THE IMPLEMENTATION OF COMPUTING SERVICES IN A MEDICAL RESEARCH ENVIRONMENT

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ABSTRACT

The process of implementing computing services into any medical research environment is a complex assortment of definitions, staffing, equipment, funding and political factors. The importance of defining one's needs is uppermost. Without clearly stated terms of reference, the foundations of any computing facility vacillate, the consequences of which can be calamitous.

With firmly established objectives, a Director initiates procurement of the equipment required to satisfy the specific needs of investigator-users. The choice of equipment is almost solely dependent on the type of services to be provided. A simple batch terminal to an existing computer does not require the same expertise as a real-time, on-line computer system. The latter demands a staff of intelligent, well qualified individuals, versed in operations, education, statistics and systems software.

Although each type of staff specialist is vital to the success of a facility, the educational group can produce the greatest results. The dirth of health professionals knowledgable in computing techniques is one of the greatest barriers to the successful implementation of computers in the health care system. The problems of the health care system are many and cannot be solved by computer scientists or data processing experts. These disciplines can be of valuable assistance, however the impetus must come from those who control the medical process.

Significant amounts of funds are needed to staff and equip any computing facility. With the decreasing emphasis on basic research, subtle encouragements to study the problems of the health care system are being generated by numerous funding agencies. This thinking cannot be ignored if a viable, permanent biomedical research computing facility is envisaged.

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I N T R O D U C T I O N

"Computers suffer from the same difficulty as electron microscopes, recording spectrophotometers and multichannel pulse height analyzers, i.e. everyone wants one."

Saenger, E.L., Sterling, T.D.
Annals N.Y. Academy of Sciences
Vol. 115 - 591-599, April 1964

A. THESIS STRUCTURE

Establishing the guidelines as to how biomedical computing facilities can service this desire is the primary goal of this dissertation. That computers have arrived, are currently being used in many basic and clinical research applications and will become integrated into the health care system is taken for granted. Not taken for granted, however, is their role in direct patient care; the areas in which they can be most efficiently applied; and the related costs involved.

Many investigators have had access to or have made use of a computer over the past fifteen years and the results of their work is well documented. The 1969 issue of cumulated Index Medicus contained over 900 citations related to computers and data processing. The fact that a significant portion of these papers are highly research oriented attributes to the arrival of the computer as a tool in medical research. However, much controversy is centered about the lack of progress in applying computers to the care of the sick. A well known authority (W9) has written that the purpose of any research in medicine is to find new relationships and refine knowledge of already known relationships among the elements which constitute living systems and to find better ways of using this knowledge for prediction and control of living systems. As medical research must, in the end, justify its existence by contributing to health care delivery, the tone of this work, though research oriented, is slanted to the implementation of computing services which will have an indirect if not direct benefit on the nation's health.

To paraphrase Hamming (H4), it would be more satisfactory and certainly much easier to discuss one small technical application of computers in medicine. However, there exists a danger of getting lost in the details of a singular problem expecially in the veritable blizzard of papers appearing each month. Narrower and narrower specialization is not the answer. A good part of our difficulties is in the rapid growth of the interrelationships between medical research, clinical medicine and computing science. There is a pregnant analogy in the words of a FORTUNE editor (W8) who wrote "....the root cause of our abuse of the environment: in modern society, the principle of fragmentation, out-running the principle of unity, is producing a higher and higher degree of disorder and disutility."

The material for this work has been gathered from four years of experience in the field, as well as an extensive review of the literature on the subject. A MEDLARS search of 1968 - 1970 publications related to medical use of computers extracted 729 citations, less than 3% of which were directly relevant to the thesis topic. Information received from over 60% of the medical schools in the United States has provided unpublished statistics in the form of annual reports, grant proposals and task force recommendations. Personal visits to over a dozen medical computing centres as well as personal communication with some seventy individuals complete the sources of information.

In order that the reader understand the scope of the thesis, the next section outlines the assumptions under which it was written. The limitations imposed by time and academic considerations are also presented. A comprehensive analysis of computer applications in medicine is not intended. Rather, the pertinent factors to be considered in establishing a biomedical computing facility are outlined and discussed. The findings will be of most benefit to those individuals responsible for or involved in the implementation of computing services in a medical research environment.

Chapter 1 unfolds as a brief history of early biomedical computing and reveals that, clinically speaking, little has changed over the past fifteen years. Chapter 2 suggests the foundations and principles upon which a medical computing facility should be laid. It stresses the importance of clearly specifying and defining what type of research the facility is to service. It further concerns itself with the variety of equipment available to meet the variety of research applications present in most medical schools. Arguments that no one computer can service this variety of needs are presented and the suggestion of a hierarchy of computers is outlined.

The staffing requirements, based on the findings outlined in Chapter 2, are the contents of the third chapter. The inter-disciplinary role of any computing facility and the need for capable management is discussed in depth. The political and non-political aspects of financing a computing facility are covered in Chapter 4, including the need to continually assess what investment in dollars would be needed to achieve stated goals and to predict the ultimate value of the investment in advancing medical research and the delivery of health care.

An introduction to a few of the problems of computing in the wider "Health Sciences or Medical Centre" complex concludes the work.

B. ASSUMPTIONS

Avoidance of some technical computer terminology is not possible although it has been kept to a minimum bearing in mind that the text was prepared for an audience of senior medical administrators.

The first assumption made is that the facility being discussed is organizationally within a university medical school. This premise can be extended to include a facility in a medical centre affiliated to a number of hospitals and research institutes.

A "central computing facility" concept has been adopted and is clarified in subsequent chapters. It is assumed that there exists a need to provide some integrated or co-ordinated approach to the computing services of a medical institution. Hence, all discussions pertain to a multi-departmental computing facility - not a smaller laboratory machine, although the centralized facility may encourage installation of other computers in laboratories or departments.

In order to clear up semantic differences, the term "small computer" refers to that class of machine which have 16 - 18 bit word lengths, has a maximum of 65 thousand words of core and cycle time in the order of 1 microsecond. Sometimes called, "process control" computers they differ from other similar computers by virtue of their memory protection and direct storage-access features which enable them to multi-program and time-share.

For compactness the text contains statements referring to the Dean of a medical school. These can easily be related to the Executive Director of a medical centre or any other similarly placed official. Dollar figures within the text are Canadian although the built-in error of such predictions negates any great difference. All references to the male pronoun "he" can be freely translated to "she" if so desired. Finally, it is expected that not all readers will agree with the findings and that discussions will arise therefrom.

C. LIMITATIONS

Although one should not isolate biomedical research computing from the total health field, certain limitations have been imposed on this work. The many varied and intertwined aspects of hospital accounting and administration are not covered. Many existing biomedical computing facilities process both research and administrative matters and some controversy exists as to the effectiveness of such an organization (L3, P2). One hears a similar debate in industry that accounting jobs are more important than scientific development ones. Although the issue is brought up, no in-depth analysis of the problems is given.

The computer oriented clinical service aspects of a hospital such as the generation and retrieval of automated medical records, capturing of patient histories, laboratory systems, multi-phasic screening and electrocardiogram analysis are also mentioned but not covered in depth. Although analog computers are being used in medical research, their numbers are few and their applications limited, hence, they are not included in this work.

No one specific application is pursued in great detail nor are the sometimes unique problems related to the general practitioner focused upon.

The philosophical arguments that "doctors are not properly trained to use computers", the lack of standardized terminology; existing emphasis on the memorization of numerous facts and the lack of unique identification of all individuals are considered but only in the general context of education as opposed to the live problems encountered in implementing hospital oriented clinical systems.

Detailed information as to the physical dimension of computers; their heat, space and electrical requirements; arguments for and against the leasing/renting, importance of accessibility; the planning of proper working conditions, and the many day to day aspects of operating a computing facility is not given. These topics are well documented in the general computing and management literature and the points to be considered are no different in medicine than in any other field.

Although the need for capable management is stressed, proven management and administrative techniques are not discussed. Matters concerning the medico-legal aspects of confidentiality of the patient record are not brought up nor are the related security systems needed to assure the legibility of both the originator and extractor of medical data.

C H A P T E R   I

H I S T O R Y

"The United States boasts of having the best medical care in the world. Yet this care is inadequate. A young house physician from one of our large metropolitan hospitals recently complained that he and two other doctors were forced to see and treat 180 patients in the course of a 3 hour clinic. The expanding demand for medical services that has resulted from Blue Cross and similar prepaid medical care plans, cannot be met by our present facilities with present methods. To establish a diagnosis, takes too long. Co-ordination of the efforts of those responsible for various care is too haphazard. All our work is piecework and it is all done by hand."

Duncan A. Holaday
Science, Vol. 134: 1172
October, 1961

To cite at length, the pioneering efforts of biomedical computing would reveal what areas of medical research were first to explore the use of a computer as a new scientific tool. Such an account would be of minimal practical value, other than providing an interesting exercise in learning the reasons why the military consequences of World War 11 started it all. However, to sample the thinking and philosophies which were prevalent in the late fifties and early sixties might be of some benefit. Their content is enlightening to say the least.

A. PRE-FIFTIES

Prior to 1950, digital computers were relatively unknown to medical research. Gibbs and Grass (G3) had developed in 1947, mechanical devices to integrate and frequency analyze electroencephalogram samples. Others such as Hessburg and Burch (B4) used analog computers to conduct similar studies. The famous Cornell Medical Index questionaire to collect self-administered, medical and psychiatric data without physician participation had its initial beginnings in the late forties (B6, B7).

By the mid-fifties, an expanding interest (L7, M5), in the use of electronic devices to study the low signal amplitudes of the human body was apparent, stimulated in part by the work of Schmitt and his colleagues who used computers to suggest biological servomechanisms for certain features of vector electrocardiograms (S10).

The punched card system of data processing was invented in 1889 and by 1936, Atanasoff (A3) was using cards to assist in the study of complex optical spectra. In 1943, Black-Schaffer (B5) designed an elaborate (and surprisingly modern) Hollerith punched coding scheme for syphilis studies. This technique was used by others (H5, R7) although in some cases, the cards were "marginal punched cards" which were separated by rods and could be only loosely defined as being automated (L6). By the late fifties, more computer-assisted work was underway and one could find 15 citations under automated data processing in the 1960 issue of Cumulated Index Medicus. By 1965, there were more than 35 biomedical computer facilities in the United States, dedicated to research studies (A4), and over 450 citations in Cumulated Index Medicus were related to the subject.

This exponential growth in published material is most encouraging if one looks upon the computer as a powerful tool which has helped in the advancement of medical research and medical cures of human illnesses (AN5). One the other hand,

"During the last decade, there has been increasing awareness of the need for improved techniques in handling clinical research data."

This rather general statement appears quite often in today's literature and could be construed as prophetizing the role of computers in clinical medicine for the seventies. Yet, the quote is taken from the May 7th issue of J.A.M.A., 1960 (S11).

B. LATE FIFTIES AND EARLY SIXTIES

In July of 1959, Ledley and Lusted reported (L8) that before computers could be used as an aid to the medical diagnostic processes, much more needed to be known about how the physician makes a medical diagnosis. No one was arguing that complex reasoning processes were involved. It was widely believed that errors in differential diagnosis resulted more frequently from errors of omission than from other sources. A few months later, Ledley (L9) discussed the great advances in medical knowledge which had not been matched with a parallel advance in making this knowledge available to the practicing physician. He pointed out that the media for exchange of ideas had not yet been adequately developed and that most communication amongst researchers took place at conferences and symposia. The inability of the overworked practising physician to attend such meetings was not mentioned but no doubt was implied.

A 1961 editorial (AN6) pointed out that the thorough system review required to capture, analyze, and act upon patient data may too often be eliminated because of impatience on the doctor's part or because evaluation of the diagnostic implication of many seemingly unrelated symptoms detected is a difficult exercise in logic. It was suggested that a computer might be used to evaluate the information collected through a .careful system review by a physician whose only concern would be the accurate determination of the presence or absence of a discrete list of symptoms and signs. Diagnosis might then be improved.

Considering the $19 billion spent on biomedical research in the past 10 years (Figure 1), the suggestions of the early sixties do not appear to have been heartily endorsed. A cursory scan of almost any given journal, reveals suggestions of an amazingly similar nature.

The reasons for this are not straightforward and are in part due to the highly conservative motives of medicine and to the oversell of the early sixties. The advocates of "hospital information systems", "clinical management information system", "total general information medical processing systems" were listened to, funded and trusted. Unfortunately, these individuals for the most part had succumbed to pressures of modern advertising and to the subtle marketing tactics of computer manufacturers. They were not those concerned with the problems just cited. They refused to accept the principle that medical objectives were not clearly formulated and hence, unacceptable to automated proceedures. Their "information systems" were more "patchwork quilts" which functioned, in many cases, only on the knowledge and inherent idiosyncrosies of several key clerical employees (J5).

Commercial and accounting-oriented computer specialists, as well trained as they might be, do not have the necessary background to successfully apply computing technology in the health sciences (S17, L18). As will be discussed in subsequent chapters, most successful applications of computers to date are in those limited areas the project leader has the highest level of medical competence.

The incidental, pedestrian programs which automate the inventory in pharmacy or prepare payrolls do not "turn on" the medical community (G2). It is of course quite natural, and useful, to use computers to perform existing tasks more quickly and comprehensively. But they will begin to improve things really dramatically only when existing processes are reconstructed to take full advantage of the capabilities of computers (N6).

Some comfort may be had in the knowledge that in the past, any new technological advance has been initially rejected and feared: rejected because of the belief that it could not work as well as existing devices; feared because of the suspicion that it might (F8).

	60	61	62	63	64	65	66	67	68	69	70
Health Services	27	(29)	(31)	(33)	(35)	36.8	4.1	46.7	52.4	(56)	60
Biomedical Research	0.8	(1.0)	(1.2)	(1.5)	(1.7)	1.8	2.1	2.3	2.4	(2.5)	2.7

Notes: 1.( ): indicate estimate

2. Source: B1

Figure 1.

Aggregate U.S. National Health Expenditures by Type of Expenditure for Calendar Years 1960 - 1970 in Billions of Dollars.

C. SEVENTIES

One would expect, nevertheless, that much has been learnt during the relatively static growth period of the sixties. That the advice of the intellectual and experienced leaders of today will be acted upon, can only be hoped for. Alarm about applying computers in medicine, fully justified by the facts and long overdue, is a required precondition of reform. But alarm, by itself, puts out no fires (W8). The suggestions being currently made, are not easily digested for they imply significant changes in medical education, the role of the physician in the cure of the sick and the funding of health delivery agencies. Yet computers are involved in the evolutionary process of social change and improvement. As they come to play a prominent part in the study of social and health care problems, it must be insured that they are used for the actual implementation of change, not as one more destracting influence. (F7).

The perfect analogy to the history of biomedical computing during the past fifteen years, is difficult to find. In some ways, one can consider the growth to that experienced by the teenager who from his/her thirteenth birthday, goes through a period of unknown adjustment, constant questioning and moral confusion. Upon becoming an adult, he/she then matures, prepared, trained, capable and wanting to make a contribution to society. The teenager's growth to adulthood spans a total of nine years. Biomedical computing has gone through fifteen years to date and has as yet to reach adolescence. Nevertheless he/she is becoming more mature.