THE NEED FOR AUTOMATION IN HEALTH CARE

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This symposium is titled "Computer Applications in Medical Care." Many have applied computers to the problems of health and medicine. Solutions to many problems have been found. But the use of computers in health and medicine has not yet reached the level at which it has produced the answer to our nationally recognized problems of cost, accessibility and quality in health and medical care. Can a "computer" do that? That is a basic question that I must ask today.

A second question refers to our continuing use of the word "computer" in medical care. Does the physician in practice have any reason to be concerned with a piece of hardware, such as a computer? The answer is no. Should anyone be surprised at that answer? Again, I think the answer is no.

What I do think the physician in practice must be concerned with, is the utilization of readily available technology for all aspects of routine health and medical care. That implies, as an immediate follow-up, that the physician be concerned with the utilization of "automation" in health and medical care. I would like to suggest that future symposia perhaps change their names to more functional and less hardware-oriented ones. Physicians, like patients, are interested in the end result -- so we must be interested in the useful output, and only as an item of interest, the tool and the application of that tool.

Automation is a process. Automation is not a process which involves only a computer. Automation involves the people that work with the computer -- who give it input -- who use its output. Because the automation process requires and involves people (and because it has useful health and medical output), the physician must be concerned with it even if he or she is not interested in computers.

Automation is a system which is concerned with practicality and reality, as well as personalities. In the field of health and medicine, those three items are essential considerations. So the concept that I am presenting is that we not emphasize the hardware and its software, but the total process and how it is going to change health or medicine in relationship to quality, accessibility or cost.

There are problems in medical quality we know, but in this country we have a high quality health care comparable to the best in the world, I believe. There are problems with accessibility. But on the whole, I know of no circumstance in which we can say that health care is routinely unavailable. But we do know that we have problems of cost. Our Congress emphasizes these. Our patients are aware of the high cost, and the press, I think quite properly, does not let us forget that problem. So I would emphasize with priority the area of cost and ask another question.

"Does automation help in reducing costs?" The answer should be obvious. Automation is used to achieve a defined level of quality and accessibility but, as every business knows, it is used to reduce costs or to allow a process or a product to become cost effective. So another question can be asked. Why have we not answered the challenge of costs in health care through the utilization of automation? Is it that the applications have not been good? Is it that our utilization of computers in the automation process has been inappropriate? Or, is it simply that we have, perhaps as an act of omission, concerned ourselves with quality foremost and forgotten the basic necessities of cost and cost effectiveness.

In this last year, under a study grant from the Fannie E. Rippel Foundation, in a project for the Association for the Advancement of Medical Instrumentation, we have done searches through the National Library of Medicine in reference to various applications of computers in health and medical care. We
Have done some of these searches, limiting the code words to "costs" and "cost effectiveness." We've been surprised that there are so few papers in this area in literally every application. Ten or twelve in the last 2 years in any specific area is good.

What that means effectively is that when press, Congress, and patients look at us we appear not to be concerned with costs, even though we may be using technology, automation and computers which inherently will reduce costs. I believe it is time for us to emphasize the basic reason for the use of technology and automation. It is, I believe, to meet the challenge of the goals that we have set for ourselves -- quality, accessibility, and emphatically, cost.

However, if we cannot find many references to studies on costs in the National Library of Medicine, I would point to foci of government like HEW, which has indicated that technology adds to the cost of health care and say that, if there are few references pointing to the cost reductions, there are fewer that would point to technology adding to cost. I am concerned that some of our health planners, and particularly some in administration, seem to ignore data in this regard and appear to be more interested in attempts to regulate for regulations sake and from their fear, not substantiated in the literature, that technology will increase costs. Technology, and particularly automation, have routinely decreased costs in other areas, hence, should certainly not be expected to increase them in health and medical care.

My first theme then is (1) that we should emphasize technology as an answer to the challenge of costs in health and medical care, and (2) to propose as a primary area for research, development, and analysis, review of the multiplicity of technology already available. I agree that consideration of mode of payment for health care is important, and that there is a need to consider regulation to assure quality and consistency with our national ethic -- but just as computers are only hardware and not the only consideration when we think of automation or technology, the mode of payment is only a tool. Making the best computer or the best system to pay a bill will not improve health or medical care -- only gradually correcting or improving the process that is used with that piece of hardware, or with the payment system will. This tells us that the mode of payment for health care will be more cost effective, if it pays for optimal health care delivery which, I believe, can be achieved in today's era, only through the utilization of technology, that is the utilization of the art and science of industry.

To best know what to improve or correct in the process, one must know the limitations. That is the next stage of significance and the second theme that I would like to emphasize this morning. To utilize hardware, one must know the conceptual limitations of that hardware.

**TYPES OF COMPUTER LIMITATIONS**

Computer analysis of many medical parameters is now commonplace. However, the practicing physician should be aware of certain limitations of computer performance. There are four general orders of limitations.

First-Order Limitations

First-order limitations are those based on hardware (computer memory, etc.). The computer may not allow us to store, retrieve, or analyze as we would wish. This is generally more an economic than a real technical limitation.

Second-Order Limitations

Second-order limitations are those resulting from errors in programming. Sometimes errors are due to lack of comprehension on the part of the programmer; or, they may be errors similar to those made by a typesetter. Second-order limitations (if they are the result of a programmer's poor comprehension) are easily noticed in illogical output displays.

But sometimes output errors are subtle and can change the meaning of the output without our being aware of the error. This is particularly true when minor errors are made, so that one number or decimal can be shifted in a rarely occurring circumstance. Often months or years pass before it is possible to catch these errors. They may be found more often by opportunistic than deterministic events. The physician can do little more than know that such exist and (as for every laboratory test) exert his or her own quality control to avoid becoming subject to them.

Third-Order Limitations

A third-order limitation is dependent on the ability of the computer to abstract the data to be used in measuring -- data
such as electrophysiological signals. The method for determination of the waveforms in a medical signal might pose the limiting factor in such a case. This potential limitation is tied to the background know-how of the programmer designer, suggesting that a professional programmer/engineer with an interdisciplinary mind should do the programming.

Avoidance of third-order limitations is the difficult area in the mechanical aspects of computers in medicine. Avoidance depends on an integrated knowledge of what is desired at the output criteria stage; the hardware characteristics of the computer; and methods of determination, which might involve statistics, mathematics, or pattern recognition. Clearly, until we know everything there is to know about the details of these aspects and other developing fields, there will be errors in output which may be deceptive.

What is desired is clinical accuracy and not research precision. Hence, to avoid third-order limitations, the physician must ascertain (a) that the programs are intended for routine clinical use, developed under guidance by experts who are aware of clinical practice, (b) that they have been evaluated for clinical use, and (c) that the programs have the qualities found in industrial products and not in research laboratories.

Fourth-Order Limitations

Third-order limitations could be markedly affected in a beneficial way if fourth-order limitations were removed. This last area where the physician/researcher should play the greatest role in the work of computer use in medicine. The fourth-order limitation is dependent on the clinical criteria used to handle the raw data. It is generally as a result of review of this area alone that the practicing physician will indicate that a program is right or wrong, good or bad.

This fourth area is the simplest area to redefine and to correct in the computer system if (a) medicine has defined it, and (b) the physician has realized his human variability when he operates on the same data, i.e., attempting to use the same criteria as the computer used it. A number of fourth-order limitations will be rapidly obliterated as criteria become more standardized and agreed upon. The interface actions of the researcher with the practicing physician can markedly help in this and need reemphasis. Of course, some clinical problems are too complex to expect today's experience, judgment, or intuition to suffice for precise codification into any computer program.

ANALYSIS SYSTEMS

Most automated analysis systems are examples of one of three classes of technology. The first is a manual system (such as the ECG) that supports the acquisition, recognition, interpretation, use, storage, transfer, and updating of patient-based data. This man-machine system, used for decades, now can be considered inadequate for the provision of medical measurements.

Semi-Automated Systems

Introduction of a digital computer into the measurement system converts it into a semiautomated system. With a semiautomated system, the experience of specialists can be brought immediately to every patient's bedside. Medical signals can be transmitted directly to the processing system by telemetry devices or by hard wire and indirectly by tape or another transfer medium. This second class of system can analyze signals instantly, and results can be displayed on a variety of output devices.

Fully-Automated Systems

The fully automated system is the third class of medical measurement system. Such a system, which can in part operate without direct human intervention, exists only in carefully controlled, developmental situations such as in the monitoring of post-surgical patients, where certain programmed decisions are initiated automatically (triggered by patient-emitted signals), properly recognized, and interpreted. For example, a fall in blood pressure, an increase in pulse rate, and a decline in urinary output -- all signals that can be detected by automated instrumentation and interpreted as indicative of shock -- can lead automatically to an increase in the electrically controlled infusion rate of blood transfusion.

Computerization of ECG analysis led the way in automating data received directly from the patient. Now, there are perhaps 50 regional groups in the United States providing partially or completely automated electrocardiographic processing on a supplier basis to providers of care. There are numerous studies of diagnostic capability, accuracy, and reliability of automated ECG.
Of utmost significance is the value of computer ECGs in predicting disease. For example, the computer initially interpreted tracings in one population we reviewed as showing a 26 percent incidence of ischemic heart disease, an incidence far higher than that obtained by human readers' interpretation. Five-year followups of cases classified as infarct by computer and not by cardiologists showed very high predictive value. Thus, the computer was not false-positive, but prepositive in many cases. This suggests that one should take great care before dismissing a false-positive computer diagnosis.

The analysis of other physiologic signals can be automated in the same way. The ECG was chosen as the first signal for automated recognition and interpretation of patterns because physicians were familiar with it and because they had 50 years of experience relating its waveforms to specific clinical means; but almost any other physiological signal (e.g., electroencephalogram, spirometer, phonocardiogram) could have been chosen as an initial effort. Many have since demonstrated that each of these signals lends itself to automated measurement and interpretation.

Continued refinement of the computer software, and miniaturization techniques and electronic advances have led to the marketing of a variety of systems that incorporate many cumbersome steps into small, portable instruments that acquire, measure, and interpret the signal and produce a graphic or hard copy result. In addition, entirely new diagnostic and monitoring devices, such as computerized tomography, have within five years been developed and widely distributed.

Automated Signal Analysis Systems That Support Managerial Decisions

Most systems that support clinical managerial decisions are designed on the assumption that the critical deficiency under which clinicians operate is the lack of relevant information. However, the most important deficiency from which clinicians suffer is rather an overabundance of irrelevant information. Failure to recognize this distinction in system design is critical. If one sees the clinician's need as the choice of optimal actions in various clinical situations, then the system design ought to change the emphasis from providing all the relevant data to discarding the irrelevant data. The most important function of the latter is the condensation of data by data reduction and filtration.

The application of computer-based technology to clinical medicine has been hampered in the past by inattention to the definition of discrete, project-oriented tasks, by the lack of a suitable basic science to support the managerial decision making processes required, and by a scarcity of medical personnel trained and educated in the science of automation.

Among potential benefits of automation are: (a) improved legibility, accuracy, and precision of observations and results; (b) standardization of terminology and format; (c) increased accessibility and availability of patient data for the decisionmaker; (d) reduction in observer variation; and (e) provision of individual and collective patient records with multiple observation in manageable form so that patient-derived data can be used to satisfy a wide range of administrative and clerical needs including billing, status reporting, and the provision of basic data for peer review. Properly structured, an automated system can support internal efficiencies in staffing, skill transfer, and facility utilization that, together with the provision of an improved patient data base and continuity of clinical observations, can lead to a more effective product -- improved patient care-- and cost effectiveness.

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