Chapter 1
SUMMARY AND ANALYSIS

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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 fea-

sible 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 settin$_g$ 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 exami - nations 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.