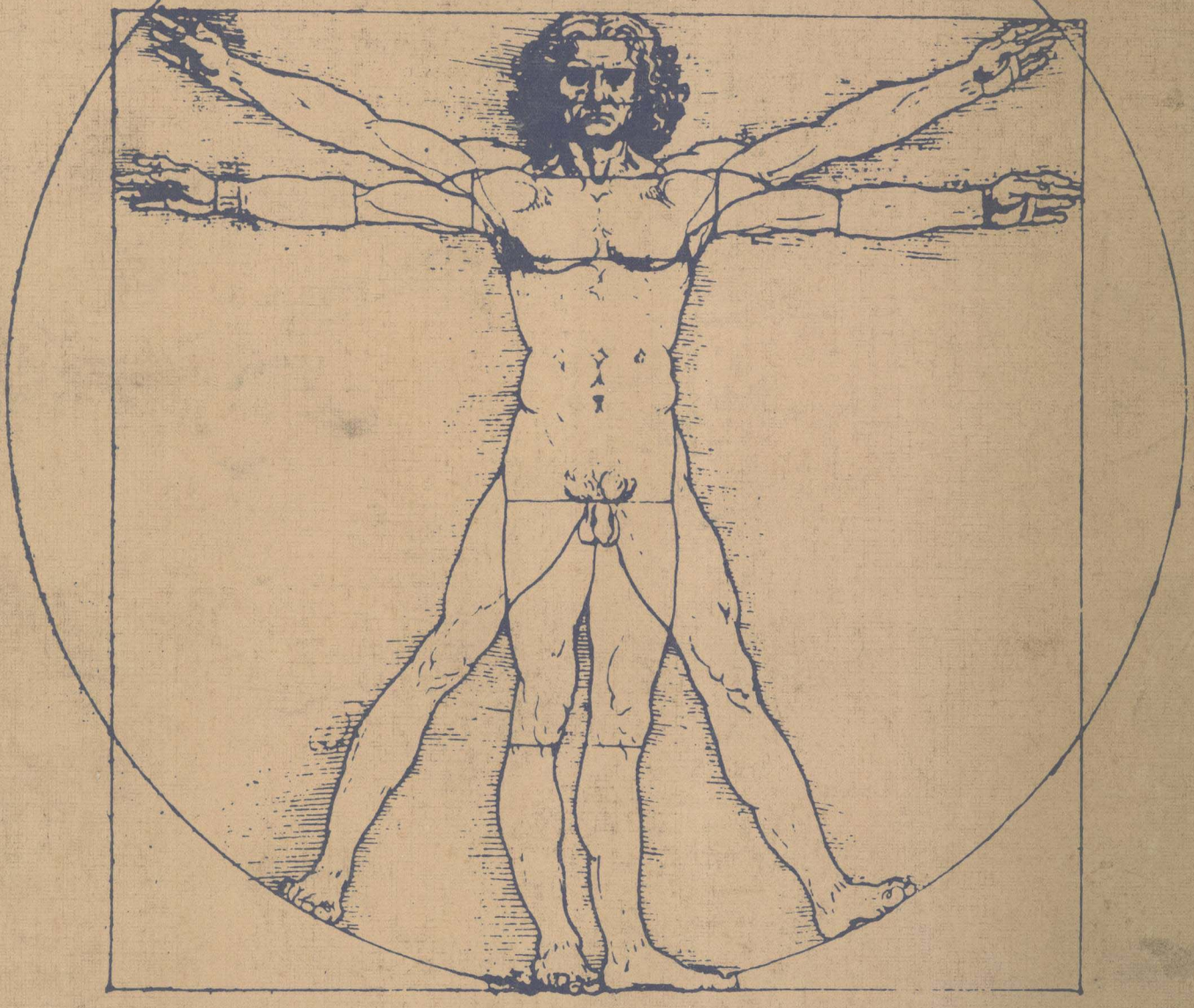
COMPUTERS and MEDICINE



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INTRODUCTION

The application of computers to medical problems dates back to the dawn of the computer revolution. In fact, one of the first large-scale applications of punched card processing was for medical records, during World War I. As the complexity, cost, and dynamics of health care increased, computerized solutions evolved as the natural approach. Nevertheless, the use of computers in medicine has been far from universally successful. Too frequently, the level of expectation has far exceeded the practical reality.

This book was prepared in the hope that an organized presentation which highlights the areas, techniques, and potential problems of computer applications in both clinical and administrative medicine will improve the situation in the future.

The book is divided into eight chapters. Each of the chapters deals with a vital, current area of medical applications. The papers were chosen to provide the reader with a perspective on the state-of-the-art in that particular specialty or application. The authors' commentary was designed to offer an overview and orientation for the material. When appropriate, additional references are included. The editorial viewpoint was to treat the field realistically, even if the results tend to "deglamorize" the computer. The field of medical applications of computers is already saturated with over-sold, under-performing systems.

Despite the setbacks and failures, the computer has made unique, innovative, and even dramatic contributions to medical care and delivery systems when the application was well designed and properly executed.

This work is the result of the authors' conviction that the sophistication of medical practitioners and the maturity of the computer industry will allow both groups to profit by the knowledge of past mistakes and successes. Its aim is to acquaint the first-time computer user as well as the expert with the nature and application of computers and computer based systems in the field of medicine.

The authors firmly believe that the application of computers to the field of medicine may well be the most valuable use to which the computer has been put. We trust that you, the readers, will prove us correct.

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CONTENTS

CHAPTER 1

Physicians, Patients, and Computers — An Overview

The impact of computers on day-to-day life over the past two decades has been enormous. Applications of computer technology range from the esoteric to the mundane, from space flight to company payrolls. Accomplishments beyond the capabilities of the brightest, most diligent people are performed by computers in minute fractions of a second. These feats have not been overlooked by the medical profession. Physicians and computer scientists alike have sought ways to bring the power of the computer to bear on the complex problems inherent in modern medicine. This book is a testament to the achievements already historic and to those yet to come.

In Paper 1.1, Friedman and Gustafson acknowledge these achievements, but they state that "the overall impact of computers on health care delivery has been less than . . . expected". Why? The answer to that question is both complicated and incomplete. The authors list several key factors that have contributed to this state of affairs. Particularly significant are: 1) the failure to provide systems whose capabilities exceed those of the physician; 2) the failure to prove computers have had a significant positive impact on health care; 3) the failure to provide computer applications in areas where their use would be most beneficial.

Glantz amplifies some of these themes in Paper 1.2. He also notes the tremendous electronics market that clinical medicine is coming to represent. The economic pressure to serve this burgeoning market, however, often leads to new technologies being applied piecemeal or in situations where their utility has not been fully evaluated.

Both these articles emphasize that medicine is an area in which indiscriminate computerization will not guarantee improved health care. Having been warned, therefore, as to why computerized systems have been unsatisfactory in the past, we will turn our attention to analyzing the computer systems presented in the remainder of this book. If the system fails to meet the criteria Friedman and Gustafson and Glantz have laid down, chances are it will be of limited clinical use. On the other hand — and this is more difficult to quantify — the mere act of computerizing a process may force a more rational, standardized approach to that process. This is a real benefit that computerization can offer.

Paper 1.3 by McDonald reports on a system which measures up to the criteria we have just discussed; namely, a system that can exceed the capabilities of the physician utilizing it, and it is applied in a setting where it can be most useful. The system under study monitors physician behavior in an outpatient clinic and indicates any errors or oversights on the part of the doctor. The program scans each medical record for possible drug toxicities or abnormal test results, in addition to several other programmed situations, and then outputs a "reminder" to the physician if action is required. Physicians showed a significantly higher response rate to these potential problems when the computerized reminders were given than when they were not. Key features, in light of the previous article, of this system are: 1) the computer is better able than a physician to survey an entire record, without overlooking anything, in a short time span; 2) the computer-generated "reminders" led to *clinically* important alterations in physician behavior; and 3) the system is used in a setting which affords physicians maximum usefulness. This last point is a consequence of the inherent level of unfamiliarity that physicians rotating through a clinic will have with the patients, and the brief interval of time available for studying charts. This type of system would probably not be as useful to a physician with a small private practice he or she has been following for many years. McDonald has further analyzed physician response to this system in a subsequent article (Ref. 1-1).

Obviously, the *raison d'etre* of computers in clinical medicine is to improve patient care. The issue of patient acceptance of computers in medicine is examined in Paper 1.4 by Slack

and Van Cura, who document patient reaction to interviews conducted by computer and compare it to reactions to interviews by doctors. While not designed to prove the superiority of one or the other form of interviewing, it does provide an index of the acceptability of computers among patients (both hospitalized and out-patients). The patients found the computer to be a very acceptable history-taker, and some preferred to confide personal information in the computer rather than the physician. The results indicate no evidence of an inherent bias against the computer among patients tested. This is important in view of the potential to view computers as leading to a "dehumanizing" of medicine. (Ref. 1-2).

A less immediately obvious part of the big picture is the medicolegal impact of computerized medicine. This has been examined by several authors (Refs. 1-3, 1-4), and a full discussion of this issue would be beyond the scope of this text. Suffice it to say that in the legal sense as well as in every aspect of medicine to which they are applied, computers must not be expected to replace humans, only to complement them.

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Computers in Clinical Medicine, A Critical Review
R.B. Friedman and D.H. Gustafson
Computers and Biomedical Research, Vol. 10, 1977
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1.1

A recent solicitation for grant proposals by the National Institute of Health for Computer Laboratory Health Care Resources contained the following preamble: "Computer technology and information science have been applied with recognized success to many areas of modern scientific and industrial development and have been a major determinant in accelerated pace of advances in physical and basic sciences. However, critical applications in the area of medical and health care, although frequently supposed and increasingly attempted, have been disappointing in their impact on the health care system" (*1*). The failure of computer impact on health care delivery alluded to in this statement has been far from complete. The progress in Hospital Bookkeeping, Clinical Laboratory Automation, and Computerized Axial Tomography has been significant and many hospitals throughout the country utilize computers in one of these capacities. The impact of computers in radiotherapy, ECG analysis, and physiological monitoring is also well documented. Successful applications in many other areas have been reported but the overall impact of computers on health care delivery has been less than was expected as recently as 5 years ago.

What then have been the impediments to a more universal application of computers to medicine?

(I) We have not successfully accomplished the patient–computer and/or physician–computer interaction.

In medicine we are dealing with very special populations. The patient who is frequently uncomfortable, anxious, depressed, or incapacitated, and the highly trained physician who is often busy with no time to learn how to operate a new device.

In trying to connect these two very different populations to the computer, investigators have utilized punch cards, mark–sense forms, terminals, voice response systems, and microfilm. The encounters have been accomplished via a telephone at home, terminal at the doctor's office, or directly at the computer console. The interface has been in dark rooms, light rooms, quiet rooms, and noisy rooms for short periods or for long periods.

There can be no question that the computer–user communication has been accomplished; what is questioned is whether this has been successfully accomplished. Almost no data have been collected comparing or contrasting different methods of computer–user interaction. User satisfaction during an initial encounter has frequently been the only factor evaluated and often the most glowing reports came from projects later quietly abandoned. Our own experience indicates that the main impediments to a successful computer–physician and/or patient–computer communication have been: (1) Many computer terminals have been poorly engineered, resulting in mechanical breakdowns. (2) The computer terminals have often been placed in out-of-the-way places making them inconvenient to operate and useless for rapid data retrieval. (3) The computer response-time often has been quite slow because of low-speed teletype output (10 characters/sec) or excessive delay between responses (over 3 sec). (4) In order to obtain information from the computer the physician has often been required to take part in a long and complicated technical dialogue (sign-on codes). (5) The use of computers has often required knowledge of special passwords, codes, or computer languages. (6) Computer terminals have been expensive and this has made it difficult to develop accessible yet cost-effective applications.

(II) The physician has not been provided with computer-based medical applications that exceed his own capabilities.

The great majority of computer applications to medicine attempted to date have been excessively modest in scope. Where in other fields the computer has been utilized to perform tasks previously incomprehensive to mankind, in health care delivery we have been quite satisfied to merely duplicate the physician. In mathematics, physics, banking, space exploration, etc., the computer routinely is called upon to perform tasks that all mankind working 24 hr a day from creation could not begin to duplicate, but in medicine our measure of success is diagnostic accuracy approaching a skilled clinician, ECG analysis which is substantially correct, or historical data acquisition which saves the physician 5 min per patient. If our timidity were matched in other fields, it is very unlikely anyone could have justified the expense or efforts necessary in these more successful efforts. The disappointing impact of computer technology on medicine may have been caused by our inability to see beyond the single physician and, therefore, our inability to produce tools that do more than emulate the efforts of the individual physician. We have developed programs that have attempted to duplicate the physician; and then have been dismayed to find there

was no stampede to utilize these programs. When researchers developed a technology capable of seeing inside the body, developed a technology to measure the electricity of the heart, or developed a new antibiotic, there was such a stampede. No hesitancy about cost, justification, impersonal nature, or technicality.

(III) A major impediment of the successful utilization of computer technology in medicine and health care has been our inability to prove a significant positive impact on patient care.

While many applications developed to date, such as historical data acquisition, computer-assisted disease diagnosis, ECG analysis, therapy, consultation, etc., appear intuitively to be of great value in improving patient care, no hard evidence has ever been presented to support this thesis. As other studies have indicated, this inability to demonstrate a definite potential for improving health care delivery prior to the wholesale introduction of a new technology has been a serious problem in all areas of health care delivery. We have been able to demonstrate the reliability and validity of information collected by computer-based patient interfaces. But we have not demonstrated that providers can make better or less costly decisions because of it.

The cost effectiveness of many computer systems is never investigated, much less demonstrated. Part of the problem may lie in the relative isolation with which computer researchers function. They are often not part of an interdisciplinary team and have little appreciation of those skills necessary to bring about change. These include how to create a climate for change, how to involve users in the reexamination of the problem, how to show the field it is really better off because of the computer system, and how to gain wide acceptance of a new system. These limitations have resulted in the expenditure of large sums of money and effort on innovations that at first appeared to hold great promise for improved patient care, but which in practice had little or no clinical impact. For computer technology, this inability to demonstrate the potential for significantly improving health care delivery is particularly damaging, since introduction of computer-based applications requires a large investment for equipment and personnel. Is it unreasonable to expect resistance to change under these conditions?

(IV) We have not produced applications that are easily transferred from one institution to another.

Unlike the business community, where IBM equipment accounts for the vast majority of computing equipment, or the large governmental scientific projects where directors can mandate a single computer language or computer system, the medical community has been strongly independent in its choice of computing systems. Consequently, we are faced with a disorganized array of computer languages and computer systems dedicated to medical applications.

Almost all medical applications begin as research efforts. Considerable expertise goes into designing systems that run on the smallest possible machines and utilize

the more economical *lower level* machine languages. This further hampers inter-institution transfer. While more recently there has been an effort to select MUMPS (and the Digital Equipment Corp. PDP-11, PDP-7, and PDP-15 computers) as a standard language of medical computing. This effort remains embryonic. Promising applications at one institution are not easily transferred to another, so multiple users hesitate to share development costs.

(V) We have not conducted research in a manner that is change oriented.

Since it first entered the health field, the computer has been portrayed as (among other things) a tremendous way to collect and store data. This is certainly true but it may have also proven to be a partial cause of the computer's failure. Researchers have developed systems to collect data rather than improve decision making. A good example is the medical record. Several attempts have been made to automate it, yet very rarely have there been attempts to determine beforehand how the resulting data would be used. As a result, millions of dollars have been spent on the development of systems whose eventual use never justified their initial cost. In a few cases, clinicians first determined those factors which limited their ability to prevent, diagnose, and treat disease, then decided how to reduce those limitations, and finally identified the role the computer could play in assisting them to overcome these limitations. In those cases the results have been impressive. It is the thesis of the authors that computers cannot be used successfully as long as computer scientists function apart from the needs of the users. They must begin to view the computer as one, but only one, possible solution to the problem. They must begin to function as part of the problem-solving teams where the computer is used only after it has been chosen as the best tool to solve the problem at hand.

Research into successful social change supports this view (*2*). Successful innovations are characterized by user identification of the problems. Computer research is characterized by computer scientists (who do not deliver health care) working on solutions to health care problems without drawing sufficiently on the advice of actual providers or potential users. Successful change is characterized by clearly understanding the problem first and then finally working out the best solution to that problem. Computer research has been characterized by people skilled in one solution (computers) searching for a problem to fit their solution. Finally, successful change is characterized by the development of a solution unique to the problem and environment at hand. Computer research is characterized by the development of relatively inflexible systems that are based on the concept that the existing system must adapt to the program rather than the other way around.

(VI) We have not learned from previous mistakes.

The application of a new technology to the battle against disease has always been good copy. The application of computer technology to health care delivery has been

no exception. The development of each new application has generated considerable interest both in the scientific and lay press. Unfortunately, this atmosphere has generated pressure on researchers to publish articles on each new application long before such programs had demonstrated their long-term viability. This rush to publish has resulted in literally hundreds of reports on applications long before they had been adequately field tested. As a consequence, the majority of projects in the area of Computer Applications to Medicine, once reported, subsequently prove to be impractical, too expensive, or unacceptable. Unfortunately, there have been very few follow-up articles detailing the reasons for these failures. Certainly some of the responsibility for this failure to communicate negative follow-up information rests on the author's natural hesitance to be associated with an unsuccessful effort. However, much of the blame must rest with those journals that are quick to publish the latest computer novelty but are very reluctant to publish responsible negative follow-up studies. A graphic example of this can be found in the area of computer applications to the acquisition of Medical History Data. Numerous groups across the country have worked and published in this area, often duplicating previous efforts. However, although the great majority of these efforts have since been abandoned we could find no publications detailing the reasons for these failures.

In most cases researchers are quite willing to discuss the reasons for their failures. The problem is that there is no forum for such presentations. In an attempt to gauge the difficulty of gathering retrospective data, we searched four major journals (*New England Journal of Medicine*, *Journal of the American Medical Association*, *Annals of Internal Medicine*, *Archives of Internal Medicine*) for all articles dealing with computer applications to medicine published during a 5-year period. We found 32 articles that presented applications of computers to medical problems and sent a 1-page questionnaire requesting follow-up data to the principal authors of each article. For 51% of the projects reviewed, the work detailed in the article had either been abandoned or temporarily stalled. In only 19% of the cases was the program now in routine use at their medical center. In the majority of the cases (63%) the authors felt the work had lived up to their initial expectations, yet over 41% of these projects were now unfunded and only 18% were funded out of direct patient fees or hospital funds. In almost every case where the project had been abandoned, the researchers indicated that this had occurred because the project never became cost-effective and when research funding ran out the hospital would not assume the funding. For those projects that the authors indicated were successful and were now funded from patient or hospital fees, the authors uniformly reported that they had begun with a limited well-defined goal and that the project had consistently remained cost-effective.

Computer technology has already changed the posture of modern medical practice; applications in laboratory automation, on-line patient monitoring, and computerized axial tomography have resulted in whole new fields of medical expertise. Progress to date may not have been as rapid as some might have hoped,

but given the long history of medicine and the short tenure of computer technology, the advances have been truly significant. The failures to date may have been the result of initial physician or patient resistance to a new technology. More likely, they were victims of one of the six pitfalls highlighted in this paper. If each new application is first examined for these potential deficiencies, perhaps further nonproductive efforts can be avoided.

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