline review are reported to educational committees. The educational committee assigns one or more of its members to follow up the case. The case is researched by an educational committee member, who writes the physician in question explaining why certain standards should be met. This explanation is supported by appropriate scientific and medical facts and includes literature citations. Physicians on prepayment review whose responses fail the guidelines may be denied all or partial payment and may be referred to the ambulatory care review committee for possible future educational intervention by the committee.

Chapter 4

COMPUTER APPLICATIONS IN MEDICAL EDUCATION AND ASSESSMENT

4.

COMPUTER APPLICATIONS IN MEDICAL EDUCATION AND ASSESSMENT

INTRODUCTION

Computers are being used throughout the continuum of medical education and assessment. The unique capabilities of computers, particularly their ability to rapidly store, process, and retrieve large volumes of data, provide assistance in and help manage education, assessment, and patient care activities. They allow a much wider range of individualized responses in tutorial sessions, a greater degree of "instructor" responsiveness to individual backgrounds and needs, and more immediate feedback in the teaching or testing setting. Also, aspects of the patient-physician encounter can be simulated for training purposes and for providing a more objective testing mechanism for assessing clinical problem-solving abilities.

The diagnosis and choice of treatments now depend largely on the subjective recall of the individual physician. Some of the deductive reasoning processes that take place in diagnosing and treating patients can be done more consistently, comprehensively, and instantaneously by using computers as "consultants. " Computers are comparable to other medical aids upon which the physician has come to depend; they serve as replacements for less dependable technologies, Physicians no longer reIy on fingertip percussion of the chest wall to gauge heart size; instead, X-rays, electrocardiograms, echocardiograms, and other more sophisticated technologies are used.

Finally, computers have a unique role in the management of large volumes of data for reimbursement of health services, utilization review, and the planning, monitoring, and evaluation of medical care services.

Four different types of computer applications in medical education and assessment are discussed in this chapter. These four types are: 1) computer-supported independent study in the basic medical sciences, 2) the use of computerized simulations in training and testing for clinical competence, 3) computer-based medical consultation systems, and 4) computer uses in quality assurance/data management systems. These applications were chosen to illustrate the uses of computers across the education and assessment continuum. Each case study also was chosen to emphasize a particular capability of the computer. Each application may have multiple capabilities both in instruction and in assessment, and the concepts underlying each application are potentially applicable to other portions of the continuum.

COMPUTER-SUPPORTED INDEPENDENT STUDY PROGRAM IN THE BASIC MEDICAL SCIENCES

The Ohio State University (OSU) College of Medicine has two programs for completing the basic science portions of the Doctor of Medicine curriculum (Beran et al., 1976; Merola et al., 1978; Cramblett et al., 1979). The lecture-discussion program follows a traditional format in which students progress through a standard content sequence in a fixed amount of time—is months. In contrast, the independent study program (ISP) follows a self-study format in which students progress through the curriculum at independent rates. The principal difference between ISP and the traditional system is the former's acceptance of time as a variable in the learning process. The student progresses when he/she achieves a prescribed level of competency, not when the next lecture series begins. Individual progression rates require that students completing their basic science studies be allowed to enter their clinical clerkships in almost any month of the year.

ISP features an integrated curriculum, modular student study objectives, computer-based tutorial evaluation systems, and a means of managing a student population progressing at independent rates. In July 1970, the first class of 32 students was accepted into ISP, followed by classes of approximately 60 students each in 1971 and 1972. The latter two classes comprised a little over one-fourth of the entering medical students of each year. Currently, 40 percent of the entering classes select ISP.

The ISP curriculum is designed around two main segments: normal man and pathophysiology. Table 7 outlines the components (units) of the ISP curriculum. Each student is required not only to master the units, but also to participate in laboratory exercises, attend clinical correlation sessions and psychosocial seminars, and demonstrate satisfactory verbal communicative skills through oral exercises with basic science and clinical faculty. The student flow through an independent study learning unit is shown in figure 7.

Each student's progress is monitored by the computer through the computer-based self-evaluation or Tutorial Evaluation System (TES), a series of interactive computer-assisted instruction (CAI) "question and answer" sessions between the student and the computer terminal. When the student answers a question correctly, he/she is immediately reinforced and then advanced to the next question, If a student answers a question incorrectly, the student must complete corrective feedback and/or remedial work before reanswering the question. If a student shows a total lack of understanding of a concept, he/she may be branched to a remedial review unit. If an answer is given that the course author did not anticipate, the student may be taken to a coaching sequence designed to guide him/her to the correct answer. If serious weakness in an area is demonstrated, a study prescription may be given, such as "you lack understanding in area X and should review pages Y through Z in text W" (See figure 4 in chapter 2 for a schematic summary of this process). The faculty controls generation of these study prescriptions. Figure 8 gives a sample student-computer dialog.

ISP presents logistical problems in terms of managing the flow of students through the program. With students presenting themselves individually and at different times for tutorial evaluation, lab work, and subject matter consultations, the faculty member must be assisted in monitoring each student's progress and performance. To meet this need for monitoring students, student reports are provided at various intervals. The reports comprise the computer-based management system for ISP. Sample reports are depicted in figure 9.

Table 7.—The Independent Study Program Curriculum Outline

Unit	Title	Associated tutorial evaluation system module(s)
	Normal man	
1	Cell structure and function	A
2	The cardiovascular system	B
	Exam 1	
3	The respiratory system	C
4	Kidney function, urinary system, body fluids	D
5	The gastrointestinal system	E
	Exam 2	
6	Skin and supporting tissues	G
7	Muscle. the spinal cord, and peripheral nervous system	H
8	The central nervous system	I
	Exam 3	
9	The endocrine-metabolic system	J
10	Nutrition	F
11	Reproduction	L
12	Hematology	0
	Exam 4	
	Comprehensive exams-Sections 1.2, and 3 (anatomy, biochemistry and physiology) of the NBME exam.	
	Pathophysiology	
13	The immunologic system	P
14	Pathologic mechanisms and genetics	Q/K
15	Mlcrobiology	R
16	Epidemiology	T
	Exam 5	
17	Drug mechanisms	S
18	The cardiovascular system	X
	Exam6	
19	Infectious diseases	V
20	The respiratory system	Y
	Exam7	
21	Hematology	U
22	The gastrointestinal system	W
23	The renal system	Z
	Exam8	
24	The central and peripheral nervous system	1
25	The musculoskeletal system	2
26	Behaviorial science	L/3
	Exam9	
27	Introduction to pediatrics	M/4
28	The endocrine system	5
29	The reproductive system	

Final Comprehensive NBME Part I(all sections)
SOURCE Ohio State University 1979

The student progress report provides information regarding: 1) units and subunits completed to date, 2) cumulative time spent on TES, and 3) a summary of the week's activity, including a listing of study prescriptions. The TES timeis only 1 1/2 hours out of a 40-hour work week. Most student time is spent in independent study of the learning resources. The computer, however, can easily provide the reporting described herein since the student must complete a TES exercise within each subunit.

Figure 7.—Student Flow Through a Typical Module

1. Student reviews educational objectives and examines list of available instructional resources.
II. Student pursues instructional resources in accord with his individual needs.
III. Student utilizes self-evaluation system where he receives tutorial feedback as to his mastery of the educational objectives.
IV. Student confers with faculty member for final review of instruction unit (optional).
(Typically, from one to five submodules are included in each module, with the student proceeding through steps I-IV for each submodule.)
V. At specified points in the curriculum he must take a written exam covering several modules, and
VI. Demonstrate his ability to transmit information orally in prescheduled oral exams.

SOURCE: Merola et al , 1978

The student response printout can provide every response entered at the terminal sorted by student and/or by question. The student cluster report is used primarily by the curriculum directors and faculty to determine the location of the ISP students throughout the curriculum in order to schedule labs or clinical sessions. The student status report is

Figure 8.— Part of a Student-Computer Dialog

Explanation	Student-Computer Dialogue
Computer poses a question.	Computer: Name the pathological conditions within the brain caused by blockage of the lateral and medial foramina of the inferior medullary vellum.
Student responds (unanticipated response) .	Student: I don't remember.
Computer poses review question.	Computer: Are you having difficulty placing the location of the inferior medullary velure and/or the significance of the foramina?
Student responds.	Student: Yes.
Computer offers coaching information and poses another question.	Computer: The inferior medullary velure forms part of the roof of the fourth ventricle. The foramina communicate with the cisterna *magna* and/or cisterna pontis. What is contained in these cisternae?
Student responds (correctly)	Student: Cerebrospinal fluid (CSF).
Computer gives reinforcement to correct answer.	Computer: Correct. Now consider blockage of the foramina and answer the *original* question.
Computer re-poses the original question.	Computer: Name the pathological conditions within the brain caused by blockage of the lateral and medial foramina of the inferior medullary vellum.
Student answers (wrong answer)	Student: Water on the brain.
Computer offers tutorial feedback pointing to the correct answer.	Computer: Not acceptable. It's time to become more professional in your terminology!
Student responds (correct answer).	Student: Hydrocephaly.
Computer gives reinforcement to the correct answer.	Computer: Very good! The obstruction will cause an increased quantity of cerebrospinal fluid in the ventricular system.

SOURCE The Ohio State University College of Medicine,1978.

an abbreviated version of the student progress report and is available on demand at the CAI terminal.

Another kind of report provides item statistics information that the faculty can use to analyze, correct, and revise TES items. This report also may be used to help determine how well students responded as a group to TES questions. Most importantly, this report lists all student responses that were unanticipatedly the TES author. Responses that will improve TES sessions, as determined by faculty members, are added immediately to the TES program. Figure 10 depicts an item statistics report.

Faculty members in a specific discipline are responsible for the preparation of individual aspects of each unit and may revise and design changes in relevant modules of TES. The almost infinite variety of question types that involve corrective feedback,

Figure 9.—Sample Computer-Based Management System Reports

```
ISP PROGRESS REPORT ON COURSE PILOT FOR JOHN DOE

PRINTED ON MAY 5, 1976 AT 17:44

STUDENT  NBR/0316        CLASS/75          PERSONAL CHART/75
FACULTY  ADVISOR/AJM     TYPE/LINEAR       LAST USAGE /MAY 3

PROGRESS CHART USED FOR THIS REPORT/75

 7/09/75
SCHED  - - A   A   B   C   D   D   F   F   G   G   H   H
COMP—  A  AB   BC  CD  DE  EF    F FG   G  GE  H   H   H

10/08/75
SCHED-   I   J   K   L   M   N     O   O   P   P   P   P   P
COMP— HI  IJK  K   K   KL  LM   MNO  OP   P   P   P   P   P

 1/07/76
SCHED- P  P    Q   Q                  R    R   ST   T   T   U   U
COMP-- P PQ    Q   Q   QR   RS   S    S    S    S   S   S SJ

 4/07/76                    *CURRENT WEEK
SCHED-   U   V   V   V   W   W   W   X   X   Y   Y   Z   Z
COMP--   u   w   v   v-w  w   w   w   w
                           *CURRENT
NOTE:  CHART SHOWS ONLY MODULES COMPLETED - STUDENT CURRENTLY AT XA
```

A Student Progress Report. This report gives a linear view of an individual student's progress as compared to a projected rate of progress through the entire curriculum. It also gives the faculty. adviser and the last date of usage.

STUDENT STATUS - PILOT
DATE 04/07/76 TIME 4: 57 SELECTION = ALL

STUDENT NAME	STUDENT NO.	GROUP	AREA	TYREC	START DATE	LAST DATE	TIME	SEG	LABEL-PROB-SEQ	030
CHARLES JONES	339	75	0	15	7/17/75	3/04 /76	22: 00	QW	UAOOOT- 3-	O
PHYLLIS SMITH	340	75	0	15	7/14/75	3/20/76	32: 14	QW	UAOOOT- 3-	O
DALE WITHE	341	75	0	15	7/18/75	1/ 14/76	27: 52	QW	QAOOOT- 1-	O
Scott GREEN	342	75	0	15	7/14/75	4/03/76	42: 22	QW	WG999Z- 1-	O
JOANN BROWN	344	75	0	15	7/22/75	3 /04 /76	15: 57	AP	LAOOOT- 1-	O
ROSALIND DOE	171	73	0	15	7/19/73	8 /20/75	35: 16	QW	WF1OOS- 1-	O
TONI BLACK	345	75	0	15	7/14/75	3/01 /76	57: 55	QW	UAOOOT- 3-	O
JAMES DILL	351	75	0	15	7/14/75	4/02/76	36: 50	QW	WAOOOT- 1-	O
MARY HILL	352	75	0	15	7/11/75	4/01 /76	32: 03	QW	klA060S- 1-	O
DOUGLAS HALL	231	74	0	15	7/12/74	1/ 16/76	02: 47	36	5BUIOS- 1-	O
JOHN DORN	353	75	0	15	7/21/75	4/03/76	19: 03	QW	QA020S- 1-	O

etc.

A portion of the Student Status Report. (Student names are fictitious.) This report gives the location of each student in the curriculum (label), when each student started in the program, and the last date that student had any activity at the terminal.

SOURCE Pengov,1974

coaching statements, and immediate reinforcement permits individualistic approaches to the same material. The possibility of making constant changes in TES design affords each faculty member the opportunity to instantly correct errors, update content, or change the emphasis in the original system's content.

The authorship of TES changes as new faculty become involved in the program. The design of individual TES items is modified and revised by new faculty concomitantly

Figure 10.— Item Statistics Report

ITEM STATISTICS FOR QUESTION, IA1106- 1   COURSE: PILOT
TIME PERIOD: 10/01/75 - 12/29/75   DATA COVERS 47 STUDENTS USAGE

RESPONSE	ATTEMPT NUMBER 1	2	3	4	>4	RESPONSE TOTALS	% OF TIME WA LEAD TO UN	% OF TIME UN LEADS TO UN
1- 2 CA	4	19	9	3		35		
1- 3 CA	1					1		
1- 9 WA		2	1			3	33%	
1- 14 WA			1			1	100%	
1- 18 WA	2	3				5	60%	
1- 24 WA	14	3				17	71%	
99- 99 UN	26	15	3			44		14%
ATTEMPT TOTALS	47	42	14	3		106		

UNANTICIPATED RESPONSES MADE ON FIRST AND SECOND ATTEMPTS:

1. NUCLEUS RUBRUM
   INFERIOR CEREBELLA PEDUNCLE

   MLF
   BASES PEDUNCULI
   MLF
   RED NUCLEEI

   MIDDLE CEREBELLA peduncle
   ***ALL UNS NOT LISTED*AA

2. BRACHIUM PONTIS
   RED NUCLEUS
   NO

   TECTUM
   CEREBRAL PEEDUNCLE
   CERBRAL PEDUNCLE
   RETICULAR FORMATION
   TEGMENTUM
   ALL UNS NOT LIST~

STATISTICS FOR NUMBER OF RESPONSES
RANGE 1- 4
MEAN 2
MODE 1

Item Statistics for a Single Question. Correct answer is designated CA, wrong answer is designated WA, and unanticipated responses are designated UN. In this example, "red nucleus" was a common unanticipated response, and would be logically added to the bank of anticipated responses in the computer program.

SOURCE Pengov 1974

with changes in objectives and source materials. Each new faculty member is encouraged during the -TES revision process to collaborate with instructional programers indesigning the module. Such collaboration can take the form of correcting obvious problem areas in TES or discussing and implementing new approaches to TES, such as greater use of problem-solving techniques.

Faculty responsibilities are somewhat different in ISP than in a traditional lecture curriculum. The emphasis in ISP is placed on integrating material into learning units prepared by an interdisciplinary team of faculty, not on designing and presenting lectures. Faculty members assess the ability of students to grasp the materials presented in the unit he/she designed through small group discussion sessions with students working on the

51-541 0 - 79 - 5

module. Occasional clinical correlation sessions, conducted with both basic science and clinical faculty, facilitate the extension of concepts of normal function to those of pathophysiology. The emphasis placed on developing the curriculum within an interdisciplinary team and small group discussions, rather than lecture preparation, has created a curriculum that is changing constantly as faculty receive helpful suggestions from both students and other faculty.

The ISP curriculum attracts a wide range of students, and they perform comparably to lecture-discussion students on both clinical and preclinical portions of standard exams. ISP appeals to some students who wish to accelerate the completion of their medical education and to others who wish, or need, to reduce the academic pressure of medical studies. The flexibility inherent in ISP and the student's ability to control a rather intense curriculum benefit students with academic deficiencies, as well as those with strong academic credentials. Students who have had extended absences from a formal education setting, previous to their admission into the college, also benefit from ISP.

The groups that progress at the slowest rates through the program include a significant number of minority students who need special assistance to complete their medical studies. However, many students with no apparent academic weaknesses are taking more time to complete the curriculum than their lecture-discussion counterparts. Despite a delayed graduation, most of these students prefer more time than the standard 15 months the lecture-discussion program allows. The range of completion time in ISP is 10 to 29 months, the mean is 17 months.

The experience of ISP has illustrated that:

- Independent preclerkship study is a useful and viable alternative to traditional programs.
- Computer-assisted and computer-managed independent study is feasible for large numbers of preclinical medical students.
- Medical education can be tailored to the individual needs of each learner.
- Computer-assisted instructional and management techniques allow each student to progress independently of others according to his/her own educational background, learning speed, or needs. CAI/CMI allows faculty and administrators to manage large numbers of students progressing at independent rates. Such monitoring techniques are an essential element for the implementation of any large-scale independent study program.
- Many faculty have become orchestraters of learning rather than disseminators of knowledge. The computer does the repetitive tutorial work, thereby providing faculty members more time for individual student interactions. Overall faculty time requirements do not change; the nature of their roles and the use of their time, however, do change.
- Student response to ISP has been very positive. They find it enjoyable to learn by discovering with a faculty member as well as from a faculty member.
- Despite the high investment costs for courseware development, overall CAI operational costs compare favorably with the costs for other instructional methods, such as labs or group discussions.

THE USE OF COMPUTER-BASED SIMULATIONS IN EDUCATION AND ASSESSMENT

Introduction

Several different models of computer simulations used for educational assessment are described below. The use of computer simulations by the Royal College of Physicians and Surgeons of Canada, the American Board of Internal Medicine (ABIM), and the National Board of Medical Examiners (NBME) in actual assessment activities is then discussed.

A wide variety of computerized, clinical encounter simulations have evolved in the last decade. Computers are used to simulate "patients;" physicians or students interact with typewriter-like computer terminals to solve the "patient's" problems. Although the setting does not simulate all aspects of a physician's interaction with a live patient, the essential feature of information flow between the two is captured well, particularly if efforts are made to make the simulated interaction more "human" and less machine-like (Senior, 1976). A more "human" system is characterized by language that is easily understood, by responses that can be corrected quickly, and by courteous and considerate instructions (Sterling, 1975). Only rudimentary typing skills, and no knowledge of computers or programing, are required of the user. Inquiries can be directed to the patient by typing in actual questions, either as words or sentences, or as code numbers referring to questions or desired studies. Successful experiments also have used a standard touch-type telephone to communicate with the computer patient (Friedman et al., *1977)*. Diagnoses can be entered, management decisions or actions can be initiated, and data may be reviewed. If needed, special assistance can be provided by attendants at the computer terminal site. However, brief introductory training exercises are usually conducted to familiarize the users with the terminal equipment and mode of operation.

Prior to the use of computers, simulations were primarily *paper-and-pencil* in format. The best known paper-and-pencil simulation is the patient management problem (PMP) (Hubbard et al., 1965). A traditional PMP simulates various aspects of a realistic clinical situation in which the physician or student must manage a patient. After reviewing a paragraph of information describing the patient, the user may request additional data. On the basis of the information collected, the user diagnoses, treats, or manages the patient's problem by choosing from a limited set of options or interventions that he/she thinks are necessary to reach a proper solution to the patient's complaints. Appendix I contains an example of a segment of a conventional paper-and-pencil PMP. Most often, the branching sequence offers a choice between the physical examination section, the laboratory section, and the history section of the patient management problem. Each section presents a list of items, including essential, optional, and irrelevant information. The task of the user is to choose those items that are pertinent to the resolution of the problem. Early PMPs were linear, somewhat inflexible, and offered cues to the user. "The validation of the PMP has been called into question in that attempts to show that practicing physicians behave similarly in a PMP as they do in the real-life situation have not been generally successful. This is thought to derive from the fact that in this simulated situation the physician is given a series of options and clinical investigations from which selections may be made thereby affording cues to the examinee. In the clinical situation the options, confirmatory tests, and consultations possible are legion and require an internally generated selection" (Meyer, 1978). Computer simulations can help avoid the problem of "cueing. " The computerized simulations described below overcome, in varying degrees of sophistication, the limitations of paper and pencil simulations.

Sophisticated *computerized versions* of PMPs contain multiple branches and require the physician to make choices that lead to any number of strategic routes, several of which could result in an acceptable solution to the patient's problem. These computerized versions allow much more complex branching; provide immediate feedback to the physician; permit the review of previously selected items; utilize audio/visual capabilities; and provide mechanisms for timing, control, or monitoring of the examination. Additionally, user performance recordings are more detailed, retracing by the user is minimized, and scoring of the problem is instantaneous. For each problem the user receives both introductory information about the patient, the setting of the problem, and an explanation of his/her role and tasks.

Sim One is a Iifesize manikin that has several functions, including respiratory activity, pulse rate, blood pressure, skin color, and pupillary size, that are controlled by the computer. Each function responds to drug administration and other interventions used by an anesthesiologist to manage patients in surgery. This model simulates a variety of operating room situations. The clinician can repeatedly experience these situations in credentialing or educational settings without risk to real patients and with immediate feedback regarding the effects of judgments and actions (Abrahamson et al., 1969).

INDEX has a glossary or index list of over 1,000 history questions, physical findings, laboratory procedures, and diagnoses that physicians use to obtain information from the patient. A sample report summarizing an interaction between a physician and a patient is illustrated in figure 11. The physician, identified as "No. 136, " has examined a patient who has blood loss anemia that is caused by fibroid tumors of the uterus and von Willebrand's disease. All inquiries or diagnoses made are listed in order as four-digit numbers. The final diagnosis and management plan, the time the examinee took to complete the problem, the dollar costs of studies ordered, the time consumed, and an estimate of the aggregate discomfort and risk to the patient from the workup are listed in the figure. Such a record is available for analysis, evaluation, and scoring in printed and computer-readable form.

MATRIX is a modification of a teaching program designed to illustrate that a diagnosis is based on statistical probabilities of the condition in question. These probabilities are based on factors such as the patient's age, sex, symptom complex, physical findings, and results of laboratory tests. The teaching program was adapted to a testing program on the diagnosis of acute abdominal pain. As in INDEX, the candidate is given an index of inquiry possibilities and then enters the inquiry by code (Senior, 1976).

Mac Puf is a computerized cardiovascular-pulmonary model in which the computer program calculates the effects of changing one variable on all the other physiological variables (Dickinson, 1977). Values of the variables are interrelated by equations, and the computer solves all the equations simultaneously. The program can be made to simulate diseases such as acute myocardial infarction, arterial or venous bleeding at any rate, pulmonary emboli, and obstructive lung disease. It can be designed to respond to treatments such as digoxin, intravenous fluids, oxygen, respirators, rotating tourniquets, vasopressor drugs, and bicarbonate. If untreated, the patient may deteriorate and "die" or stabilize at some lower level of function. Appropriate and timely therapy may reverse the downward trend of simulated illness, and vital signs will improve. Complications and new medical crises can be programed to occur at any time. Thus, this model of a changing and responsive patient represents a potentially useful tool for assessing management skills or the ability of a clinician both to treat crisis problems and to avoid complications.

Figure 11 .—Example of an INDEX Case Interaction Printout

```
    #136
     CASE:  4          TIME:    14: 50        DATE:      10/31/72

HISTORY     PHYSICAL  STUDIES               DIAGNOSES

PROBLEM BEGAN 1010
MAIN PROBLEM 1000
FAMILY BLEEDING 2716
HOSPITALIZATIONS  2340
     TMM
ALCOHOL 2330
PROLONGED BLEEDING 1963
ANTICOAGULANTS 1564
HEPATITIS 1760
ALLERGIES 2550
              PALLOR 3024
MENSTRUATION 1920
MENORRHAGIA 1926
            SPLEEN PALPABLE 3748
            FECAL BLOOD 3834
            LIVER ENLARGED 3747
                        SMEAR AND DIFFERENTIAL: 5008
                        ROUTINE STUDIES: 5000
                        PLATELET COUNT: 5058
                        PROTHROMBIN TIME: 5066
                        CAPILLARY FRAGILITY: 3506
                        BLEEDING TIME: 5060
            PETECHIAE 3054                      APLASTIC ANEMIA
                                          IRON DEFICIENCY ANEMIA

                                          THROMBOCYTOPEMIC PURPURA
                                          VON WILLEBRAND'S DISEASE
                                               (IMPRESSION LIST)
                        SPECIAL COAGULATION TESTS: 5086
                                               (FINAL LIST)
                                          IRON DEFICIENCY ANEMIA

                                          VON WILLEBRAND'S DISEASE

PATIENT MANAGEMENT PLAN

FERROUS GLUCONATE 300 MG PO TID
ADVISE PATIENT TO REMAIN UNDER SUPERVISION FOR BASIC DISEASE

DOLLAR COST OF STUDIES: $25
TOTAL TIME TO COMPLETE ALL LAB STUDIES:   1 DAYS 12 HRS O MIN
PATIENT TIME CONSUMED: O DAYS 1 1-HRS 25 MIN
PATIENT RISK: 7        PATIENT DISCOMFORT: 35

ELAPSED TIME FOR PROBLEM SOLUTION:   28 MINUTES.
```

SOURCE Senlor,1976

CASE, a computer-assisted simulation of the clinical patient encounter, was developed in the late-1960's at the University of Illinois (Harless et al., 1971; 1973). CASE uses an unprompted and undirected process. The interaction occurs at a computer terminal and the physician elicits whatever history, physical examination, and laboratory data that are needed for the diagnosis and management of the patient's problem by typing unstructured, English language phrases or sentences into the computer. The computer provides brief introductory materials to the physician, including a description of the clinical setting, the circumstances around the patient's visit, and some physical characteristics of the patient. After the introduction, the physician receives no further clues. Candidates must determine what information they think is important in order to define and manage the patient's problem. Appendix I contains a typical undirected interaction between a physician and a CASE patient.

A wide and representative variety of internists' patients can be simulated by this computer model, and each simulated, computerized patient (CASE) can be refined to respond appropriately to approximately 95 percent of the physician's inquiries. Over 50 CASES have been created to date; most are housed at the OSU College of Medicine.

The costs of creating, refining, and field testing each CASE are estimated to range from *$5,000* to *$15,000,* depending on the degree and type of review provided. The relatively low development cost for a simulation as complex as CASE is made possible by the existence of a series of computer programs that guide the creation or generation of new CASES. This generating system (GENESYS) allows the creation of a large number of CASES in a relatively short time.

GENESYS essentially involves a three-phase process: 1) author preparation, 2) technical creation, and 3) refinement. During the first phase, the author compiles data describing his/her patients for subsequent use in a CASE simulation. The technical creation phase entails entering the author-supplied information into the computer according to a standardized format. The final phase, refinement, is designed not only to ensure that the CASE simulation can respond to the widest possible variety of anticipated questions, but also to "humanize" the computerized patient.

Computerized PMPs, INDEX, and CASE have been used and are being tested for actual physician assessment activities by the Royal College of Physicians and Surgeons in Canada, by NBME, and by ABIM. The use of each simulation is described in more detail below.

Pediatric Fellowship Examination of the Royal College of Physicians and Surgeons of Canada.

The Royal College of Physicians and Surgeons of Canada uses Computerized Patient Management Problems (CPMP) regularly in their Pediatric Fellowship Examination process to test the ability of pediatric candidates to manage patients (see appendix I for an example of a CPMP). The College also uses conventional multiple-choice questions and oral examinations in the Fellowship exam. The specific objectives of the CPMP section are to assess the candidate's skill and ability in data gathering, formulating hypotheses regarding the patient's problem, and resolving the problem. Candidates have a choice of taking an examination in either English or French.

The computer portion of the examination has been administered annually since 1974 to all candidates eligible for certification in pediatrics. The development of the CPMP examination was precipitated by several factors (Skakun, 1978): 1) concerns about the inability of multiple choice and essay examinations to measure various clinical aspects of medicine; 2) concerns about using a single examination, such as mutiple choice or essay, to certify specialists; and 3) concerns about the degree of reliability, validity, and standardization of oral examinations.

The types of CPMPs used in the Royal College exam are the linear and the sequential. The linear uses two response strategies. In the simple choice, the candidate selects six items or less from a list of possibilities; in the ordered choice, the candidate chooses a fixed number of options and then rank orders them. In the sequential type of CPMP, the candidate scales each option on a scale of 1 to 20; the most pertinent information is given a weight of 20 and the least pertinent a weight of 1. In this type of problem each candidate is presented with the same amount of information and is led, in an identical step-by-step manner, to the next options in the problem.

Officials of the Royal College note that the examination could have been administered using conventional paper-and-pencil PMPs. Use of the computer, however, has advantages in that it prevents the retracing of physician questioning and allows for more complex branching problems, incorporation of visual and audio components (i. e., X-rays, heart sounds, etc.), and immediate scoring of the problem (Skakun, 1978).

Most of the CPMPs used are developed and tested on the IBM 1500 computing system at the Division of Education Research Services in the Faculty of Education at the University of Alberta. Each member of a five-person committee is asked to develop two problems in areas relevant to pediatric practice. Each problem is then reviewed by the entire committee. Once the committee reaches agreement on the content, the problems are programed for presentation by a computer. A group of pediatricians not involved in the preparation or initial review of the problems takes an examination in which the problems are presented. On completion of the examination, their comments and suggestions are used to further refine CPMPs. These updated problems are then used in the Royal College examination. Problems are reviewed annually for accuracy and relevance by practitioners not involved in their initial construction.

CPMPs also have been used since 1974 as part of the examination process for approximately 110 final year medical undergraduates at the University of Alberta. Additionally, CPMPs have been incorporated into a self-assessment package that is available to fellows of the Royal College during the time of the College's annual meeting.

The Royal College exam is administered at eight different centers across Canada, using either available computing facilities in each center, or a network such as the CHARGEX system of the Canadian Imperial Bank of Commerce.

Each year, approximately 150 candidates take the Royal College's CPMP examination in addition to taking a multiple choice test, an oral examination, and an in-training survey. The cost per candidate in 1974 for administering four CPMP problems was approximately $225. These costs have been decreasing gradually since 1974; in 1977, the cost per candidate was approximately $150. For the self-assessment tests held at the time of the College's annual meeting, approximately 200 fellows participate at a cost of significantly less than $100 per fellow.

Evaluation studies of the Royal College Fellowship exam indicate (Fincham et al., 1976; Berner et al., 1977; Skakun et al., 1977):

- No positive correlations exist between CPMP, multiple choice, and oral examination portions of the Fellowship Examination. This finding suggests that different aspects of competence are being measured by the various types of tests.

- There are low interproblem correlations between CPMPs. This suggests that candidate performance might be case- or problem-specific, or that the skills required to manage the patient, such as problem solving and decisionmaking, differ from case to case.
- Candidates had no difficulty in using the computer terminal and viewed the problems as realistic and relevant to pediatrics. They suggested that CPMPs were better tests of pediatric skills than the multiple choice questions.
- Nationwide computer-based testing is feasible and computerized patient management problems can be translated to multiple computer languages and hardware systems and still operate successfully to support such testing.

The Computer-Based Examination (CBX) Project of the American Board of Internal Medicine and the National Board of Medical Examiners

The CBX project, initiated in 1968, is based on a computer simulation of a patient with a given disease or diseases. Although various computer simulations have been explored, all involve physician interactions with a computerized patient that is or is not hospitalized. In the current CBX simulation model (which evolved from INDEX), laboratory tests, medical procedures or consultations, and drug therapies interact with the patient's disease in a time sequence similar to one occurring in real life. By simulating the effect of physician action on the patient, and by adjusting the patient's status accordingly, the computer model provides an almost life-like, dynamic simulation of the patient/physician encounter.

The computer model, through a sampling of the physician's interaction with a patient, permits the assessment of a number of factors, including cost of workup, risk (pain, complications, and mortality) to the patient, time taken to initiate corrective therapy, and length of a patient's hospital stay. The model also permits a step-by-step evaluation of the physician's action in ordering tests and prescribing therapy. Appendix I contains a sample interaction between a physician and a simulated patient.

The major reservation to implementing this system centers around the ability of the project: 1) to develop a scoring strategy and to determine whether the competencies assessed by this model are appropriate to measure, and 2) to develop a method for the cost-effective production of new simulations. Future plans involve further testing and refinement of the model as well as development of additional patients or scripts. Studies have been initiated to evaluate the model and determine its economic feasibility for large-scale testing and use by NBME and ABIM as part of their certification and recertification processes (Friedman, 1978).

A Model for Evaluation and Recertification through Individualized Testing (MERIT) of the American Board of Internal Medicine.

MERIT was begun in 1973 to investigate: 1) an approach to recertification that uses the specific patient problems of each internist as the basis for the evaluation of his/her skills, knowledge, and clinical judgment; 2) the use of an advanced computer-assisted simulation of the clinical patient encounter (CASE) as the examination instrument for the individualized evaluation; 3) the development of a scoring system for CASE to assess various dimensions of clinical behavior; 4) the involvement of each participating internist in an evaluation process that will help him/her to identify deficiencies and thus to plan for more meaningful, individualized continuing education; and, 5) the attitudes of practicing internists toward a recertification process that embraces the preceding components (Harless et al., 1978).

The MERIT process has undergone extensive evaluation during the past 5 years with 450 Board-certified internists in 3 field studies. The first study was conducted in San Francisco with 28 physicians in *1973-74;* the second study, held in 1976, included *90* physicians located in 9 health care and training institutions throughout the State of Ohio; and the third study was conducted in January 1978 at 15 centers nationwide and involved 332 physicians.

The MERIT process was designed to incorporate individualized evaluations of a candidate's performance in patient care as a major part of the recertification procedure. It is meant to supplement the multiple choice questions and paper-and-pencil PMPs used in current examinations. MERIT incorporates a number of steps, the first of which is the gathering of information from each candidate about the types of patients he/she sees in practice. This patient information is summarized into an individual practice profile that is used to select the three most representative computerized patient simulations for that physician's exam. Table 8 depicts a typical practice profile.

The MERIT process uses the CASE simulation and generates six separate scores (a seventh, history and physical exam minimum data base score, is under consideration):

1. *Diagnosis Score.* Diagnoses for each CASE that a candidate is required to list have been identified. Each diagnosis is then assigned some proportion of a total 100 percent. This weight is based on the degree to which the disease can be treated and the degree to which it threatens life. An individual's diagnosis score is the total of the weighted value for the correct diagnoses listed; the possible range is *O* to 100 percent.
2. *Management Score.* The management steps (medications, procedures or consultations, and patient instructions) that a candidate is required to list have been identified. Each management step listed as a scoring criterion is weighted differently, totaling 100 percent across all three therapy areas. An individual's score is the sum of the weights of each correct therapeutic step he/she lists in the interaction.
3. *Critical Concept Score.* Information from the history, physical examination, and laboratory workup for each CASE that is considered critical in determining both the patient's problems and an appropriate treatment plan has been identified. Each piece of information ("critical concept") is then weighted nine, four, or one to reflect its importance in the patient's workup. An individual's critical concept score is either the total weighted value of critical concepts he/she elicited, divided by the weighted total of critical concepts in the CASE, or the percentage of the total possible critical concept value elicited.
4. *Efficiency Score.* This score is applied in the laboratory section only. In addition to identifying critical laboratory information, procedures or tests that are neither critical nor excessive (0-weight) have been identified. An individual's efficiency score is the total number of critical laboratory results elicited, divided by the sum of critical and inefficient procedures (or divided by total procedures minus 0-weighted procedures). An individual's efficiency score is, then, the percentage of total laboratory results elicited that are critical to the CASE.
5. *Danger/Discomfort (D/D) Score.* Laboratory procedures that entail some risk and/or discomfort are weighted (– 9, –4, and – 1) to reflect the degree of risk or discomfort. An individual's D/D score is a total of the negative weight received. This is not a percentage score; zero is perfect.

Table 8.—Sample Practice Profile to Select Appropriate CASEs

Physician: Dr. A. Sample

Diagnostic areas	Distribution of diagnoses in practice	Referrals In	Referrals Out
Infectious disease	1%	—%	—%
Neoplasms	5	2	40
Diabetes	2	—	—
Other endocrine	1	—	—
Nutritional and metabolic	4		
Hematology	2	—	10
Organic brain syndrome	—	—	—
Psychiatric disorder	2	—	20
Neurology	2	—	—
Hypertension	14	20	—
Cardiac disease	24	75	—
Cerebrovascular disease	2	—	—
Other vascular disease	1	—	—
Upper respiratory disease	3	—	—
Pulmonary disease	7	—	—
Gastrointestinal	9	3	—
Genitourinary	2		
Gynecology	1	—	10
Obstetrics	—	—	—
Dermatology	2	—	10
Rheumatology	8	—	10
Congenital disease	—	—	—
Trauma and injury	1	—	—
Adverse chemical and drug effects	1	—	—
Symptoms	3	—	—
Well patients	3	—	—
Total	100%	100%	100%

Distribution of complaints	
General symptoms	20%
Nervous system	2
Skin, nails, hair	—
Cardiovascular and lymphatic	7
Respiratory	30
Musculoskeletal	5
Digestive	15
Urinary	7
Male reproductive	1
Female reproductive	2
Eyes and ears	3
Mental health	5
Nonsymptomatic	3
Total	100%

Circumstances of patients visits	
Outpatient	65%
Inpatient	33%
Home	2
New complaint	35%
Followup	50
General checkup	15
Patients hospitalized after visit	10%

Demographic data	
Female	65%
Male	35
Age 0-19	10%
Age 20-44	25
Age 45-64	35
Age greater than 64	30
Low socioeconomic	25%
Middle	50
High	25
Black	10%
Chicano	2
Oriental	7
White	78
Other	3

Source: MERIT project.

6. Cost Score. Every laboratory procedure or test has a dollar cost value associated with it. An individual's cost score is the sum of the value of every procedure and/or test ordered.

The CASE model, when used in an examination, requires that the examinee use his/her own intellectual resources to resolve the problems of the simulated patient. No direction is provided, such as in a multiple choice list, to resolve the problem. Differences between CASE and a multiple choice list are analogous, though more pronounced, to the difference between a multiple choice and an essay exam; in both CASE and an essay exam, the uncued behavior and deeper thinking of the examinee are being assessed.

Patterns of behavior can be determined for each physician being examined because each is acting without cues. Behavior patterns that are dysfunctional or potentially harmful to a patient can be corrected. For example, a physician may demonstrate a tendency to use some drugs excessively or some procedures unnecessarily. Alternatively, patterns that are creative and effective can be rewarded and shared with the physician community.

Dramatic errors can be uncovered since the examinee is not cued or restricted in what he/she does to the simulated patient. An example of this occurred during MERIT field trials. A phyician dealing with a simulated patient determined that exploratory surgery should be performed on his patient. As it turned out, the patient was in congestive heart failure, but the physician had not discovered this during his workup. A cued or multiple choice exam would never uncover this situation, since the treatment plan suggested by the physician was so radical it probably would not have been a multiple-choice option.

In the course of the MERIT project a variety of research questions have been addressed with the following results:

- It is feasible to individualize an examination based on the kinds of patients an internist sees in practice.
- It is technically and logistically feasible to reliably examine physicians simultaneously at different sites nationwide.
- Internists gather information and initiate patient management steps similarly with CASE as with real patients.
- Internists generally found the MERIT process to be an acceptable and desirable form of evaluation.
- The need for reliability suggests that any implementation of MERIT include the use of five to seven, as opposed to three, CASES.
- Comparison of MERIT scores with other component scores in the recertification examination confirmed that MERIT measures substantially different aspects of competence.
- The validity of MERIT CASE scores compares favorably with other examination methods employed in the study.

ABIM is improving the current scoring system and examining the logistics and costs of full-scale implementation of this methodology (Meskauskas and Norcini, 1978).

COMPUTER-BASED MEDICAL CONSULTATION SYSTEMS

Computer-based consultation systems range from those used in specific disease or problem areas to those used for more general purposes. A number of these systems are briefly summarized below. More general purpose computer systems also are used to help guide the physician in diagnosing and managing patient problems. Some of these will be described in the next section on quality assurance/data management systems.

Most of the consultation systems accumulate data on patient characteristics, histories, physical findings, laboratory data, treatments, and outcomes. These data are then analyzed for correlations that might be found between certain patient characteristics and treatments with specified outcomes. This information is then used to help guide the physician in managing the patient and in discovering new knowledge regarding patient care.

Duke University Cardiovascular information System. This system provides physicians with a large data base regarding clinical experiences with coronary artery disease. The data describe outcomes of patients with various sets of attributes (Rosati et al., 1975). The patient attributes, laboratory and physical findings, history, and outcome of a large number of patients are stored in a computer, which then classifies the information. When attributes of a new patient are entered, the computer selects the most closely matched subgroup. The disease courses and outcomes of all patients previously categorized in the same subgroup are displayed. The computer's memory is accurate, unbiased by recent or dramatic events, and enhanced by the great number of entries derived from the entire institution, rather than from one physician's experience. Therefore, the physician's management decision can be based on far more accurate and unbiased information than could be possible without the computer.

Electrolyte and Acid-Base Consultation System. Beth Israel Hospital in Boston, Mass., has constructed a computer consultation program to help physicians manage patients with electrolyte and acid-base disorders (Bleich, 1971). The program directs a dialog in which the physician, or other user, enters clinical and laboratory information. On the basis of the abnormalities detected, the program asks traditional questions to further characterize the electrolyte and acid-base disturbance. During or after the completion of the dialog, an evaluation note is produced that contains a list of diagnostic possibilities, an explanation of underlying pathophysiology, therapeutic recommendations, precautionary measures, suggestions for further studies, and references to the medical literature.

HELP. The HELP system is the core of a complex group of computerized subsystems developed at the Latter Day Saints Hospital in Salt Lake City, Utah (Giebink and Hurst, 1975). A variety of findings on symptoms data and patient status information is incorporated into the system after being acquired through laboratory tests, blood gas analysis, intensive care monitoring units, multiphasic health testing stations, and medical record abstracts. Decision logic that uses a variety of statistical techniques is employed to develop probabilities for certain diagnoses or treatment selections based on the historical data base. In addition, the system provides warnings of patient conditions that may require intervention in several areas of the hospital, including the emergency room. The rapidly growing data base and the decision logic are also being used in evaluation and research.

INTERNIST. The INTERNIST was developed at the University of Pittsburgh as a computer-based diagnostic consultation system for problems in internal medicine (Lawrence, 1978). It is based on assigning rough estimates of the likelihood of the association of a disease, given a finding, and a similar estimate of the likelihood of the finding, given a disease. It currently covers about two-thirds of internal medicine. Internist represents an attempt to model, within a computer program, the thinking processes that the author uses to evaluate a case and make a diagnosis. It is not a model based on probabilities in the statistical sense and, therefore, is subject to the individual perspective brought to the model. The system mimics the diagnostic behavior of the "excellent clinician" and is an example of a number of decision analysis types of systems currently being developed and tests.

Indiana University Medical Center Computer Reminders System. The computer reminders system is based on the assumption that the physician must apply a few simple rules to a few items of information many times (McDonald, 1976 and 1978). Using a very simplified computer language, developed especially for this use, the physician writes the rules he/she wishes applied to the data and then lets the computer repeatedly apply them.

The system provides reminders for a large percentage of the simple clinical decisions; it assures that baseline screening tests have been done, checks that abnormal test findings are examined further, and assures that treatments are followed with appropriate measures. The system occasionally suggests a diagnosis when a particular pattern of abnormalities is evident, but more often suggests treatments that might correct a pattern of abnormalities. Studies of the system's impact on patient care are currently underway.

COMPUTER USES IN QUALITY ASSURANCE/DATA MANAGEMENT SYSTEMS

As described in the previous chapter, the practicing physician is subject to the requirements of various "quality assurance" programs designed to measure, evaluate, monitor, and/or improve medical services. Computers provide the basis for the data processing components of these programs. Some of these activities have been described earlier using examples from both the private and governmental sectors. These examples included activities sponsored by the Joint Commission on Accreditation of Hospitals, private health insurance companies (e.g., Blue Shield) in payment of claims and quality and utilization review, hospital discharge abstract services, the Medicaid Management Information System (MMIS), and activities related to Professional Standards Review Organizations (PSROs). The latter two programs are briefly summarized below, followed by short descriptions of two multipurpose systems.

Medicaid Management Information System

MMISs are used to assist States in the management of their Medicaid programs. The Surveillance and Utilization Review (S/UR) module of MMIS: 1) produces a pre-screen set of profiles that have been compared to the average pattern of care as defined by the State, 2) limits production of profiles to those providers demonstrating aberrant behavior, 3) performs postperformance utilization review, and 4) offers options in the individual State's approach to utilization review. *

Professional Standards Review Organizations

PSROs are federally mandated programs organized primarily to determine the medical necessity and appropriateness of medical services provided to patients in federally financed programs. Major functions of the review process include admissions certification, continued stay review, retrospective review, and medical care evaluation studies.

Computers are used principally to schedule both admissions certification and concurrent review activities and to evaluate patterns of care. Computer applications that

*See ch. 3 for a more detailed discussion.

provide length of stay indicators and norms and standards are also used to properly certify the appropriate length of stay for a particular case. Review function computer applications include profiling and, to some extent, evaluating medical care. Since profiling is an aggregation of data elements, the computer is particularly useful because it handles a wide variety and a large number of cases. Statistical analyses are performed to display the information in a variety of ways. The computer is used in medical care evaluation studies not only to process data that focus on the individual problems being studied, but also to monitor those problems after solutions have been implemented to determine whether or not the action taken has solved the problem. *

Computer-Stored Ambulatory Record System

The Computer-Stored Ambulatory Record System (COSTAR) developed at Massachusetts General Hospital (Barnett, *1976)* is used in the Harvard Community Health Plan to provide automated medical records and business office support. The data base is also available for retrospective quality assurance review and to preprogram reminders or alerts within the system for patient followup and selection of preferred therapies.

Problem Oriented Medical Information System

The Problem Oriented Medical Information System (PROMIS), developed at the University of Vermont (USDHEW, 1977) is unique in two respects. It not only radically restructures the medical record, but also directs the process of clinical care. The PROMIS laboratory staff developed these capabilities in order to address problems hindering the provision of medical care: dependence on the physician's memory, ineffective organization for massive amounts of medical data, and lack of meaningful feedback about the appropriateness of care.

In PROMIS, data is organized by patient problems. The computer record is structured around four phases of medical action: an initial *data base* on each patient, including medical history and physical examination; a *list* of the patient's problems; diagnostic and treatment *plans* for each problem; and *progress notes* on each problem indicating how the patient is progressing during therapy. Except for the initial data base, every entry into the computer record is associated with a particular problem of the patient. Thus, when a technician enters the result of a laboratory test, the data is entered under the problem for which the test was initially ordered. By structuring the record in this way, all information pertinent to a problem is organized logically for review by the physician and other medical care professionals.

Personnel enter data about patients through video terminals. The videoscreen of the terminal displays an array of choices, and the provider makes a selection by touching the screen. Data is entered by the medical care professionals who originate them. For example, physicians and nurses enter notes about the patient's progress, radiologists enter notes as they read films, and technicians in the clinical laboratory enter results of tests. In addition, patients enter their own medical histories. Each staff member has a unique identification code that allows entry and access only to those parts of the computer record necessary for the provision of care.

*See ch. 3 for a more detailed discussion, including the application to ambulatory care in New Mexico and Utah.

SUMMARY

Medical education and assessment and patient care could be integrated, interactive subsystems of the medical care system. Computer technology not only has shown promise in helping achieve this integration, but also has aided advances in this direction. The capabilities of computer-assisted instruction, testing, and management to provide individualized assistance in the medical school curriculum are being extended toward individualized examination on entry to and during practice. In the future, some of these examinations will be based on data extracted from the actual practice experience of examinees, thereby allowing both for better measurement of practice strengths and weaknesses and for better definition of continuing education needs.

Computer capabilities to maintain and analyze institutional, regional, and national data bases on actual patient care will allow better correlation between the condition of the patient (outcome) and patient care techniques (process). These capabilities also will help provide better indicators both of patient care techniques that are successful or unsuccessful for specific diseases, individuals and situations, and of the costs, for example, of alternative methods of diagnosis and treatment. This type of information will enhance an outcomes approach to quality of care measurement and reduce the present emphasis on process measures. Better definition and correlation also will restructure the content and emphasis of undergraduate and graduate medical education.

The creation and use of computer-based simulations enable better assessments of aspects of clinical competency. These simulations may hasten consensus formation regarding the definition of certain dimensions of competent care because of the requirement for specificity in therapeutic responses to simulated illnesses. Since patterns of performance behavior can be recorded in detail by the computer, cumulatively, they can be used to create diagnostic and therapeutic profiles for particular diseases. These cumulative profiles of care can be used in PSRO and other quality review situations as more detailed standards against which to measure appropriate care. For example, the extent to which a repertoire of tests or a particular test is indicated or required can be used in addition to the rougher measures of quality of care, such as length of hospital stay.

Inversely, using computerized recordkeeping profiles, appropriate care for disease entities can be defined and verified in great detail within norms and ranges. These profiles of appropriate care can be added to the medical knowledge base and create computer simulations for teaching and testing. Such simulations could expose students to patients and diseases not experienced in the clinical setting. Through individualization of instruction and the use of computers for patient scheduling, students in clinical rotations can be matched to patients to provide them with the proper, rather than random, exposure to different diseases. These experiences can be recorded so that simulated patients may be used appropriately to fill voids in experience.

The computer's information storage and retrieval capabilities can increase the accessibility of the medical knowledge base. Textbook as well as clinical data can be quickly updated and restructured to provide the same data organized in a variety of ways. This ability to reorganize, restructure, and analyze data also facilitates creation of new medical knowledge.

The computer can be a viable and cost-effective resource if used in a coordinated manner. Having one computerized data base for education, another for assessment, another for patient care, and another for administration, not only is inefficient in most cases, but also prohibits reaping of combined benefits. Thus, one of the challenges facing the increased use of computer technology in medicine is the design of a system that facilitates and enhances data and information flow among the subsystems described in this chapter.

Chapter 5

DEVELOPMENT AND DISSEMINATION OF COMPUTER-BASED EDUCATION

5.

DEVELOPMENT AND DISSEMINATION OF COMPUTER-BASED EDUCATION

OVERVIEW

This chapter describes the extent of development, use, and dissemination of the computer-based educational materials discussed in the previous chapter. The institutions described in this chapter were selected to represent a variety of institutional developers and users of health sciences computer-based education (CBE) materials. Each institution applies computer technologies differently and possesses a range of computer hardware, software, and mechanisms by which users access computer-based materials.

Three centers that have different types of CBE are described in this chapter: the Ohio State University College of Medicine, the University of Illinois School of Basic Medical Sciences, and the Massachusetts General Hospital. The Ohio State CBE system serves most health areas, including nursing and allied health. The University of Illinois center uses one of the most sophisticated CBE hardware systems and concentrates CBE use in the basic medical sciences. The Massachusetts General Hospital has a hospital-based program focusing on clinical applications.

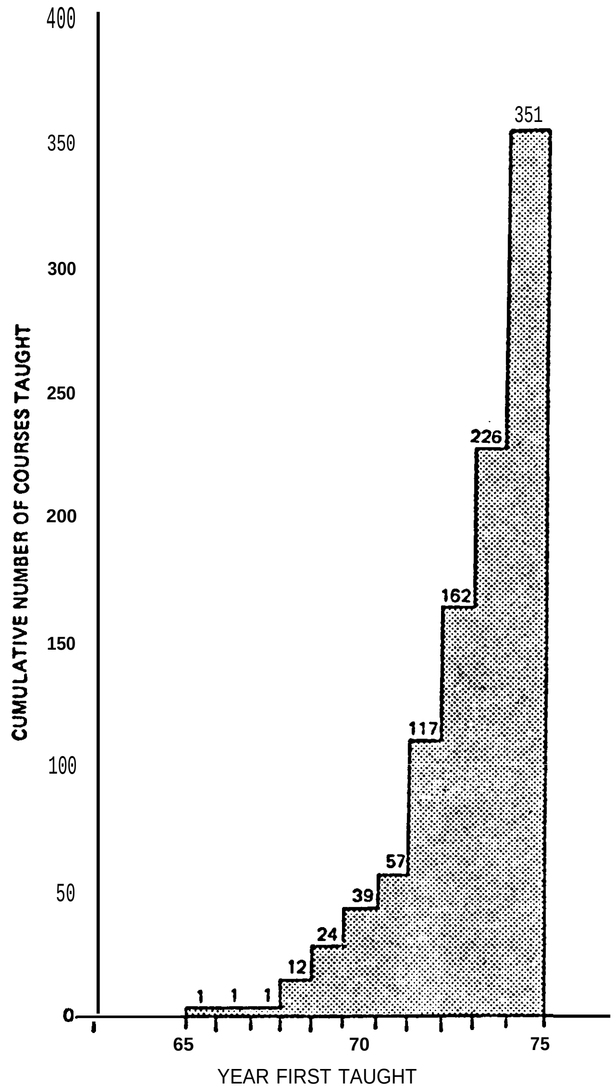
The methods of disseminating CBE materials are described in the second section of this chapter. These methods represent both *on-line* and off-line methods of sharing. In off-line dissemination, CBE courseware is transferred to the users' computer; in on-line dissemination, CBE courseware is made available to the user by networking or some other form of communication. The Health Education Network, Inc., is one example of on-line dissemination; the Computer-Assisted Teaching Systems Consortium and Milliken Communications Corporation are examples of two different off-line sharing methods.

INSTITUTIONAL DEVELOPMENT AND USE

During the past decade, the development and dissemination of computer-based educational and assessment materials in the health sciences have been rapid. In *80* American and 4 Canadian institutions that responded to a 1975 survey of the 135 U.S. and Canadian medical schools (Lefever and Johnson, 1976; Tidball, 1976), there was at least a 60-percent annual growth rate, since *1967*, in the number of medical school courses using CBE. Figure 12 shows the cumulative number of such courses versus the year in which they were first taught. The 351 courses taught in 1975 were divided almost evenly between the basic and the clinical sciences, These courses were developed using more than 15 different types of computers and programing languages.

Of the 84 schools that responded to the 1975 survey, 69 percent generated programs at their own institutions, and 64 percent used programs from other institutions via networking or time-sharing arrangements (an institution can both create its own programs

Figure 12.—Cumulative Number of Courses Involving CBE Versus the Year in Which They Were First Taught



SOURCE Tldball, 1976

and use those of any number of other institutions). Fifty-one percent of the institutions reported having permanent facilities for computer-based instruction.

The critical factors that facilitate or inhibit the development or use of CBE in the institutions described in this chapter are the following (Casburgue, 1978):

- the high financial investment required for the development of CBE is a primary inhibiting factor to use;
- a reliable computer system is an essential prerequisite for CBE development or use;

- an institutional commitment must be made not only to the development and use of CBE, but also to the provision of support staff;
- educational programs must be available for faculty administrators and technical personnel; and
- the degree of CBE integration with other instructional modalities is an important determinant of its use.

Table 9 ranks the top 10 medical institutions according to both the number of CBE course hours and the number of CBE programs or units they have produced. * Three of the institutions are described below.

Table 9.—Institutions Producing Computer-Based Materials

Ten most productive institutions (by course hours)		Ten most productive institutions (by number of programs)	
Institution	Course hours	Institution	Programs
Ohio State	229	Ohio State	63
Illinois	58	Cornell	33
Pennsylvania State	58	Massachusetts General Hospital	27*
Kansas	52	Purdue	21
U.S. Army	39	California (SF)	16
Massachusetts General Hospital	36	Michigan	14
Florida	25	Harvard	10
British Columbia	25	Northwestern	10
California (Los Angeles)	19	Connecticut	9
Cornell	17	Missouri (Kansas City)	9

. Each of these basic programs can create multiple cases so that over 200 different learning situations are available
SOURCE Kamp, 1975

The Ohio State University College of Medicine

The largest collection of available CBE courseware in medicine and health-related areas resides at The Ohio State University (OSU) College of Medicine (Kamp, 1975). This CBE system has grown from a one-terminal, one-course system in 1967 to a system that provides 22-hours-per-day, 7-days-per-week CBE access for students and health professionals throughout the United States; maintains a program library of over 425 interactive hours of CBE materials; logs approximately 3,000 usage hours per month; and adds CBE course materials to its library at the average rate of 5 interactive hours per month (Pengov, 1978).

The computer has been an important element at OSU in undergraduate medical education, nursing education, allied health education, continuing health sciences education, and patient and nonmedical support staff education. It is used both to assist in instruction and to help manage the instructional process. Every medical and nursing student in the college uses the computer. A smaller but significant percentage of allied health students also uses the computer.

In the traditional lecture-discussion curriculum, as in the independent study program (ISP), computer-assisted instruction programs are rather extensively employed. Fifty-two CBE programs are used by medical students in this curriculum; each student spends a minimum of 25 interactive hours at the computer terminal. The most extensive use of CBE is in physiology; CBE tutorial units parallel class lectures and readings on physiology. Since 1973, the college has refined, developed, and used the computer-

*There are other producers of CBE medical materials (e.g., the Air Force) that are not described in this table but are described elsewhere (Deland, 1978).

assisted simulation of the clinical patient encounter (CASE) (Pengov, 1978). The model, a natural language simulation of the patient-physician encounter, is used on an elective basis by students in the clinical areas.

The School of Nursing's Bachelor of Science curriculum includes more than 35 interactive hours of CBE materials that are used in a variety of ways by over 600 nursing students. Eight CBE programs, representing 20 interactive hours, are required of all nursing students; 7 CBE programs, 15 interactive hours, are used as optional, supplemental learning materials (Mourad and Forman, 1976).

The degree of CBE integration into the curriculum of the 11 divisions in the School of Allied Medical Professions varies by division. Six divisions do not use CBE; others use 40 CBE programs in approximately 20 required courses. Student involvement with CBE varies from 4 hours in radiation therapy to over 100 hours in medical dietetics (Breeze and Schimpfhauser, 1976).

During 1968, a pilot network, designed to provide continuing education to Ohio physicians, was established and placed in four community hospitals chosen to represent various geographical areas of the State. The goals of this project were revised in 1970; other health professionals were included, and the network was expanded to 10 hospitals within the State. Federal subsidies to the hospitals for program development declined between 1970 and 1975, and, as a result, 18 institutions began to pay the full costs of using CBE through OSU's Computer-Assisted Instruction Regional Education Network (CAIREN) (Forman et al., 1978).

Throughout its history, CAIREN has attracted some 29 institutions to its membership roles. The CAIREN membership has fluctuated according to the educational needs of each member institution; membership has also changed for reasons of cost. Membership has ranged from 1 to 7 years, from small community hospitals of less than 300 beds to large teaching hospitals of nearly 1,000 beds, and from mental institutions to health-related educational institutions and to technical schools offering nursing and allied health training programs. Table 10 summarizes the membership profile during CAIREN'S first 10 years.

The institutional libraries of most CAIREN users have a terminal that provides access to CBE materials. CAIREN avails CBE to hospital personnel on all shifts, every day of the week, for both in-service training and orientation programs. CBE continuing education courses are accredited for use in Ohio by the professional societies listed in table 11.

Table 10.–Computer-Assisted Instruction Regional Education Network (CAIREN) Membership Profile

Year ending	Number of members	Institution type: Community hospitals	Health-related educational facility	Mental health institution	Hours of use
1969	4	4			—
1970	12	12			—
1971	13	12	1		—
1972	19	15	4		8,536
1973	16	12	4		13,300
1974	20	10	4	6	11,374
1975	15	8	3	4	8,430
1976	9	8	1		6,220
1977	8	7	1		4,164
1978	12	7	5		4,326

SOURCE: Ohio State University College of Medicine.

Table 11 .—Accreditation of Computer-Based Continuing Education Courses by Professional Societies

Professional society	Approximate hours of CBE credit available
American Dietetic Association.	108
American Medical Association.	70
American Osteopathic Association	All programs eligible for Category II-A credit
Ohio Council of Medical Technology.	60
Ohio Nurses Association	6
State of Ohio Board of Pharmacy	106

SOURCE Pengov. 1978

As a direct result of the continuing education efforts, courses have been developed for use by nonmedical support staff and patients. Courses on the medical record and on medical terminology are examples of two support staff courses that have been useful in CAIREN hospitals. Examples of CBE patient courses include those that offer instruction to mothers in the care and feeding of newborns, allow patients to assess the probability of heart attacks, and provide guidance on proper menu planning. The variety of audiences that use the college's CBE materials is shown in table 12.

The college's CBE materials are available to users via two routes. In the first, "off-line, " the CBE programs are removed from the OSU computer and put in the user's computer. Over 100 C-BE programs have been transferred "off-line" and are used largely on compatible IBM equipment using COURSEWRITER III programing language. In the second and more heavily used route, the user has a terminal onsite but links via telephone lines to the CBE data base at OSU. The extent of CBE use at OSU has been influenced by the ability of one integrated data base and CBE hardware system to service a wide variety of users. CBE use also has been influenced by the large numbers of support staff whose existence minimizes the extent to which faculty authors must learn about computer operations. Figure 13 delineates the three major user groups: the college's own educational programs, the statewide sharing network (CAIREN), and the nationwide Health Education Network. * Table 13 provides data on the three groups of users. Figure 14 shows the breakdown of the use by the College of Medicine itself, and table 14 summarizes this use over 6 years.

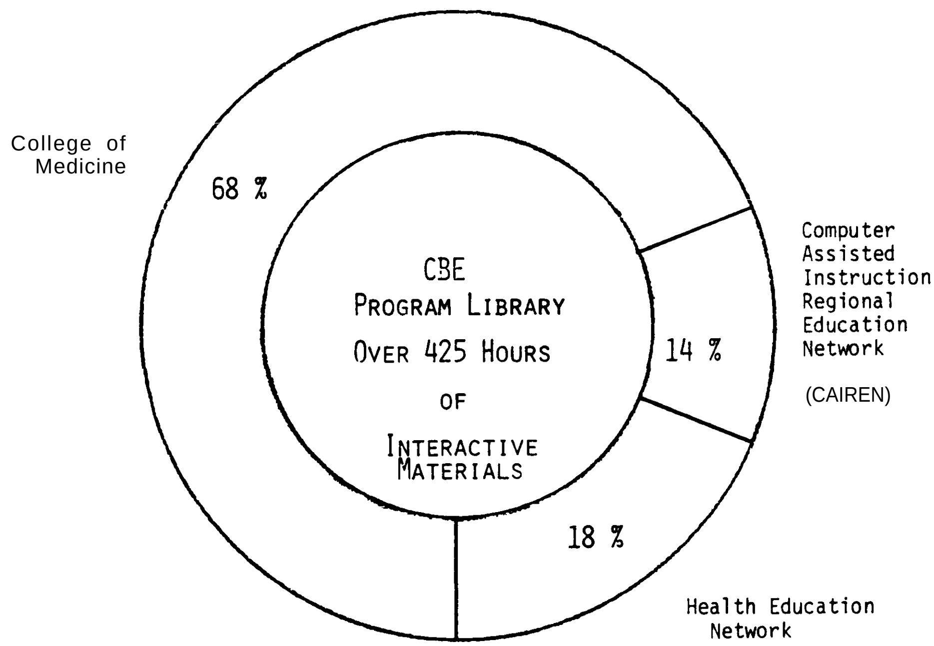
Table 12.—The Ohio State University College of Medicine Computer-Based Education Programs Indexed by Audience

Audience	Number of programs
Clinical laboratory.	27
Dietary	26
Dental.	6
Emergency medical.	14
Environmental services	8
Management	6
Medical records. ., ...	8
Medical (physicians, residents, interns, students)	113
Nursing.	51
Occupational therapy ., ...	18
Optometry	5
Patients and families	**10**
Pharmacy	6
Physical therapy	20
Respiratory	15
Radiology.	17
Secretarial	11

SOURCE Pengov, 1978

*This is a network for interinstitutional sharing of CAI materials described later in this chapter.

Figure 13.—Data Base and CBE System User Group Overview



SOURCE. The Ohio State University, 1978

Table 13.—College of Medicine Computer-Based Education User Group Summary

Category	Number of terminals	Average usage hrs./month	Total usage[b]
College of Medicine	24	1,728	20,738
Computer Assisted Instruction Region Education Network (CAIREN)	9	347	4,164
Health Education Network	39[a]	348	4,174
Totals	72	2,423	29,076

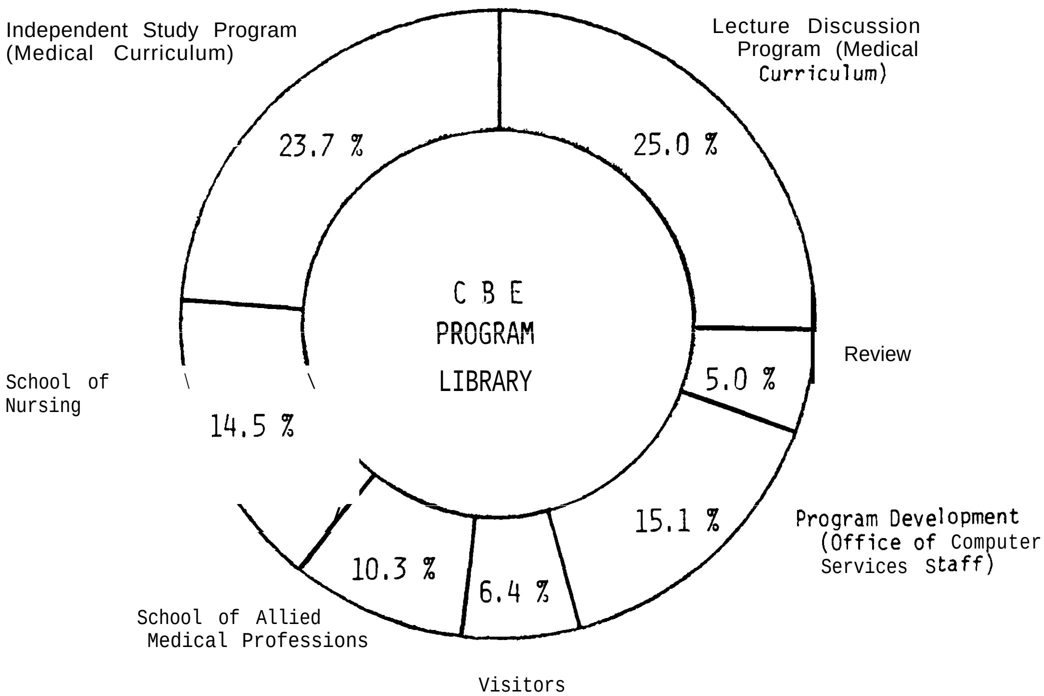
[a]This number represents the monthly average number of institutions throughout the country accessing OSU CBE materials Each institution may have a number of terminals which are used for accessing the system
[b]January-June 1977
SOURCE Ohio State University College of Medicine, 1978.

Although early CBE efforts at Ohio State received considerable outside funding, current operational support comes primarily from college funds *(68* percent) and from income generated through National and State network use *(32* percent). Users of the Health Education Network pay $6 to $10 per connect hour depending on volume of use. Users in the CAIREN network pay approximately $650 per month for unlimited access through a single terminal. Average user dollar expenditures for CAIREN are shown in figure 15. All cost figures include expenditures for CBE courseware development.

The University of Illinois School of Basic Medical Sciences

The University of Illinois was one of the first institutions to use the programed logic for automatic teaching operations (PLATO) system for computer-based education in the health sciences. The PLATO system, developed at the University of Illinois Computer-Based Education Laboratory (Bitzer and Boudreaux, *1969),* is primarily committed to

Figure 14.–CBE Usage Profile for the College of Medicine (1977)



SOURCE The Ohio State University College of Medicine, 1978

Table 14.— Computer-Based Education Utilization Summary for the College of Medicine

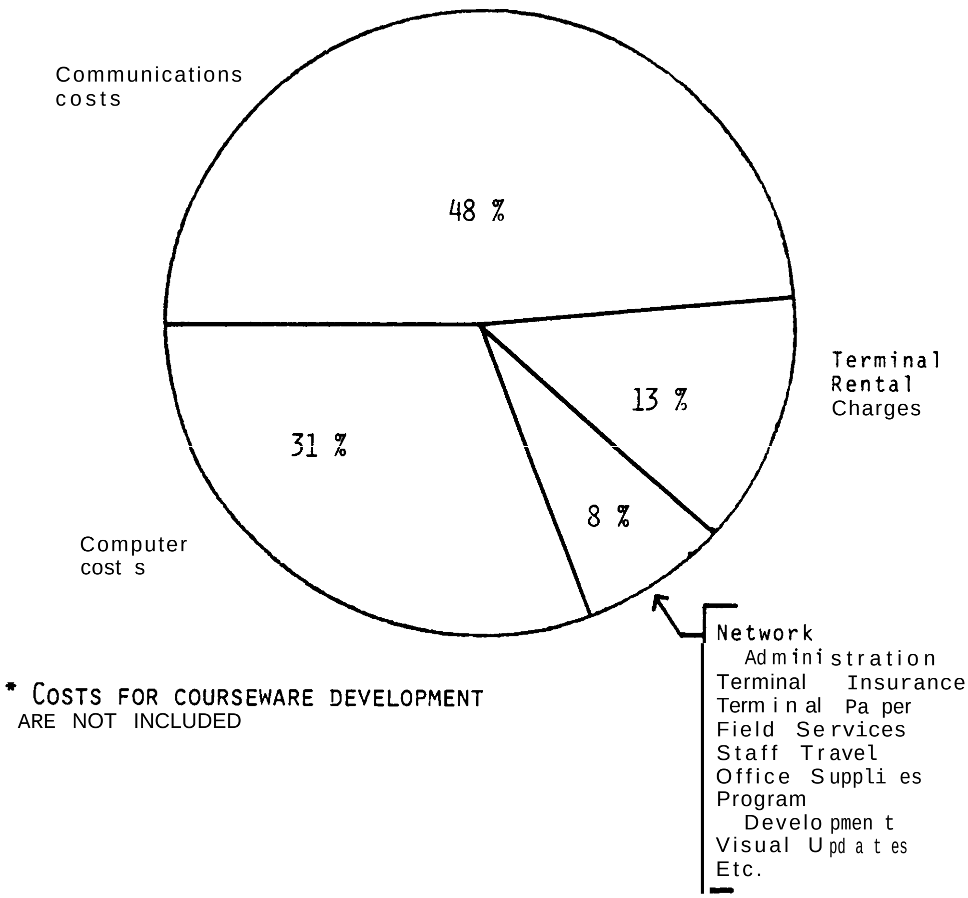
Year	Hours	Percent increase/decrease
1972	9,693	—
1973	16,884	+42.6
1974	19,159	+11.9
1975	17,140	–11.8
1976	21,711	+21.1
1977	20,737	– 4.7

SOURCE Ohio State University, 1978

research in CBE. However, it also is used to support accredited instruction in a variety of subjects during at least 80 hours of a typical week at the University (Hody and Avner, 1978). Currently some 950 terminals are linked to the system (Bloomfield et al., 1978). The unique graphic, audio, tactile, and other capabilitiesof the PLATO terminal distinguish it as one of the most advanced CBE terminals available (Sherwood and Stifle, 1975).

The University of Illinois' PLATO system and its several years of operational experience provided the requisite groundwork for the School of Basic Medical Sciences to develop a computer-based core curriculum. This effort began in 1973 with funding from both the U.S. Department of Health, Education, and Welfare and the State of Illinois. Lessons used in CBE provide both primary and supplementary instructional materials, drills, vocabulary builders, and simulations. Building upon the initial CASE work (Harless et al., 1973), simulated exercises now involve social counseling, differential diagno-

Figure 15.—Average User Dollar Expenditures* Computer Assisted Instruction Regional Education Network (CAIREN)



SOURCE: The Ohio State University College of Medicine, 1978

sis, physician attitudes toward the dying patient, as well as traditional case studies of diseases (Bloomfield et al., 1978).

A computer-based diagnostic examination system, used in the undergraduate medical curriculum, allows students to evaluate themselves. Students are encouraged to take an exam via the PLATO terminal after they have completed each of 10 clinical problems. Each exam lasts about 2 1/2 hours, allows the student an opportunity to retry questions, and provides literature references for incorrect responses. Combining all types of CBE materials, there are about 150 modules of basic medical science materials.

In 1974, PLATO terminals were made available to a number of medical schools upon their agreement to author lessons and to make the materials available to their students. Illinois provided the terminals and computer time free; participants paid a share of the service costs and all of their communication costs. Seven institutions have taken advantage of this opportunity. These seven and Illinois have logged over 17,000 student instructional hours on 80 terminals, or over 4,000 to 5,000 hours per year of use. This level of use accounts for approximately 10 percent of the total University of Illinois PLATO system use (Bloomfield et al., 1978). The number of PLATO users is growing as more courseware is made available.

Massachusetts General Hospital

The Massachusetts General Hospital (MGH) Laboratory of Computer Science developed its first computer simulations approximately 10 years ago. The programs were developed to teach and test clinical problem-solving skills and serve as a supplement to traditional methods of medical education.

The MGH data base now contains simulations in approximately 30 subject areas; most of the topics are presented in a case-oriented format (see appendix I). Each case requires approximately 10 to 45 minutes to complete, depending on the program strategy, the format employed, and the pace preferred by the user. The user can select whatever content material is of particular interest and a time and location that are most convenient. Programs are updated frequently. User comments, analyzed daily by the MGH staff, are often the source of program revision.

MGH became the first host computer on the experimental Health Education Network in 1972. Since May 1975, the programs have continued to be available through a national communications network with MGH assuming administrative and financial responsibilities. Under contractual arrangements, user institutions are charged for program use on a monthly basis.

In the past 7 years, MGH has served 20,000 individuals in over 150 institutions throughout the United States and in several foreign countries with approximately 70,000 hours of computer-based medical education. Monthly usage has ranged from 20 to more than 1,500 hours. While institutions using the MGH materials vary in size and type, most user groups are medical schools or university medical centers (68 percent of total groups) and hospitals (16 percent).

Through local and hospital program use as well as the network activity, MGH provides access to its computer simulations for medical students, physicians, and other health professionals. In undergraduate medical education, some students use the programs as required or recommended course material; others use them on an ad hoc basis for independent study. Programs are used by individuals and by student or student/teacher groups to discuss alternate actions and likely outcomes at each point requiring user input. To enhance the learning experience, most of the simulations have HELP or CONSULTATION options to offer medical or program advice in addition to the feedback to a particular response.

In graduate medical education, practicing physicians use the simulations for private self-assessment, for continuing medical education, and for certification and recertification requirements. Acceleration in the growth of medical knowledge, diversity of training programs, and growing State and specialty society requirements for continuing medical education activity have contributed to the need for new sources of continuing education credit.

The Harvard Department of Continuing Education has approved many of the MGH programs for over 70 hours of Category I credit toward the Physician's Recognition Award of the American Medical Association (AMA). Also, CME approval has been received by two specialty groups: The American Academy of Family Physicians (AAFP) for elective credits and The American College of Emergency Physicians (ACEP) for Category I credit. Table 15 lists the program names and shows the maximum number of hours of continuing education credit for which each program can be used. Physicians using the MGH programs can register for credits on-line at the time of program use. At the end of the registration period, a certificate listing total hours earned is forwarded to

Table 15.—Massachusetts General Hospital: Computer-Assisted Continuing Medical Education Program (1979)

Program module	Maximum hours approved by: AMA[a]	AAFP[b]	ACEP[c]
Abdominal pain	5	5	5
Arterial blood gas	3	3	2
Cardiac arrhythmias	3	3	4
Cardiopulmonary resuscitation	10	10	6
Coma	10	10	14
Cough and fever (Pediatrics)	5	5	6
Digitalis usage	5	5	—
Diabetic ketoacidosis	—	—	3
Fluid and electrolyte management	2	2	2
Gastrointestinal bleeding	3	3	5
Hypertension diagnosis	5	5	—
Hypertensive emergencies	3	3	3
Hypertension treatment	10	10	—
Joint pain	5	5	5
Orthopaedic problems	3	3	1
Respiratory distress—newborn	3	3	—
Trauma	3	3	4

[a]American Medical Association
[b]American Academy of Family Physicians
[c]American College of Emergency Physicians.
SOURCE Health Education Network information Packet, 1979

the participating physician. With a computer terminal and a telephone call (usually local) to the network, a physician can have a personal, interactive method of education from home, office, or hospital without leaving his/herpractice to attend acourse orlecture.

The programs have proven to be quite popular with a large number of medicaI students and physicians. Users have expressed a very positive attitude to the computer teaching experience as a valuable supplement to other educational formats. This unique approach to medical education is judged as entertaining and productive. The continuing survivaI of the network with no outside funding also attests to the favorable appraisaI given the programs by thousands of users.

NETWORKS, CONSORTIA, AND OTHER DISSEMINATION MECHANISMS

Interinstitutional sharing of CBE resource materials is necessary if CBE is to continue to be used in the health sciences. The impetus for resource sharing is provided by a variety of factors. For example, the high developmental costs of CBE materials make sharing a necessity; no one institution can afford to develop all the courseware to meet its needs. The costs of maintaining hardware are also high. It is not cost-effective or even possible for faculty authors, who must ensure the ongoing relevance and accuracy of the materials, to perform maintenance functions or distribute lesson updates to each institution that uses them. Via networking, the most scarce resource, the author, is effectively shared, because all users are on-line and interact with the same copy of the CBE courseware.

Via “off-line” sharing, author resources also are shared, but updated and new courseware must be added continually to the computer at each user site. Hence, “off-line” sharing of CBE materials will depend on the availability of mechanisms to develop and provide access to modified versions of each program. “On-line” sharing in contrast, is subject to the costs of long distance communication. Another obstacle to sharing CBE is the lack of cooperation among schools in developing and distributing learning resource materials.

In this section, programs that utilize the three mechanisms for sharing CBE materials are summarized: the Health Education Network, Inc., on-line use; the Computer-Assisted Testing Consortium (CATS), transfer of CBE programs off-line from one institution to another; and Milliken Communications Corporation (MCC), transfer of programs off-line to a single individual.

The Health Education Network

The Health Education Network, Inc., evolved from a federally supported and federally directed experimental network to a user-supported and user-directed operational network (Wooster, 1976). In 1972, the Lister Hill National Center for Biomedical Communications of the National Libary of Medicine established an experimental network to: 1) assess the technical feasibility of interinstitutional sharing of CBE materials through networking, and 2) determine whether CBE materials developed at one institution would be accepted and used by others. Both the technical feasibility of networking and user acceptance of sharing CBE materials were established in *1974,* after 18 months of network operation. Federal support continued until May of 1975. Currently, the Health Education Network enables institutions to share CBE materials at a fraction of the cost of developing and maintaining these materials individually.

The federally supported experimental network began as a result of a 1968 conference sponsored by the Council of Academic Societies of the Association of American Medical Colleges and the Lister Hill Center. Conference participants concluded that there was a need for a national network and that there were many services that might be provided. As a result, the Lister Hill Center convened a meeting in 1971 of potential hosts to discuss providing programs for networking. The center thought it could obtain programs from the hosts, put them on a central computer, and distribute them to users. Hosts were willing to share the programs, but they insisted that the programs reside on their own computers for continued courseware control and maintenance by the author team. Potential hosts disagreed with the center's demonstration plans. The center wanted to demonstrate programs to a wide group of users by employing a small number of programs; the hosts, on the other hand, wanted to work extensively with a small number of users. This issue was resolved by devising two classifications of users, trial and operational.

In June 1972, MGH became the first hospital to offer materials on the Network. Two months later, The OSU College of Medicine was officially connected to the Network, and in January 1973, the University of Illinois Medical Center was joined to the Network. Connection involved installation of a TYMNET minicomputer and development of software to interface with the host computers. MGH was an original test site for TYMNET node connection to Digital Equipment Corporation hardware, and OSU was an original test site for TYMNET node connection to IBM *360/370* series equipment. Given the "stat e-of-the-art," a period of some months was required to achieve smooth transmission of technical messages and to establish a stable and reliable network connection for users.

The University of Illinois Medical Center ceased to be a host on the Network in May 1974. The Lister Hill Center made the decision to transfer a portion of that data base, the CASE simulation materials, to the OSU College of Medicine.

Initially, the experimental network provided free service to institutions willing to support their own computer terminal(s) and connection to the nearest TYMNEI" network node. The center did not anticipate the high user acceptance which was, in fact, so great that the center was forced to recover some of its costs from participating institutions. In February 1974, user charges of $2.50 per connect hour were instituted. Network usage continued to outreach budget allocations. Therefore, a plan evolved both for gradual increases in user charges and for beginning the transition from a federally supported network experiment to a user-supported network.

Less than a year after the first user fee announcement, the Lister Hill Center increased the usage fee to $5.00 per connect hour. Still, the fee covered less than one-third of the total cost for Network operation. This circumstance is perceived as a major reason for the decision and subsequent announcement by the Lister Hill Center in January 1975, to withdraw support from the Network in May 1975. In May of 1975, the Lister Hill Center officially terminated its support of the Network. The next day the operational, user-supported Network began. By June 1976 the Network had become an incorporated, tax-exempt organization.

The Health Education Network is managed by a board of directors elected by the user communities of various hosts who coordinate their sharing under the Network umbrella. The Network is comprised of: 1) host institutions with well-developed health-related CBE materials on their own computers, 2) a communications carrier with a nationwide network, 3) institutions that wish to access and pay for available CBE courseware, and 4) a management structure to preserve and enhance the interinstitutional sharing (Tidball, 1978).

Currently, the Network's hosts are: the OSU College of Medicine, MGH's Laboratory of Computer Sciences, The University of Texas Health Sciences Center at Dallas, and Washington University (St. Louis) Department of Surgery, and Milliken Communications Corporation (as joint hosts). Through these hosts, the Health Education Network provides access to the largest library of health-related CBE materials in the world—over 600 interactive hours. The Network's CBE materials are comprised of the cumulative data bases of the several hosts.

Access to the library of programs is provided through TYMNET, a commercial telecommunications company that operates a nationwide network with approximately 165 connected sites. Using almost any computer terminal, the user need only to call the nearest connected city on the Network to access any Network host.

To date, over 150 institutions have used the Network. The largest groups of users have been medical schools (65 percent) and teaching hospitals (10 to 15 percent); other categories of users include professional societies, group practices, allied health schools, Federal agencies, industry, and individuals. Some 60 institutions are now members of the Network. Cumulatively, the Network has provided over 250,000 interactive user sessions, with on-line usage ranging from 600 to 2,000 hours per month. Composite, annual use of the Network is presented in table 16.

Member institutions use the Network for a variety of purposes. Many use the Network primarily for demonstrations, faculty education, and as an optional learning resource for students. Several institutions have integrated the Network's CBE materials into their teaching programs; some have required CBE courses that are offered by the Network, especially anatomy and physiology. The University of Washington modified the OSU independent study tutorial programs to meet the needs of their own independent study program. Before a local system was available, the medical students in Seattle used CBE programs based in Columbus, Ohio, to pursue their medical studies.

Table 16.—Health Education Network (annual hours of use)*

Year	Hours
1972	1,340
1973	18,140
1974	19,390
1975	15,600
1976	14,800
1977	12,820
1978	12,940

"Source of CBE materials only from Ohio State Unversity and Massachusetts General Hospital

The Network has supported computer-based continuing education activities by such groups as the Connecticut and Ohio Academies of Family Physicians, and the American Academy of Orthopedic Surgeons. Without the Network, many such activities could not have been undertaken.

The current cost to the user of the Health Education Network ranges from $4 to $10 per connect hour depending on the time of day (prime time v. nonprime time) and the level of user commitment. The higher the commitment in usage hours, the lower the unit cost. The Network supports a wide variety of terminals that can be purchased for less than $2,000 or rented for $50 per month. The user institutions provide their own computer terminals and phone connections to the nearest Network node. Hourly user fees include local host computer costs, costs for personnel to support and maintain the hardware and software systems, costs for personnel to provide support to users, and communication costs. Charges for development and evaluation of CBE materials and for assisting users in curricular incorporation of the CBE materials are not included. These costs are generally assumed by the hosts, which have developed the CBE materials for their own use.

The Network has stimulated the development of educational computing in the health professions and increased awareness of the potential of CBE. Faculty, student, and staff users have had an opportunity to use a new learning resource without a large initial investment in hardware, software, or personnel. They have had access to recognized materials and to the work of accomplished CBE authors. FacuIty aIso have had the opportunity to develop new lessons or alter existing lessons from their own terminals. Finally, they have had access to computer and educational consultants at the host sites.

The quality of CBE materials has improved as a result of national exposure. Widespread peer review, although still an emergent phenomenon, has accelerated review and refinement of programs. Remote authoring has further refined course development and added new materials to the CBE library. Reliable, multi-institutional access to, and use of, lessons has fostered developments in CBE materials analogous to publication in the print media.

Via the Network, the hosts have a relatively trouble-free mechanism for sharing their CBE materials with others. Sharing materials has forced other changes that are of long-term benefit to hosts and users, including: the development of simplified procedures for user access; the implementation of standards for courseware documentation; improvements in remote authoring; and the refinement of user services to address the problems of consultations on the use of CBE courseware. In addition, reporting systems and program development procedures were generalized, extensive management reporting systems were installed, and methods of billing and contracts management were implemented.

The Computer-Assisted Teaching Systems Consortium

The Computer-Assisted Teaching Systems (CATS) Consortium is a CBE sharing mechanism whereby participating medical schools cooperate in the development of new approaches to medical education, exchange educational and CBE materials, and generally encourage the development of innovative teaching in pharmacology (Doull and Walaszek, 1978). The system primarily uses computer assisted and managed testing (CAT); however, the system also uses some computer-assisted instruction (CAI).

The Health Education Network, Inc. shares materials "on-line" via network link of the user to the host computer. CATS, in contrast, shares materials "off-line" by sending computer tapes, documentation, and other materials to the user for operation on his/her own computer. This choice of sharing mode was consciously planned to enable users to control the program's uses and modifications and to minimize user costs by avoiding expensive communication links. Although developed on IBM computers, the system may be used on several types of large computers and on minicomputers.

Similar computerized test-item banks exist in several basic science areas, most notably pathology (Group for Research in Pathology Education, 1974) and physiology (Dennis, 1978). The pathology materials are maintained in Iowa and shared through a consortium similar to CATS. The physiology materials are maintained at OSU and are shared through the Health Education Network and CAIREN,

In 1970, the Department of Pharmacology began developing a system that would both teach pharmacology more effectively to medical and nursing students and attempt to meet the needs of medical technicians, hearing and speech therapists, graduate students, pharmacists, house staff, and other health professional groups. Pharmacology course material was subdivided into a number of modules or units, and CAI and computer-managed instruction /computer-assisted testing (CMI/CAT) materials were developed to help assess student competence in each of these modules or units.

CATS was used on a pilot basis in 1971 and 1972 to teach pharmacology to medical students and was fully implemented and extended to other teaching areas in pharmacology in 1973. The CATS Consortium was formed in 1974 and includes over 50 American and 12 European medical schools. They all use the CATS CMI/CAT materials developed at the University of Kansas Medical Center's Department of Pharmacology. A much smaller number use the CAI materials.

The CMI/CAT portion of CATS contains over 25,000 test items, along with software, to create and maintain new questions, to generate tests from the test-item bank, and to grade and post scores from the exams. Only objective type, versus open-ended or essay type, questions are included in the CMI/CAT item bank. The questions come from recent exams given by the Kansas pharmacology faculty, various Consortium members, and other pharmacologic colleagues of the Kansas faculty. New questions are screened for appropriateness and acceptability of question-type format. Each question is classified and tagged so that it can be automatically retrieved by content and difficulty when a test is generated. Questions are reviewed for currency and correctness when they are selected from the file for inclusion in the exams, rather than when they are added to the file.

Faculty responsible for teaching each unit in pharmacology decide how many exams they wish to prepare and how many questions from each category they wish to include in their exams. The faculty can personally select test items from a large set produced by the computer, or they can use statistical information or a random number generator to produce a test for their review.

At Kansas, exams containing 100 questions in each of the 5 units of the pharmacology course are offered weekly throughout the 20-week teaching period. Each student who registers for the independent study program is given a packet of prepunched cards containing his/her name, number, mail box number, and course number and section. Whenever a student wishes to take an exam, he/she submits one of the cards, and an optical scanning answer sheet with individual information is generated. The sheets are automatically scored and reports for the faculty and the department are prepared. Item analysis information is added to the question so that cumulative data can be kept on the difficulty and use, for example, of each question.

The CAI portion of CATS serves primarily as an enrichment or adjunct to the medical student pharmacology course. Although only a few optional CAI programs were available in 1972, 98 percent of the students in a pilot program used all of the programs, and virtually all were in favor of expanding this approach. A significant increase was demonstrated in student performance in both of the pharmacology units in which CAI material was available (Norton et al., 1972). Currently over 120 simulations and tutorials are used, for an average of 20 hours by each of the 160 medical students at Kansas. These CAI programs are available to CATS Consortium members, although most use only the CMI/CAT portion of CATS. This is due in part to the difficulties in translating the CAI programs to other computer languages and to the costs of CAI operation as compared to CMI/CAT operation (Doull and Walaszek, 1978).

Consortium growth indicates that faculty are willing to use materials developed by others if they have some editorial control over the materials. Also, the availability of a body of materials that covers a defined subject area facilitates incorporation of the materials into ongoing educational programs rather than into optional, adjunct programs. Another important aspect of the CATS Consortium is the membership requirements; each school must contribute questions to the item bank and its data must be made available to others for revision of questions and for peer review purposes. This facilitates sharing because each school considers itself an active, rather than a passive, participant.

Milliken Communications Corporation

Milliken Communications Corporation (MCC), a for-profit publisher of CBE materials, is a wholly owned subsidiary of Milliken Publishing Company formed specifically to develop and market CBE continuing education materials to physicians. Its courseware is entirely oriented to continuing education provided through the use of microprocessors and the home computing market.

In 1975 the Department of Surgery, Washington University School of Medicine, began the experimental development of a CBE system to provide students with individualized instruction in general surgery and to determine the feasibility of CAI as a means of providing postgraduate continuing medical education (Halverson and Ballinger, 1978). The work was initially supported by the Institute of Medical Education and Research, St. Louis, Me., and by Milliken. CBE courseware was authored by experts from across the country, and the Department of Surgery coordinated the effort. A series of computer programs called "drivers" were prepared so that authors could write and edit CBE seminars without learning computer programing. The standard MUMPS language and PDP computers were used for the development of the CBE programs (Bowie and Barnett, 1976).

The seminars were initially used by medical students as a supplement to the usual third-year general surgery curriculum. Although use of the CBE materials was not com-

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pulsory, about two-thirds of the students took advantage of these materials. Eighty-five percent of the 59 students felt the experience was beneficial and wanted more opportunities to take CBE seminars (Halverson and Ballinger, 1978).

As an outgrowth of the success of the Department of Surgery's efforts and with its help, Milliken Publishing Company formed MCC to adapt the undergraduate seminars to continuing education courses. Milliken, in conjunction with Washington University, is now developing continuing education series in internal medicine, primary care, and psychiatry. Experts author the materials, and MCC provides programing and computer support. An editorial board consisting of Washington University and MCC personnel review all materials. MCC pays a varying honorarium, but no royalty, to its authors. To date approximately 70 authors from 30 medical schools have participated (Milliken Communications Corporation, *1979).*

Milliken's CBE seminars are designed to simulate a conversation between the physician and the author; the mode is primarily tutorial. The computer presents a concept or basic information and asks the physician a question that requires recall, inference, or judgment. The physician responds by typing in his/her answer; the computer responds using the preprogrammed responses provided by the author. Table 17 shows the seminars currently being marketed by MCC. Over 50 interactive hours are now available, with more in development. The 'number of Category 1 Continuing Education Credit hours which can be earned is noted following each seminar title. To receive credit, the physician places the computer-generated completion code on a completion card and returns the card to Milliken.

Table 17.—Continuing Education Seminars Currently Marketed by Milliken Communications Corporation

Surgery	AMA category 1 credit hours	Internal medicine	AMA category 1 credit hours
Surgical infection	2.0	● Management of cardiac arrhythmias-1	1.5
Diagnosis and treatment of abdominal injuries	1.5	● Management of cardiac arrhythmias-n	1.5
Immunology for surgeons	1.5	● Management of cardiac arrhythmias-ill	1.0
● Surgical treatment of peptic ulcer disease	1.5	● Athletic injuries (jogging and tennis)	1.5
● Gastrointestinal inflammatory disease (Crohn's disease)-1	1.5	● Clinical approach to patients with chronic obstructive lung disease	1.5
Acute and chronic pancreatitis	1.5	● Asthma	1.5
Surgical parathyroid disease	1.0	● Chronic renal failure	1.5
Gastroesophageal reflux	1.5	● Gonorrhea	1.5
● Clinical management of advanced breast disease	1.5	● Hodgkin's disease	1.5
● Multiple endocrine neoplasis	1.5	● Thyroid dysfunction	1.5
Malignant melanoma	1.5	*Understanding nutrition	1.5
Peripheral arterial disease-1	1.5	● Evaluation of cardiac sounds	1.5
Peripheral arterial disease-n	1.5		
● Colorectal polyposis	1.0		
Cutaneous thermal burns	1.5		
Surgical nutrition	1.5		
Colorectal cancer	1.5		
● Gastrointestinal bleeding	1.5		
● Gastrointestinal inflammatory disease-n	1.5		
● Shock	1.5		
● Cancer of the thyroid	1.5		
● Trauma	1.5		
● Portal hypertension	1.0		
Extrahepatic biliary surgery	1.5		
● Thrombosis, thrombolysis and thrombophlebitis	1.5		

"Also qualifies for primary care.
SOURCE: Milliken Communications Corporation, St. Louis, Mo,, 1979,

Seminars are programed and stored on courseware diskettes that provide approximately 45 minutes of interaction each and can be used hundreds of times. The user can start, stop, exit, and reenter the seminar at will. To use the CBE seminars, the physician must purchase or lease an APPLE microprocessor (the same model available in hobby or home computing stores), and the diskettes which contain the CBE materials. MCC seminars are also available for demonstration through the Health Education Network, but, thus far, usage has been limited to less than *200* hours (Milliken Communications Corporation, 1979).

MCC both sells and leases all materials and equipment. The purchase price of the total system ranges from *$2,525* to *$2,850*, depending on the number of diskettes purchased; the lease price ranges from *$2OO* to *$3OO* per month, depending on the length of the lease; and individual diskettes cost $2o to $22, depending on the number purchased.

APPENDIX

Appendix I

EXAMPLES OF SIMULATIONS OF THE PATIENT-PHYSICIAN ENCOUNTER

INTRODUCTION

This appendix contains abbreviated examples of different methods of simulating the patient-physician encounter. The paper-and-pencil patient management problem (PMP) presents a brief description of a patient, then offers the user a series of choices. The user rubs out the block accompanying his/her choice(s) to obtain information, which is then used to help in choosing among subsequent choices.

A computerized patient management problem (CPMP) is designed similarly to a paper-and-pencil PMP. The advantages of the CPMP include: 1) more complex branching of the decisionmaking process; 2) immediate feedback to the user; 3) review of previously selected items; 4) easier access to adjunct use of audio/visual materials; and 5) better timing, control, monitoring, and scoring of the exam.

Simulations in approximately 30 subject areas are contained in the data base of the Massachusetts General Hospital. The user can select whatever content material is of particular interest and a time and location that are most convenient. In addition to the feedback to a particular response, most simulations offer medical or program advice through HELP or CONSULTATION, which provide probabilities for certain diagnostic or treatment selections based on historical data bases.

In the simulation used in the Computer Based Examination (CBX) Project, the laboratory tests ordered by the user, the procedures or consultations which are initiated, and the amount and route of drug administration interact with the patient's disease in a realistic time sequence. By simulating the effect on the patient of each action taken by the user and adjusting the patient's status accordingly, the computer model provides a much more life-like, dynamic simulation of the patient-physician encounter than does the CPMP. Through a sampling of the interaction, assessment of a number of patient-oriented factors can be accomplished, such as costs of the workup, risk (pain, complications, mortality), time taken to initiate corrective therapy, and amount of time the patient is kept in the hospital (if hospitalized). In addition, a step-by-step evaluation of the user's actions in test and therapy ordering can be done.

In the computer-assisted simulation of the clinical patient encounter (CASE), the patient-physician encounter is unprompted and undirected. After a brief introduction to the patient, the user receives no further clues. He/she must determine what information is important. The user elicits whatever history, physical examination, and laboratory data are needed for the diagnosis and management of the "patient's" problem.

PART 1

A SEGMENT OF A PAPER AND PENCIL PATIENT MANAGEMENT PROBLEM (PMP)

(Note: In this example, the examinee is presented with a short description of the problem and given a series of choices. Here, he has chosen number 3, followed by number 9. These choices are reflected by "rubbing out" the appropriate number.)

A 42-year-old man with known diabetes is brought to the hospital in a comatose state. There is no obvious evidence of trauma. There is Kussmaul breathing and the breath has an acetone odor. The skin is dry. The eyeballs are soft to palpation. Examination of the heart and lungs shows nothing abnormal except for labored respiration and rapid, regular heart rate of 120 per minute. The abdomen is soft. There is no evidence of enlarged liver or spleen or abnormal masses. Deep tendon reflexes are somewhat hypoactive bilaterally. The rectal temperature is 36.7 C (98.0 F). Blood pressure is 100/70 mm Hg.

You would immediately

1.	Order serum calcium determination	1. xxxxxxxxxxx
2.	Order serum bicarbonate determination	2. xxxxxxxxxxx
3.	Measure venous pressure	3. 100 mm H_2O
4.	Order urinalysis (catheterized specimen)	4. xxxxxxxxxxx
5.	Perform lumbar puncture	5. xxxxxxxxxxx
6.	Order blood glucose determination	6. xxxxxxxxxxx

You would now

7.	Administer digitalis	7. xxxxxxxxxx
8.	Administer morphine	8. xxxxxxxxxx
9.	Administer insulin	9. Ordered
10.	Administer coramine	10. xxxxxxx
11.	Start intravenous infusion with normal saline	11. xxxxxxx

SOURCE: Skakun et al., 1978

PART 2

A SEGMENT OF A COMPUTERIZED PATIENT MANAGEMENT PROBLEM (CPMP) WITH FEEDBACK

(Note: In this example the computer has been asking a series of questions on a particular pediatric problem with each question followed by a list of choices. Here, the user has chosen number 101, "Type of feeding," and the computer has answered, "Breast feel...Taken well." Note that this could have been done manually. By pressing the space bar, the user is automatically branched to the appropriate next series of questions, based upon his "101" response.)

Computer: What points in the history obtained from the mother or from the nursery notes would be particularly pertinent:

101 Type of feeding

102 Mother and baby blood groups

103 Health of siblings

104 Maternal use of drugs or medication

105 Family history of blood or liver disease

106 Any vomiting?

107 Increased sweating

108 Color and nature of stools

109 Color of urine

User: 101

Computer: Breast fed ...Taken well

Press Space Bar to Continue

Source: Skakun et al., 1978

51-541 0 - 79 - 8

PART 3

EXAMPLES OF SIMULATIONS FROM THE MASSACHUSETTS GENERAL HOSPITAL

(Note: Four different types of simulations are illustrated here: (1) a static patient model, (2) a dynamic patient model, (3) a physiologic model, and (4) a disease process model. User's entries are underlined. The numbered entries correspond to the inquiries that are reproduced by the computer, with the corresponding answers, immediately following the number inquiries. For example, in the first illustration, the typed entry "#l" inquires as to the "Character of Pain." The first illustration also includes an estimate of disease probabilities provided by the HELP program.)

Illustration Number One: Static Patient Model.

A 45-YEAR OLD WHITE MALE USED-CAR SALESMAN IS BROUGHT TO THE EMERGENCY ROOM BY HIS ANXIOUS WIFE BECAUSE HE COMPLAINS OF MODERATE EPIGASTRIC PAIN WHICH STARTED ABOUT A WEEK AGO AFTER A NIGHT OUT WITH THE BOYS PLAYING POKER.

(At this point, the user begins his/her interrogation of the "patient.")

ITEM #l: CHARACTER OF PAIN: IT'S A HOT, BURNING PAIN, LIKE MY STOMACH IS ON FIRE.

ITEM #8: VOMITING: I OFTEN VOMIT, AND THEN THE PAIN IS SOMETIMES BETTER.

ITEM #18: DOES EATING A MEAL AFFECT YOUR PAIN: I FEEL BEST RIGHT AFTER A MEAL, ESPECIALLY WHEN I HAVE ICE CREAM FOR DESSERT.

ITEM #4: WHEN DID YOU FIRST HAVE THIS PAIN: I'VE BEEN HAVING PAINS LIKE THIS FOR A NUMBER OF YEARS. IT SEEMED TO START WHEN I WAS IN KOREA. IT GETS PARTICULARLY BAD WHEN THE NEW MODEL CARS COME OUT IN THE FALL.

(If the user requests the HELP function at this point, he/she receives the following information.)

ITEM #HELP

AT THIS POINT

ESTIMATED DISEASE PROBABILITIES
(3) PEPTIC ULCER (GASTRO/DUODENA.L) 0.648
(6) ACUTE GASTRITIS 0.087
(7) ACUTE GASTROENTERITIS (VIRAL OR BACTERIAL) 0.063

WOULD YOU LIKE SUGGESTIONS FOR FURTHER WORKUP? YES

COMPUTER' S SUGGESTED TESTS

(4) WHEN DID YOU FIRST GET THIS PAIN
(3) HOW LONG DO THE PAINS LAST
(33) TENDERNESS TO PALPATION
(15) ANTACID RELIEF

WHAT IS YOUR IMPRESSION? GIVEN THE DATA YOU HAVE THUS FAR, WHAT DIAGNOSIS DO YOU THINK SHOULD BE MOST SERIOUSLY CONSIDERED?

DIAGNOSIS: ULCER
BE MORE SPECIFIC

DIAGNOSIS: ULCER OF DUDENUM
WHEN YOU TYPED 'DUDENUM', DID YOU MEAN 'DUODENAL'? YES

(At this point, the computer has interrupted to request the user to state his/her leading diagnostic impression. Note that the computer can recognize non-specific diagnoses and simple mis-spellings.)

YOU MAY NOW COLLECT MORE INFORMATION IF YOU CHOOSE TO DO SO

ITEM #7: HEARTBURN: THAT'S WHAT I'VE BEEN TELLING YOU, DOC. I HAVE TERRIBLE HEARTBURN, PARTICULARLY WHEN MY WIFE NAGS ME.

(At any time, the user may terminate the interaction by indicating that he/she wishes to make a final diagnosis; i.e., by entering the letter "D.")

ITEM#D:

DIAGNOSIS: PEPTIC ULCER OF DUODENUM

AN EXCELLENT CHOICE: BUT PERHAPS A DIAGNOSIS IS SLIGHTLY PREMATURE.
WOULD YOU ADMIT THIS PATIENT TO THE HOSPITAL? YES
WOULD YOU SCHEDULE A LAPAROTOMY FOR THIS PATIENT? NO

Illustration Number Two: Dynamic Patient Model.

THE PATIENT IS A 41-YEAR-OLD WOMAN WHO WAS ADMITTED 2 WEEKS AGO WITH SEVERE BIVENTRICULAR FAILURE. SHE HAD BEEN SLOWLY IMPROVING WITH BEDREST AND DIURETICS BUT NOW, ACCORDING TO THE AIDE, "LOOKS TERRIBLE." WHAT DO YOU DO FIRST?

1. TAKE AN EKG
2. START ON IV
3. CHECK MAJOR VESSELS FOR PULSES, SEE IF PATIENT IS BREATHING
4. GIVE A SHOT OF INTRACARDIAC EPINEPHRINE
5. IMMEDIATE ELECTRICAL CARDIOVERSION
6. GIVE A SHARP BLOW TO THE PRECORDIUM

#3

THERE ARE NO PALPABLE CAROTID OR FEMORAL PULSES; THE PATIENT IS APNEIC AND DOES NOT RESPOND TO YOUR SHOUT.
WHAT IS YOUR NEXT MOVE?

1. START CHEST COMPRESSION
2. GIVE A SHARP BLOW TO THE PRECORDIUM WITH YOUR FIST
3. QUICKLY GO OUT AND YELL FOR HELP
4. TAKE AN EKG
5. TILT BACK THE HEAD AND GIVE FOUR BREATHS

#2

THE AMERICAN HEART ASSOCIATION DOES NOT RECOMMEND USE OF THE PRECORDIAL THUMP IN UN-WITNESSED ARRESTS. THE DANGER IS THAT OF PRODUCING VENTRICULAR FIBRILLATION IN THE ANOXIC HEART. THERE ARE REPORTS OF SUCCESSFUL USE OF "THUMP-VERSION" IN SITUATIONS OTHER THAN WITNESSED ARRESTS, BUT THESE ARE STILL LARGELY ANECDOTAL. THE OFFICIAL POLICY IS THAT PRE-CORDIAL THUMP SHOULD ONLY BE USED WITHIN THE FIRST MINUTE OF AN ARREST. YOU TILT BACK THE HEAD AND GIVE FOUR QUICK BREATHS. THE MOST IMPORTANT STEP IS TO ENSURE AN ADEQUATE AIRWAY AND RESPIRATIONS. THIS ALONE IS SOMETIMES SUFFICIENT TO RESUSCITATE A PATIENT. *NO* RESPONSE TO PROVIDING AN AIRWAY AND GIVING SEVERAL QUICK BREATHS.
WHAT DO YOU DO NOW?

1. START CHEST COMPRESSION
2. GIVE A SHARP BLOW TO THE PRECORDIUM
3. YELL FOR HELP WHILE STARTING EXTERNAL CHEST COMPRESSION
4. TAKE AN EKG

#3

GOOD. YOU WISH TO INITIATE CARDIOPULMONARY RESUSCITATION AS QUICKLY AS POSSIBLE, BUT MUST NOT OVERLOOK THE FACT THAT IT IS MORE EFFECTIVELY PERFORMED BY TWO PEOPLE THAN ONE. IN THE HOSPITAL, TRAINED HELP SHOULD BE JUST A SHOUT AWAY. THE PATIENT REMAINS PULSELESS. ONE OF THE FLOOR NURSES HAS JOINED YOU.
WHAT SHOULD YOU DO?

1. INTUBATE THE PATIENT
2. TAKE AN EKG
3. START VENTILATION AND CHEST COMPRESSION
4. GIVE THE PATIENT AN INJECTION OF INTRACARDIAC EPINEPHRINE

#3

The interaction continues to completion.)

Illustration Number Three: Physiologic Model.

(Note: In this illustration, the patient has a tube draining to the outside from the gallbladder area, probably following gallbladder surgery. The patient is also on anticoagulant therapy, and the purpose of this exercise is to illustrate the effect on clotting time from this related surgery.)

INITIAL CONDITIONS: PATIENT IS DRAINING MATERIAL FROM A T-TUBE.

CONTROL IS 12.5 SECONDS (This refers to the normal clotting time, and the user is attempting to slow the clotting time with the anti-coagulant drug, warfarin.)

DAY 1: PATIENT'S CLOTTING TIME IS 12.5 SECONDS.
WARFARIN DOSE: 20-MG

DAY 2: PATIENT'S CLOTTING TIME IS 14.5 SECONDS.
WARFARIN DOSE: 7.5 MG
PATIENT NOW ON DISULFIRAM

DAY 3: PATIENT'S CLOTTING TIME IS 22.7 SECONDS.
WARFARIN DOSE: HELP

THE FOLLOWING POINTS MAY BE HELPFUL:
DISULFIRAM POTENTIATES WARFARIN. IT HAS NOT BEEN WELL-STUDIED BUT IS PROBABLY DUE TO INHIBITION OF HEPATIC METABOLISM. A PATIENT WITH A BILIARY FISTULA OR T-TUBE DRAINAGE (ESPECIALLY WITH ASSOCIATED PANCREATIC DISEASE) IS MORE SENSITIVE TO WARFARIN BECAUSE OF A DECREASED VITAMIN K ABSORPTION.

WARFARIN DOSE: 7.5 MG

DAY 4: PATIENT'S CLOTTING TIME IS 31 SECONDS.
WARFARIN DOSE: 5 MG

DAY 5: PATIENT'S CLOTTING TIME IS 44.3 SECONDS.

HEMORRHAGE HAS OCCURRED BECAUSE OF EXCESSIVE ANTICOAGULATION
...WARFARIN DISCONTINUED.. .VITAMIN K GIVEN.

NEW PATIENT

INITIAL CONDITIONS. PATIENT RECEIVING ADRENOCORTICOSTEROIDS.

CONTROL IS 13.1 SECONDS.

DAY 1: PATIENT'S CLOTTING TIME IS 13.1 SECONDS.
WARFARIN DOSE: HELP
DO YOU HAVE A GENERAL IDEA OF DOSES USED? YES

THE FOLLOWING POINTS MAY BE HELPFUL:

PATIENTS ON ADRENOCORTICOSTEROIDS ARE REPORTED TO REQUIRE A LARGER DOSE OF WARFARIN. THE EFFECT IS USUALLY NOT LARGE. THE MECHANISM IS POORLY UNDERSTOOD BUT MAY BE RELATED TO THE WELL-KNOWN BUT LITTLE UNDERSTOOD TENDENCY OF THE ADRENOCORTICAL STEROIDS TO PRODUCE A 'HYPERCOAGULABLE STATE' BY INCREASING CLOTTING FACTOR SYNTHESIS.

WARFARIN DOSE: 35 MG

DAY 2: PATIENT'S CLOTTING TIME IS 15.4 SECONDS.
WARFARIN DOSE: O MG

DAY 3: PATIENT'S CLOTTING TIME IS 16.7 SECONDS.
WARFARIN DOSE: 10 MG

(The interaction can be terminated here or subsequently.)

Illustration Number Four: Disease Process Model.

THE PATIENT IS A 44 YEAR OLD FEMALE WHO HAS BEEN REFERRED FROM A COMMUNITY HOSPITAL FOR TREATMENT OF DIABETIC ACIDOSIS. THEY HAD NO BEDS. HER FAMILY IS NOT SURE ABOUT HER INSULIN DOSE.

PHYSICAL EXAM: MENTAL STATUS
WHEN YOU TYPED 'MENTAL STATUS,' DID YOU MEAN 'MENTAL STATE'?
YES OBTUNDED
PHYSICAL EXAM: ORTHOSTATIC VITAL SIGNS. BLOOD PRESSURE: 92/58 PULSE: 103
AFTER SITTING THE PATIENT UP APICAL PULSE RISES BY 23, SYSTOLIC BLOOD PRESSURE FALLS BY 32
PHYSICAL EXAM: SKIN. COLOR NORMAL. TURGOR VERY POOR.
PHYSICAL EXAM: ____ (The blank tells the computer to move on to the next section.)

TEST: BLOOD SUGAR. SENT TO THE LAB.
TEST: URINALYSIS. SPECIFIC GRAVITY: 1.040; SUGAR: 4+; ACETONE: LARGE:
MICRO: 10-20 WHITE BLOOD CELLS, FEW BACTERIA
TEST: ELECTROLYTES. SENT TO LAB.
TEST: URINE CULTURE. SENT TO LAB.
TEST: ______.

THERAPY ORDERS FOR NEXT HOUR.
RX: ONE LITER NORMAL SALINE.
RX: CZ INSULIN 50 UNITS INTRAVENOUS.
RX: CZ INSULIN 50 UNITS SUBCUTANEOUS.
RX: KCL 20 MEQ IN THE INTRAVENOUS SOLUTION.
RX: ______.

ENDING THERAPY FOR TIME O
ONE HOUR WILL NOW PASS.

LAB TEST RESULTS FROM PREVIOUS HOUR:
BLOOD SUGAR: 567 MG %.
NA: 137 MEQ/L: K: 3.1 MEQ/L: C02: 8 MEQ/L.

PHYSICAL EXAM: VITAL SIGNS. BLOOD PRESSURE: 95/57; PULSE: 102; T: 99 PO; R: 31.
PHYSICAL EXAM: ABDOMEN. BOWEL SOUNDS PRESENT. NO ENLARGED ORGANS.
PHYSICAL EXAM: ______.

TEST: EKG. PROMINENT U WAVES.
TEST: ELECTOLYTES. SENT TO LAB.
TEST: BLOOD SUGAR. SENT TO LAB.
TEST: BLOOD GAS ANALYSIS. P02: 92; PC02: 23; PH: 7.08.
TEST: ______.

THERAPY ORDERS FOR NEXT HOUR.
Rx: HELP.
DO YOU WANT l-MEDICAL ADVICE OR 2-HELP WITH THE MECHANICS OF USING THE COMPUTER? 1

YOU USED AS INITIAL THERAPY 50 UNITS CZ INSULIN AND 50 UNITS SUBCUTANEOUS CZ INSULIN . YOUR INITIAL INSULIN DOSE WAS ADEQUATE BUT THE BLOOD SUGAR IS STILL HIGH. CONTINUE WITH ANOTHER 100 UNITS INTRAVENOUS CZ INSULIN. THE AVERAGE PATIENT IN KETOACIDOSIS REQUIRES 500 UNITS OF INSULIN (TOTAL), WITH A RANGE OF 100-1500 IN LARGE SERIES!

YOU GAVE 1 LITER INTRAVENOUSLY. THIS IS REALLY ADEQUATE INITIAL HYDRATION. YOU WILL FIND THAT PATIENTS IN KETOACIDOSIS REQUIRE LARGE VOLUMES OF FLUID -- AVERAGING 6 - 8 LITERS, AND SOMETIMES OVER 15 LITERS.

BICARBONATE IS PROBABLY NOT NEEDED IN MOST PATIENTS. BECAUSE C02 DIFFUSES QUICKLY OUT OF THE CEREBROSPINAL FLUID AND HC03 LESS QUICKLY IN, YOU MAY GET A PARADOXICAL CEREBROSPINAL FLUID ACIDOSIS IF YOU CORRECT THE SYSTEMIC ACIDOSIS TOO QUICKLY WITH BICARBONATE.

YOU GAVE 20 MEQ KCL. APPROPRIATE TO START. WITH THE SERUM K FALLING, NOW IS THE TIME TO START ADDING KCL TO EACH BOTTLE. I SUGGEST 60 MEQ OVER THE NEXT HOUR.

RX: 2 LITERS HALF NORMAL SALINE.
RX: 60 MEQ KCL.
RX: 100 UNITS CZ INSULIN INTRAVENOUSLY.
Rx: _______.

ENDING THERAPY FOR TIME 1 HOUR

ONE HOUR WILL NOW PASS.

(Several simulated hours later.)

YOU SEEM TO HAVE THINGS WELL IN HAND. THE PH IS 7.33, THE K IS 3.57, THE BLOOD SUGAR IS 90 AND THE SERUM ACETONE IS NEGATIVE. THE PATIENT IS ALERT AND HAS NORMAL VITAL SIGNS.

LET US STOP NOW. YOU MAY BEGIN AGAIN WITH ANOTHER PATIENT IF YOU WISH.

PART 4

A SIMULATED PATIENT - PHYSICIAN ENCOUNTER
IN THE
COMPUTER-BASED EXAMINATION (CBX) PROJECT

(Note: In this interaction, the underlined items indicate the user inputs; all other materials are generated by the computer.)

A 58 YEAR OLD WHITE FEMALE COMES TO YOUR OFFICE REQUESTING A PHYSICAL EXAMINATION

REQUEST? HISTORY — RESULTS DUE TUESDAY AT 8:12 A.M.
**** ORDERED ****

HISTORY REQUIRES 0.2 HOURS

REQUEST? RESULT

RESULTS OF HISTORY

A 58 YEAR OLD WELL DRESSED WHITE WOMAN ENTERS YOUR OFFICE. SHE IS IN NO APPARENT ACUTE DISTRESS AND INDICATES THAT SHE IS SEEKING MEDICAL ASSISTANCE BECAUSE HER "HUSBAND IS WORRIED THAT SHE MAY HAVE HAD A HEART ATTACK THIS MORNING."

SHE INDICATES THAT SHE DOES NOT INDULGE IN MUCH PHYSICAL EXERCISE BUT DID NOTE THAT TWO DAYS AGO WHEN SHE WENT JOGGING WITH FRIENDS FOR THE FIRST TIME IN QUITE A FEW YEARS, SHE DEVELOPED A DULL PAIN IN HER CHEST WHICH WENT AWAY AFTER 3 MINUTES OF REST.

THIS MORNING SHE ATTEMPTED TO PLAY TENNIS WITH FRIENDS FOR THE FIRST TIME IN MANY YEARS AND NOTED A SHARP CHEST PAIN LOCATED IN THE MIDSTERNAL LINE HALF WAY BETWEEN THE UMBILICUS AND THE TOP OF THE STERNUM. THIS PAIN PERSISTED FOR TEN MINUTES AND WAS GREATLY AGGRAVATED BY ANY MOTION OF THE ARMS. SHE DENIES RADIATION DOWN EITHER ARMOR EITHER LEG. SHE NOTED A SLIGHT SHORTNESS OF BREATH WHICH DISAPPEARED AS THE PAIN SUBSIDED. SHE DID NOT RESUME HER TENNIS GAME AND A DULL PAIN STILL PERSISTS OVER THE ANTERIOR CHEST.

THE PATIENT HAD BEEN IN GOOD HEALTH ALL HER LIFE. SHE RECENTLY RETIRED AFTER 29 YEARS IN THE POST OFFICE AND WAS GIVEN A CLEAN BILL OF HEALTH.

1 WEEK PTA THE PATIENT HAD A PHYSICAL EXAMINATION FOR LIFE INSURANCE COVERAGE. AT THAT TIME SHE WAS TOLD THAT HER BLOOD PRESSURE WAS 135/90. SHE WAS SOMEWHAT CONCERNED ABOUT THIS SINCE ON HER YEARLY PHYSICAL ONE YEAR AGO HER BLOOD PRESSURE WAS 110/60 AND ON RETIREMENT TWO MONTHS BEFORE SHE WAS TOLD THAT HER BLOOD PRESSURE WAS 125/80.

SHE DENIES HEADACHES, CHEST PAIN, SHORTNESS OF BREATH, DECREASED TOLERANCE TO ACTIVITY OR A FAMILY HISTORY OF HEART DISEASE. NO OTHER SIGNIFICANT MEDICAL HISTORY. NO RHD, KNOWN MURMURS, CONGENITAL ANOMALIES, HYPERTENSION, OR EARLY DEATHS IN FAMILY. SHE DOES NOT TAKE MEDICATION, USE DRUGS, SMOKE CIGARETTES, OR HAVE ANY EMOTIONAL PROBLEMS.

THE PATIENT IS NEW TO YOUR PRACTICE SINCE SHE RECENTLY MOVED TO THIS TOWN. SHE CURRENTLY WORKS AS A STOCK BROKER (WHICH SHE ENJOYS BUT FINDS STRESSFUL). SHE IS MARRIED AND HAS THREE TEENAGE CHILDREN IN GOOD HEALTH. SHE HAS BLUE CROSS INSURANCE COVERAGE.

REQUEST? PHYSICAL EXAMINATION

8:12 A.M. TUESDAY DAY 1

PHYSICAL EXAMINATION REQUIRES 0.6 HOURS
RESULTS DUE TUESDAY AT 8 :48 A.M. ****ORDERED****

REQUEST? RESULT

RESULTS OF PHYSICAL EXAMINATION

GENERAL: A SLIGHTLY OBESE 58 YEAR OLD WHITE WOMAN IN NO ACUTE DISTRESS. SEE SLIDE 1-72.
PULSE 80 /MIN
PULSE QUALITY GOOD
RESPIRATION 20 /MIN
BP SYSTOLIC 135
BLOOD PRESSURE DIASTOLIC 88
HEIGHT 70 INCHES
WEIGHT 70 KILOGRAMS
TEMPERATURE 99.4 F
HEENT: NORMAL EXAM
CHEST: CLEAR A&P. DIAPHRAGMS MOVE EQUALLY AND SYMMETRICALLY.
CARDIAC: PMI IS 1 CM. LATERAL OF THE LMCL. HEART SOUNDS ARE OF GOOD QUALITY. THERE IS A SOFT GRADE II/VI APICAL SYSTOLIC MURMUR AND A DEFINITE S3. NO RUB.
ABDOMEN: SLIGHTLY OBESE, LIVER IS NOT FELT BELOW THE COSTAL MARGIN. NO MASSES, NO LESIONS, NO FLUID WAVE. SPLEEN IS NOT PALPABLE.
GU: NORMAL EXAM
RECTAL: GOOD SPHINCTER TONE, NO MASSES OR ABNORMALITIES. STOOL BROWN.
EXTREMITIES: SYMMETRICAL, WITHOUT DEFORMITIES, CYANOSIS, CLUBBING OR EDEMA.
SKIN: SLIGHTLY MOIST. NORMAL TEXTURE AND TEMPERATURE. NO LESIONS.

NEURAL: NERVOUS WOMAN. ALL CRANIAL NERVES ARE INTACT. POSTURE, MOTOR AND SENSORY EXAMINATION IS WNL.

REQUEST? CHEST X-RAY

CHEST X-RAY REQUIRES 0.5 HOURS
RESULTS DUE TUESDAY AT 9:30 A.M.
****ORDERED****

LAB NOT YET OPEN:
(THIS TEST IS AVAILABLE STAT)

REQUEST? EMERGENCY ELECTROCARDIOGRAM

EMERGENCY ELECTROCARDIOGRAM REQUIRES 0.2 HOURS
RESULTS DUE TUESDAY AT 9:00 A.M. ***ORDERED****

REQUEST? RESULT

9:00 A.M. TUESDAY DAY 1

RESULTS OF EMERGENCY ELECTROCARDIOGRAM

RATE: 100/MIN. NORMAL SINUS RHYTHM. AXIS : O
MODERATE ST SEGMENT ELEVATION IN LEADS 11, III, AND AVF;
MODERATE ST SEGMENT DEPRESSION IN 1, AVL AND V2-V4 .
SEE SLIDE 363.

REQUEST? ICU
PATIENT ADMITTED TO INTENSIVE CARE UNIT

AN XV WILL BE STARTED, PATIENT WILL BE AT BEDREST, PATIENT WILL BE ON A
CARDIAC MONITOR, AND VITAL SIGNS WILL BE TAKEN HOURLY. YOU WILL BE
NOTIFIED OF ANY CHANGES.

DO YOU WISH THE PATIENT TO RECEIVE PARENTERAL FLUIDS? YES

THE PATIENT HAS NOW BEEN PLACED ON PARENTERAL FLUIDS
THE APPROPRIATE DOSE WILL BE GIVEN.
DO YOU WISE THE PATIENT TO RECEIVE BEDREST? YES

THE PATIENT HAS NOW BEEN PLACED ON BEDREST
THE APPROPRIATE DOSE WILL BE GIVEN.

REQUEST? CREATINE PHOSPHOKINASE, SGOT, CBC, SMA-12, ELECTROLYTES

CREATINE PHOSPHOKINASE REQUIRES 4.0 HOURS
RESULTS DUE TUESDAY AT 1:00 P.M. ****ORDERED****

SGOT REQUIRES 8.0 HOURS RESULTS DUE TUESDAY AT 5:00 P.M.
**** (ODERED****

COMFLETE BLOOD COUNT REQUIRES 2.0 HOURS
RESULTS DUE TUESDAY AT 11:00 A.M. ***ORDERED****

SMA12 REQUIRES 2.5 HOURS RESULTS DUE TUESDAY AT 11:30 A.M.
****ORDERED****

ELECTROLYTES REQUIRES 6.0 HOURS RESULTS DUE TUESDAY AT 3:00 P.M.
****ORDERED****

REQUEST? RESULT

RESULTS OF CHEST X-RAY

SEE SLIDES 141 & 142.

REQUEST? RESULT

10:00 A.M. TUESDAY DAY 1 (PATIENT ADMITTED)

NURSE'S NOTES:

INTENSIVE CARE UNIT NOTE

VITAL SIGNS	P 72	BP 156/101	T 99.4	R 20

UNCHANGED:

PULSE QUALITY GOOD

APICAL PULSE: NOT TAKEN

RESULTS OF RHYTHM STRIP

NO ARRHYTHMIA

REQUEST? RESULT

RESULTS OF COMPLETE BLOOD COUNT

HEMATOCRIT 45.0 %
HEMOGLOBIN 14.0 G%
RBC 5200000 PER CU.MM
WBC 8200.0
MCV 88 CU U3
MCHC 35 %
PMN 63.0 %
LYMPH 30 %
MONO 5 %
EOS 2 %
BLAST 0 %
ATYP LYMPH 0 %
BANDS .0 %
MYELOCYTES .0 %
JUVENILE NEUTROPHILS .0 %
BASOPHILES .0 %
PLAT FROM CBC 300000

REQUEST? RESULT

RESULTS OF SMA12

CALCIUM 9.5 MG%
SERUM PHOSPHORUS 3.8 MG/100 ML
GLUCOSE 80 MG%
BLOOD UREA NITROGEN 14 MG%
URIC ACID 4.0 MG%
SERUM CHOLESTEROL 200MG%
TOTAL PROTEIN 7.0 GMS %
ALBUMIN 4.5 GMS %
TOTAL BILIRUBIN .70 MG%
ALKALINE PHOSPHATASE 4.0 BODANSKY UNITS
LACTIC DEHYDROGENASE 130.0 u/ML
SGOT 10 u/ML

REQUEST? RESULT

NOON TUESDAY DAY 1 (PATIENT ADMITTED)

NURSE'S NOTES :

PATIENT IN NO ACUTE DISTRESS.

INTENSIVE CARE UNIT NOTE
VITAL SIGNS P 72 BP 156/101 T 99.4 R20
UNCHANGED:
PULSE QUALITY GOOD
UNCHANGED:
APICAL PULSE: NOT TAKEN

RESULTS OF RHYTHM STRIP

UNCHANGED:
NO ARRHYTHMIA

REQUEST? RESULT

RESULTS OF CREATINE PHOSPHOKINASE

CREATINE PHOSPHOKINASE 260.0 UNITS

REQUEST? RESULT

RESULTS OF ELECTROLYTES

SODIUM 140
POTASSIUM 4.0 MEQ/L
CHLORIDE 103 MEQ. /L
TOTAL CARBON DIOXIDE 27.0 MEQ. /L

REQUEST? RESULT

RESULTS OF SGOT

SCOT IOU/ML

REQUEST? ADVANCE
HOW MANY HOURS DO YOU WANT TO ADVANCE THE CLOCK? &5

NURSE'S NOTES:

INTENSIVE CARE UNIT NOTE

8:00 P.M. TUESDAY DAY 1 (PATIENT ADMITTED)

VITAL SIGNS P 72 BP 139/92 T 99.4 R 18
UNCHANGED :
PULSE QUALITY GOOD
UNCHANGED :
APICAL PULSE: NOT TAKEN

RESULTS OF RHYTHM STRIP

UNCHANGED:
NO ARRHYTHMIA

REQUEST? ADVANCE
HOW MANY HOURS DO YOU WANT TO ADVANCE THE CLOCK? 12

MORNING ROUNDS:
NOW ON PARENTERAL FLUIDS IV [3173]
OW ON BEDREST [7181]
VITAL SIGNS P 72 BP 139/92 T 99.4 R 18
UNCHANGED:
PULSE QUALITY GOOD
UNCHANGED:
APICAL PULSE: NOT TAKEN
THE PATIENT IS IN THE INTENSIVE CARE UNIT.

REQUEST? EMERGENCY ELECTROCARDIOGRAM

EMERGENCY ELECTROCARDIOGRAM REQUIRES 0.2 HOURS
RESULTS DUE WEDNESDAY AT 8:12 A.M. ***ORDERED****

REQUEST? ADVANCE
HOW MANY HOURS DO YOU WANT TO ADVANCE THE CLOCK? 24

RESULTS OF EMERGENCY ELECTROCARDIOGRAM

RATE: 100/MIN. NORMAL SINUS RHYTHM, AXIS: O
Q WAVES PRESENT IN II, 111, AND AVF WITH T-WAVE INVERSION AND SLIGHT ST SEGMENT ELE'VATION IN THESE LEADS. SEE SLIDE 358.

NURSE'S NOTES:

PATIENT RESTING COMFORTABLY.

INTENSIVE CARE UNIT NOTE

NOON WEDNESDAY DAY 2 (PATIENT ADMITTED)

VITAL SIGNS P 72 BP 138/92 T 99.4 R 18
UNCHANGED :
PULSE QUALITY GOOD
UNCHANGED :
APICAL PULSE: NOT TAKEN

RESULTS OF RHYTHM STRIP

UNCHANGED :
NO ARRYTHMIA

REQUEST? ADVANCE
HOW MANY HOURS DO YOU WANT TO ADVANCE THE CLOCK? 20

NURSE'S NOTES:

INTENSIVE CARE uNIT NOTE

VITAL SIGNS P 72 BP 138/92 T 99.4 R 18
UNCHANGED :
PULSE QUALITY GOOD
UNCHANGED :
APICAL PULSE: NOT TAKEN

RESULTS OF RHYTHM STRIP

UNCHANGED :
No ARRHYTHMIA

REQUEST? ADVANCE
HOW MANY HOURS DO YOU WANT TO ADVANCE THE CLOCK? 16

MORNING ROUNDS :
NOW ON PARENTERAL FLUIDS IV [3173]
NOW ON BEDREST [7181]

VITAL SIGNS P 72 BP 138/92 T 99.4 R 18
UNCHANGED:
PULSE QUALITY GOOD
UNCHANGED :
APICAL PULSE: NOT TAKEN
THE PATIENT IS IN THE INTENSIVE CARE UNIT.

REQUEST? WARD
PATIENT DISCHARGED FROM ICU TO WARD

8:00 A.M. THURSDAY DAY 3 (PATIENT ADMITTED)

REQUEST? EMERGENCY CREATINE PHOSPHOKINASE, EMERGENCY ELECTROCARDIOGRAM
EMERGENCY CREATINE PHOSPHOKINASE REQUIRES 2.0 HOURS ***ORDERED****
RESULTS DUE THURSDAY AT 10:00 A.M.

EMERGENCY ELECTROCARDIOGRAM REQUIRES 0.2 HOURS ***ORDERED****
RESULTS DUE THURSDAY AT 8:12 A.M.

REQUEST? RESULT

RESULTS OF EMERGENCY ELECTROCARDIOGRAM

UNCHANGED:
RATE: 100/MIN. NORMAL SINUS RHYTHM. AXIS: O
Q WAVES PRESENT IN II, III, AND AVF WITH T-WAVE INVERSION AND SLIGHT ST SEGMENT ELEVATION IN THESE LEADS. SEE SLIDE 358.

REQUEST? RESULT

RESULTS OF EMERGENCY CREATINE PHOSPHOKINASE

CREATINE PHOSPHOKINASE 208.0 UNITS

REQUEST? ADVANCE
HOW MANY HOURS DO YOU WANT TO ADVANCE THE CLOCK? 24

NURSE'S NOTES:

PATIENT IN NO DISTRESS AND INDICATES SHE WISHES TO BE DISCHARGED.

REQUEST? ADVANCE
HOW MANY HOURS DO YOU WANT TO ADVANCE THE CLOCK? 24

MORNING ROUNDS:
NOW ON PARENTERAL FLUIDS IV [3173]
NOW ON BEDREST [7181]

VITAL SIGNS p 61 BP 183/92 T 99.2 R 18
UNCHANGED:
PULSE QUALITY GOOD
UNCHANGED:
APICAL PULSE: NOT TAKEN
THE PATIENT IS IN THE WARD.

REQUEST? ADVANCE
HOW MANY HOURS DO YOU WANT TO ADVANCE THE CLOCK? 9

51-541 0- 79 - 9

5:00 P.M. FRIDAY DAY 4 (PATIENT ADMITTED)

NURSE'S NOTES:

PATIENT THREATENS TO SIGN HERSELF OUT OF HOSPITAL.

REQUEST? ORDER THERAPY
NOW ON PARENTERAL FLUIDS IV [3173]
NOW ON BEDREST [7181]
DO YOU WANT TO TAKE THE PATIENT OFF ONE OF THESE? NO
ENTER THERAPY NUMBER (OR PUSH 'ENTER') 186
DO YOU WISH THE PATIENT TO RECEIVE REASSURANCE? YES

THE PATIENT HAS NOW BEEN PLACED ON REASSURANCE
THE APPROPRIATE DOSE WILL BE GIVEN.
ENTER THERAPY NUMBER (PUSH 'ENTER')

REQUEST : ADVANCE
HOW MANY HOURS IN YOU WANT TO ADVANCE THE CLOCK? 24

NURSE'S NOTES :

PATIENT CONTINUES TO HAVE UNEVENTFUL RECOVERY.
DO YOU WISH TO KNOW THE CORRECT DIAGNOSIS? YES
CORRECT DIAGNOSIS
NOT YET AVAILABLE

NUMBER OF DAYS IN HOSPITAL	5	
COST OF DIAGNOSTIC WORKUP	$	181.00
COST OF THE HOSPITAL ROOM ($90/DAY)	$	450.00
COST OF INTENSIVE CARE UNIT ($8/HOUR)	$	376.00
TOTAL COST OF MEDICAL CARE	$	1007.00

DO YOU WANT TO MANAGE ANOTHER PATIENT? NO
GOOD BYE

PART 5

AN EXAMPLE OF A COMPUTER ASSISTED SIMULATION OF THE CLINICAL PATIENT ENCOUNTER (CASE)

(Note: The question marks identify the user's inquiries. The user's input. is indicated by asterisks. Everything else is generated by the computer.)

YOU ARE THE EVENING ATTENDING PEDIATRICIAN IN A BUSY METROPOLITAN EMERGENCY ROOM. THE EMERGENCY SQUAD WHEELS IN A 15 YEAR OLD, WELL-BUILT MALE ADOLESCENT ON A STRETCHER. HE APPEARS TO BE IN MODERATE DISTRESS, LOOKING ABOUT ANXIOUSLY. HIS SPEECH IS SOMEWHAT GARBLED, AND HE IS DROOLING FROM THE CORNER OF HIS MOUTH.

? * WHY DID THEY BRING YOU HERE

I HAVEN'T BEEN ABLE TO MOVE FOR THE PAST THREE HOURS. I'M REALLY SCARED. MY AUNT CALLED THE EMERGENCY SQUAD BECAUSE SHE GOT WORRIED, SO THAT'S WHY I'M HERE.

? * HAS THIS HAPPENED BEFORE

IT HAPPENED THE FIRST TIME WHEN I WAS 14. IT'S WIERD TO WAKE UP ONE MORNING AND NOT BE ABLE TO MOVE A MUSCLE.

? * OTHER ILLNESSES

(Note: The user has begun to use abbreviated inquiries.)

I'VE ALWAYS BEEN PRETTY HEALTHY. I HAD THE MEASLES AND ALL THAT AS A KID, AND SOMETIMES I GET A COLD, BUT IT'S NEVER VERY SERIOUS.

? * GO OUT FOR SPORTS

I LIKE JUST ABOUT ANYTHING YOU DO OUTDOORS. I SPEND LOTS OF TIME ON MY BIKE. I REALLY LIKE SWIMMING TOO. WE SOMETIMES GO FOR HIKES WHEN THE WEATHER IS NICE - BERNADINE AND ME. WE'LL TAKE A PICNIC LUNCH SOMEWHERE.

? *WHO IS BERNADINE

I THINK MY BEST FRIEND ALL THE WAY AROUND IS BERNADINE. WE SPEND A LOT OF TIME TOGETHER AND CAN TALK ABOUT ANYTHING.

? * SISTERS

PAUL IS 18 AND FINISHING HIGH SCHOOL. ELLEN IS 9.

? * GO TO SCHOOL

I'M IN THE NINTH GRADE NOW.

?* ANY OTHER MEMBERS OF YOUR FAMILY HAVE THE SAME PROBLEM

I DON'T KNOW OF ANYONE WHO'S BEEN PARALYZED LIKE I AM.

? * TRAVEL

I'VE BEEN TO CANADA BEFORE. ..LAST SUMMER ON A BIKING TRIP. I HAVEN'T BEEN ANYWHERE ELSE, THOUGH.

? * HAVE SEIZURES

I'VE NEVER BEEN IN ANY ACCIDENTS OR ANYTHING. I MAY SKIN MYSELF UP SOMETIMES , BUT THAT ' S *ABOUT* IT.

? * HOW IS YOUR VISION

I HAVEN' T HAD ANY TROUBLE WITH MY VISION. I 'VE NEVER EVEN WORN GLASSES OR ANYTHING LIKE THAT.

? * MOODY

1'M PRETTY HAPPY MOST OF THE TIME.

? * SPEECH PROBLEM

IT' S JUST WHEN I'M PARALYZED. I CAN 'T GET MY WORDS OUT CLEARLY.

? * FAMILY HISTORY OF ILLNESSES

THERE AREN'T ANY DISEASES THAT RUN IN THE FAMILY, THAT I'M AWARE OF. I DO KNOW THERE ARE AN AWFUL LOT OF RELATIVES WHO HAVE JUST DIED IN THEIR SLEEP . THAT'S SCARY.

? * WHAT DO YOU MEAN DIED IN THEIR SLEEP

I AM AFRAID OF DYING. I MEAN, NOBODY KNOWS WHY MY RELATIVES HAVE DIED IN THEIR SLEEP . . . HOW DO I KNOW THE SAME THING WON'T HAPPEN TO ME? I HOPE WE CAN FIGURE THIS ALL OUT.

? * HAVE ANY PROBLEMS WITH COORDINATION

I HAVEN'T HAD ANY COORDINATION PROBLEMS, EXCEPT FOR WHEN I'M PARALYZED, OF COURSE.

? * DIZZY

I'VE NEVER HAD A DIZZY SPELL.

? * FAINTING

I PASSED OUT ONCE FROM DRINKING TOO MUCH BEER WITH FRIENDS ONCE, BUT THAT'S ALL .

? * **SMOKE**

I'VE SMOKED CIGARS AND CIGARETTES BEFORE. SOMETIMES I LIGHT UP IF I'M WITH A LOT OF GUYS WHO SMOKE. AND THE CIGARS -WELL - THE'Y ARE AWFUL.

? * DRUGS

I DON'T TAKE ANY MEDICINE.

? * DRINK

ALL OF OUR FRIENDS LIKE DRINKING BEER. WE FIND SOMEONE OLD ENOUGH TO BUY US BEER AND THEN TAKE IT OUT TO PARTY. BEER'S ALL WE EVER HAVE.

? * EATING HABITS

I LIKE JUST ABOUT EVERYTHING, SO I EAT WHATEVER IS PUT IN FRONT OF ME. I EAT OKAY WHEN I'M AT HOME. I LIKE FRUIT, GREEN VEGETABLES, MEATS. . . ALL THAT STUFF. IT'S JUST THAT WHEN I'M OUT WITH MY FRIENDS THAT I LIKE PIZZAS AND BIG MACS. I WOULDN'T SAY I'M MALNOURISHED OR ANYTHING.

? * STOMACH PROBLEMS

I'VE NEVER HAD ANY STOMACH TROUBLE.

? * HEADACHES

I VERY SELDOM HAVE HEADACHES. ASPIRIN ALWAYS GETS RID OF THEM ANYHOW.

? * PAIN

I'M NOT IN PAIN . . . I JUST CAN'T MOVE.

? * p

(Note: The user asks to enter the physical examination section "p" of the CASE.)

** PE **

GENERAL APPEARANCE--

WELL DEVELOPED, WELL NOURISHED, WELL HYDRATED WHITE MALE ADOLESCENT WHO APPEARS TO BE IN MODERATE DISTRESS, LOOKING ANXIOUSLY ABOUT. HE OCCASIONALLY DROOLS FROM THE CORNER OF HIS MOUTH.

? * H

(Note: The user asks to reenter the history section "h" of the CASE.)

** HISTORY **

? * HOW LONG HAVE YOU BEEN DROOLING

I JUST CAN'T CONTROL IT. I HATE IT WHEN I DROOL LIKE THIS. AS SOON AS I CAN'T MOVE, THIS HAPPENS. IT'S BEEN A COUPLE HOURS NOW SINCE THIS HAPPENED.

? * DO YOU ALWAYS DROOL WHEN YOU HAVE THESE PROBLEMS

THIS HAPPENED TWICE BEFORE TO ME.

? * P (Note: The user asks to reenter the physical examination sect ion "p" of the CASE.

** PE **

? * VITAL SIGNS

TEMPERATURE - 37 C. (ORAL)
PULSE - 150 AND REGULAR
RESPIRATION - 30/MINUTE
BLOOD PRESSURE - 110/70 SUPINE; 100/56 SITTING WITH ASSISTANCE

? * CHEST INSPECTION

CHEST - APPEARANCE--
SYMMETRICAL, WITH FULL EXPANSION. NORMAL A-P DIAMETER. NO DEFORMITIES OR VISIBLE PULSATIONS.

? * CHEST PERCUSSION

CHEST - PERCUSSION --
NORMAL RESONANCE. DIAPHRAGM MOVES NORMALLY WITH RESPIRATION.

? * CHEST AUSCULTATION

CHEST -AUSCULTATION--
NORMAL BREATH SOUNDS IN ALL LUNG FIELD. VOCAL FREMITUS NORMAL.

? * HEART INSPECTION

HEART - INSPECTION—
PMI VISIBLE IN 5TH INTERCOSTAL SPACE NEAR MID-CLAVICULAR LINE. THE PRECORDIUM IS SOMEWHAT HYPERACTIVE.

? * HEART PALPATION

HEART - PALPATION--
VERY ACTIVE PRECORDIUM. NO THRILLS OR HEAVES. PROMINENT SYSTOLIC IMPULSE.

? * HEART AUSCULTATION

HEART - AUSCULTATION--
150/MINUTE. GRADE 2/6 SYSTOLIC EJECTION MURMUR AT LOWER LEFT STERNAL BORDER.

? * HEART PERCUSSION

HEART - PERCUSSION--
NORMAL HEART SIZE TO PERCUSSION.

? * EXTREMITIES

EXTREMITIES--
NORMAL COLOR WITHOUT CYANOSIS, CLUBBING OR EDEMA. NO VARICOSITIES. NO TREMOR. PERIPHERAL PULSES EQUAL AND BOUNDING BILATERALLY. JOINTS NORMAL. SHOULDERS NORMAL.

? * REFLEXES

DEEP TENDON REFLEXES--
ABSENT

? * MUSCLE STRENGTH

MUSCLE STRENGTH--
FLACCID. WHEN ARM IS HELD OVER FACE AND DROPPED, IT FALLS ON PATIENT'S FACE.

? * *CRANIAL NERVES*

CRANIAL NERVES --
1 INTACT SMELL. II, III, IV, VI INTACT. PUPILS ARE EQUAL, ROUND AND REACTIVE TO LIGHT AND ACCOMMODATION. FUNDOSCOPIC NORMAL. VII FACE APPEARS DROOPY. FACIAL MOVEMENT WITH DIFFICULTY. V SLIGHT WEAKNESS OF MASSETERS. SENSATION INTACT. VIII INTACT. IX, X DECREASED BUT PRESENT GAG REFLEX. SENSATION INTACT. UVULA ELEVATES SLIGHTLY. REGURGITATES ON SWALLOWING. SOME HOARSE TONE TO VOICE. XI DECREASED STRENGTH OF TRAPEZIUS AND STERNOCLEIDOMASTOID. XII DECREASED STRENGTH OF TONGUE MOVEMENTS.

? * GAIT

GAIT--
NOT ABLE TO WALK.

? * MOTOR SYSTEM

MOTOR SYSTEM
DECREASED MUSCLE TONE, STRENGTH. MUSCLE MASS NORMAL.

? * BABINSKI

BABINSKI REFLEX--
ABSENT BILATERALLY (NO MOVEMENT OF TOES UP OR DOWN).

? * EYES

EYE EXAMINATION--
CONJUNCTIVA AND SCLERA CLEAR - NO INJECTION, PETECHIAE, JAUNDICE, PTOSIS, LID LAG, EDEMA. PUPILS EQUAL AND ROUND AND NORMAL REACTION TO LIGHT AND ACCOMMODATION.

? * JOINTS

EXTREMITIES--
NORMAL COLOR WITHOUT CYANOSIS, CLUBBING OR EDEMA. NO VARICOSITIES. NO TREMOR. PERIPHERAL PULSES EQUAL AND BOUNDING BILATERALLY. JOINTS NORMAL. SHOULDERS NORMAL.

? * L

(Note: The user asks to enter the laboratory section "L" of the CASE.)

** LAB **

? * CBC

COMPLETE BLOOD COUNT--

		NORMALS
RN	5,200,000	4,6-6.2 x 1,000,000
WBC	15,000	4.8-10.8 x 1,000
HGB	15 GM/loo ML	14-18
HCT	45%	42-52
DIFFERENTIAL -		
POLY	70%	40-70
STAB	10%	0-6
LYMPH	12%	20-45
MONO	4%	2-8
EOS	3%	0-5
BASO	1%	0-1

NRBC/100 WBC NONE
ANISOCYTOSIS NONE
POIKILOCYTOSIS NONE
CHROMICITY NORMAL
PLATELETS ADEQUATE

? * URINALYSIS

URINALYSIS--
APPEARANCE: AMBER YELLOW, CLEAR
REACTION (PH): 6.5 (NORMAL REACTION (PH): 4.6-8.0)
DIACETIC ACID: NEGATIVE
BILE PIGMENT: NEGATIVE
UROBILINOGEN: NEGATIVE
REDUCING SUGAR: NEGATIVE

PROTEIN : NEGATIVE
SPECIFIC GRAVITY : 10,010 (NORMAL: 1. 001-1• 035)
ACETONE : NEGATIVE

MICROSCOPIC URINALYSIS--
BACTERIA: NEGATIVE
CRYSTALS: NEGATIVE
EPITHELIAL CELLS: 0-3/HPF
LEUKOCYTES: O-3 WBC/HPF
ERYTHROCYTES: O-3 RBC/HPF
CASTS: NEGATIVE

? * **SMAL**
THE SPECIFIED TEST IS NOT AVAILABLE IN THE LABORATORY SECTION.

? * SMAL,2:

SMA 12--		NORMALS
CALCIUM	10 MG/100 ML	9-10.8
INORG. PHOSPH.	4 MG/100 ML	3.0-4.5
FASTING GLUCOSE	82 MG/100 ML	60-100
BUN	7 MG/100 ML	8-25
URIC ACID	6 MG/100 ML	3.5-7.0
CHOLESTEROL	210 MG/100 ML	150-27(3
TOTAL BILIRUBIN	0.7 MG/100 ML	0.3-1.1
ALBUMIN	4 GM/100 ML	3.5-5.5
TOTAL PROTEIN	7 GM/loo ML	6-8
ALK. PHOSPH.	9 KA UNITS	5-13
LDH (WACKER)	95 UNITS/ML	80-120
SGOT (KARMEN)	28 UNITS/ML	15-40

? * SERUM ELECTROLYTES

SERUM ELECTROLYTES--

		NORMAL
CL	99 MEQ/L	100-106
NA	140 MEQ/L	135-145
K	1.8 MEQ/L	3.5-5.0
TOTAL C02	27 MEQ/L	24-30

? * EKG

ELECTROCARDIOGRAM:
RATE “ 150
RHYTHM - SINUS TACHYCARDIA
QRS AXIS - +60
T AXIS - +40
PR INTERVAL - 0.17
QRS DURATION - 0.1O

QT INTERVAL - 0.34
T WAVES ARE INVERTED AND ST SEGMENTS ARE DEPRESSED. U WAVES ARE PROMINENT.

? * CHEST XRAY

CHEST --
PA AND LATERAL CHEST FILMS SHOW WELL EXPANDED LUNG FIELDS WITHOUT EVIDENCE OF CONGESTION OR ACTIVE INFECTION. DIAPHRAGMS ARE SMOOTH, COSTOPHRENIC ANGLES ARE CLEAR AND THE CARDIOVASCULAR SHADOW IS NORMAL FOR THE AGE. BONES APPEAR INTACT AND OF GOOD DENSITY.

?*SED RATE

ERYTHROCYTE SED RATE (WESTERGREN) --
10 MM/HR (NORMAL: 0-15)

? * D (Note: The user asks to enter the diagnosis "d" section.

AFTER YOU BEGIN THE DIAGNOSIS AND MANAGEMENT SECTIONS YOU WILL BE UNABLE TO GO BACK TO THE HISTORY, PHYSICAL OR LABORATORY SECTIONS OF THIS CASE. IF THERE IS ANYTHING MORE YOU WISH TO ASK THE PATIENT OR OTHER TESTS YOU'D LIKE TO ORDER, TYPE H, P OR L TO RETURN TO THESE SECTIONS. IF YOU ARE READY TO LIST YOUR DIAGNOSES AND TREATMENT FOR THE PATIENT, TYPE D .

* D

** DIAGNOSIS AND TREATMENT **

PLEASE TYPE THE DIAGNOSES FOR THE PROBLEM THAT YOU PERCEIVE ED HARRISON TO HAVE.

ENTER ONLY ONE DIAGNOSIS PER LINE. SECONDARY DIAGNOSES SHOULD BE LISTED SEPARATELY FROM PRIMARY DIAGNOSES -- E.G., DO NOT LIST 'ACUTE PYELONEPHRITIS WITH SEPSIS' ON ONE LINE. PLEASE LIST THE DIAGNOSES SEPARATELY SO THAT YOU WILL RECEIVE CREDIT FOR BOTH. HIT THE RETURN KEY AFTER EACH DIAGNOSIS AND WAIT FOR THE 'DX:' TO APPEAR BEFORE ENTERING ANOTHER. TYPE A '$' AFTER YOUR LAST DIAGNOSIS.

** NOTE - THE DOLLAR SIGN ($) INDICATES THAT YOU HAVE COMPLETED A SECTION AND TAKES YOU ON TO THE NEXT SECTION. PLEASE BE SURE YOU HAVE ENTERED ALL THE INFORMATION BEFORE TYPING '$' AS YOU WILL NOT BE ABLE TO MAKE ADDITIONS TO THE SECTION YOU HAVE JUST COMPLETED. **

DX: * HYPOKALEMIA

DX: * FAMILIAL INTERMITTENT (PERIODIC) PARALYSIS
PLEASE BE MORE DESCRIPTIVE ABOUT THE TYPE OF PARALYSIS YOU FEEL ED HARRISON HAS.

DX: * FAMILIAL PERIODIC PARALYSIS

DX: * NEUROMUSCULAR PARALYSIS

DX: * $

IN DESCRIBING YOUR MANAGEMENT PLAN FOR ED HARRISON, YOU WILL BE ASKED TO INCLUDE THE FOLLOWING INFORMATION:

1. MEDICATIONS (USING GENERIC NAMES FOR DRUGS WHEN POSSIBLE; DOSAGES AND METHOD OF ADMINISTRATION ARE NOT NECESSARY)
2. PROCEDURES, REFERRALS AND/OR CONSULTATIONS (INCLUDE HOSPITALIZATION HERE, IF NECESSARY)
3. INSTRUCTIONS TO THE PATIENT

** NOTE - YOU ARE EXPECTED TO GIVE MANAGEMENT STEPS ONLY FOR THE SHORT-TERM CARE OF THIS PATIENT.**

LIST ONLY ONE DRUG, PROCEDURE, INSTRUCTION ON EACH LINE AND HIT THE RETURN KEY AT THE END OF EACH LINE. WHEN YOU HAVE COMPLETED A SECTION, TYPE A DOLLAR SIGN ($).

MEDICATION: * IV POTASSIUM CHLORIDE

MEDICATION: * IV RINGERS

MEDICATION: * $

PLEASE LIST THE PROCEDURES, REFERRALS AND/OR CONSULTATIONS YOU WOULD RECOMMEND FOR ED HARRISON.

PROCEDURE: * HOSPITALIZE

PROCEDURE: * MONITOR POTASSIUM INTAKE

PROCEDURE: * REPEAT EKG

PROCEDURE: * REFER TO NEUROLOGY

PROCEDURE: * $

PLEASE LIST ANY INSTRUCTIONS YOU WOULD GIVE THE PATIENT REGARDING HIS RESPONSIBILITIES IN THE MANAGEMENT OF HIS HEALTH PROBLEMS.

INSTRUCTION : * COME TO SEE ME IN A WEEK AFTER DISCHARGE

INSTRUCTION : * $

SCORES AND FEEDBACK (Note: At this point the CASE is complete and the user receives feedback on his/her performance.)

YOUR SCORE FOR DIAGNOSTIC CORRECTNESS: 100

AUTHOR'S DIAGNOSTIC STATEMENT	VALUE	VALUE OBTAINED
1. HYPOKALEMIA	40	40
2. NEUROMUSCULAR PARALYSIS SECONDARY TO HYPOKALEMIA	40	40
3. FAMILIAL PERIODIC PARALYSIS	20	20

YOUR SCORE FOR MANAGEMENT: 75

AUTHOR'S SUGGESTED MANAGEMENT	VALUE	VALUE OBTAINED
1. MEDICATION	70	60
A. IV POTASSIUM CHLORIDE	60	60
B. IV HYDRATION	10	0
2. PROCEDURES, REFERRALS, CONSULT	15	0
A. HOSPITALIZATION - EKG MONITORING & .FOLLOW SERUM POTASSIUM	15	10
B. CONSULT NEUROLOGY	0	0
3. INSTRUCTIONS TO THE PATIENT	15	5
A. AVOID HIGH CARBOHYDRATE MEALS	10	0
B. FOLLOW-UP (COME IN A WEEK OR LESS AFTER DISCHARGE)	5	5

DR. STEPHEN M. FRIES (UNIVERSITY OF MICHIGAN), AUTHOR OF THE ED HARRISON CASE, FEELS THE FOLLOWING HISTORICAL INFORMATION AND PHYSICAL AND LABORATORY TESTS ARE CRITICAL FOR THE DIAGNOSIS AND MANAGEMENT OF THIS CASE.

PLEASE PRESS THE RETURN KEY TO CONTINUE . . . *

** HISTORY **

(Note: A notation is made beside each of the author's critical concepts as to whether the user did or did not obtain the information.)

CANNOT MOVE BUT ABLE TO TALK - OBTAINED
SPEECH SLURRED - OBTAINED
DROOLING - OBTAINED
MEDICATIONS - OBTAINED
SEIZURE HISTORY - OBTAINED
PAST HOSPITALIZATIONS - OBTAINED
FAMILY HISTORY OF MEMBERS DYING IN SLEEP - OBTAINED
FAMILY HISTORY OF PARALYSIS - NOT OBTAINED
ACCIDENT OR INJURIES - OBTAINED
COORDINATION PROBLEMS-OBTAINED
EYESIGHT DIFFICULTIES - OBTAINED
PSYCHIATRIC problems- OBTAINED
INJESTION OF HIGH CARBOHYDRATE MEAL PRIOR TO ONSET - NOT OBTAINED

** PHYSICAL EXAM **

PULSE - OBTAINED
RESPIRATION - OBTAINED
CHEST PERCUSSION - OBTAINED
HEART INSPECTION - OBTAINED
HEART PALPATION - OBTAINED
HEART AUSCULTATION - OBTAINED
EXTREMITIES - OBTAINED
CRANIAL NERVES - OBTAINED
MOTOR SYSTEM - OBTAINED
CEREBELLA TESTS - NOT OBTAINED
GAIT - OBTAINED
MUSCLE STRENGTH - OBTAINED
VIBRATORY, POSITIONAL, TEMPERATURE, TOUCH AND PAIN SENSATION - NOT OBTAINED
BABINSKI REFLEX - OBTAINED

** LABORATORY **

SERUM ELECTROLYTES - OBTAINED
EKG - OBTAINED

THERE ARE A NUMBER OF TESTS IN THE LABORATORY SECTION THAT WOULD BE CONSIDERED DANGEROUS OR UNNECESSARY TO PERFORM ON THIS PATIENT BECAUSE OF HIS CONDITION. YOU REQUESTED NONE OF THESE.

THE TOTAL COST OF TESTS YOU ORDERED IN THE LABORATORY SECTION IS 66 DOLLARS.

THERE ARE TWO LABORATORY TESTS WHICH SHOULD BE ORDERED FOR EVERY PATIENT YOU SEE FOR THE FIRST TIME. THESE TESTS ARE THE URINALYSIS AND COMPLETE BLOOD COUNT. YOU REQUESTED BOTH OF THESE.

DO YOU DESIRE PRINTED EVIDENCE THAT YOU HAVE COMPLETED THE FOREGOING CASE SO THAT YOU MAY OBTAIN CONTINUING EDUCATION CREDIT? (YES/NO)

* Y

IN ORDER TO VALIDATE YOUR COMPLETION OF THIS ACTIVITY, WE MUST MAINTAIN A RECORD OF YOUR NAME, DATE, AND CASE COMPLETED.

PLEASE ENTER YOUR FIRST AND LAST NAME AT THIS TIME (NO MIDDLE NAME OR INITIAL). EXAMPLE: JOHN DOE (PLEASE REMEMBER TO PUT A SPACE BETWEEN YOUR FIRST AND LAST NAMES.)

* EARLA MYER

EARLA MYER, IS YOUR NAME ENTERED CORRECTLY - NO MIDDLE NAME OR INITIAL? (YES/NO)

* Y

5/01/79

EARLA MYER HAS COMPLETED CASE 16, ED HARRISON.

THIS IS A CAI PROGRAM OFFERING OF THE OHIO STATE UNIVERSITY COLLEGE OF MEDICINE DIVISION OF COMPUTING SERVICES FOR MEDICAL EDUCATION AND RESEARCH. AS AN ORGANIZATION ACCREDITED FOR CONTINUING MEDICAL EDUCATION, THE OHIO STATE UNIVERSITY COLLEGE OF MEDICINE CENTER FOR CONTINUING MEDICAL EDUCATION CERTIFIES THAT THIS CONTINUING MEDICAL EDUCATION OFFERING MEETS THE CRITERLA FOR UP TO 1.5 CREDIT HOURS IN CATEGORY I OF THE PHYSICIAN'S RECOGNITION AWARD OF THE AMERICAN MEDICAL ASSOCIATION PROVIDED IT IS USED AND COMPLETED AS DESIGNED.

ALL PARTICIPANTS ARE REMINDED TO LIST THE TOTAL HOURS SPENT USING THIS CASE (UP TO 1.5 HOURS) IN THEIR INDIVIDUAL LOG AND TO NAME THE OSU COLLEGE OF MEDICINE CCME AS CO-SPONSOR.

(Note: Record of participation is provided for continuing education credit.)

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REFERENCES

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