Middle Articles

COMPUTERS IN MEDICINE

Relevance of the Electronic Computer to Hospital Medical Records*

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Summary: During the past 30 years an "information explosion" has completely changed patterns of illness. Unit files of individual patients have become so large that they are increasingly difficult both to store physically and to assimilate mentally. We have reached a communications barrier which poses a major threat to the efficient practice of clinical medicine.

At the same time a new kind of machine, the electronic digital computer, which was invented only 26 years ago, has already come to dominate large areas of military, scientific, commercial, and industrial activity. Its supremacy rests on its ability to perform any data procedure automatically and incredibly quickly.

Computers are being employed in clinical medicine in hospitals for various purposes. They can act as arithmetic calculators, they can process and analyse output from recording devices, and they can make possible the automation of various machine systems.

However, in the field of case records their role is much less well defined, for here the organization of data as a preliminary to computer input is the real stumbling-block. Data banks of retrospective selected clinical information have been in operation in some centres for a number of years. Attempts are now being made to design computerized "total information systems" to replace conventional paper records, and the possibility of automated diagnosis is being seriously discussed.

In my view, however, the medical profession is in danger of being dazzled by optimistic claims about the usefulness of computers in case record processing. The solution to the present problems of record storage and handling is very simple, and does not involve computerization.

Introduction

Last November Dr. L. C. Payne wrote (Payne, 1968) as follows: "Ten years ago the subject was bizarre . . . in ten years' time there will be the computer-assisted, the retiring, and the retired." This startling prophecy serves to emphasize the growing importance of the electronic computer in modern society, and it might be interpreted by many as confirmation of their optimistic belief that all the present problems of medical record handling and storage could be completely and swiftly resolved by computerization. They would be quite wrong for two reasons: firstly, because systems analysis (necessary before the computerization of any data procedure) has yet to reveal fully the exceedingly disorganized state of hospital medical records, and, secondly, because the potential usefulness of electronic computers in this field is still widely misunderstood.

Before considering the clinical uses of computers I shall first discuss briefly the nature of the machines themselves, and then define the main faults which now exist in case records. Thus I hope the issues will become much clearer.

Development of Computers

Computers are basically of two kinds—analogue and digital. An analogue computer is designed as a model, or analogue, of a multifactorial system, so that the effects of alterations of one or more of the factors in the system on the other factors may be directly observed and measured. This type of computer is irrelevant to our present discussion and need not be mentioned further.

A digital computer, on the other hand, is a machine which can store, collate, examine, and process any data which are presented to it in numerical form. Thus, obviously, it can act as a straightforward arithmetic calculator, but furthermore it can perform any data procedure provided it is supplied with the relevant data and the relevant rules of procedure, both coded in numerical form. As Laver (1965) pointed out, "The modern computer stands at the end of a long line of mechanical aids to calculation, and is distinguished from them not by any magical new method of reasoning or calculation but by being automatic, general-purpose, and fast."

The theory on which modern computers are based is not new. Blaise Pascal's mechanical calculator of 1642 performed subtraction by adding complements; and Charles Babbage, in the early 19th century, correctly reasoned that any decision can be analysed into discriminating between zero and non-zero, and between positive and negative (Payne, 1967). His failure to build his Analytical Engine was due to its being a *mechanical* digital computer. The first *electronic* machine was designed in 1943 by Eckert and Mauchley to calculate artillery firing tables for the U.S. Army, and was known as ENIAC (Electronic Numerical Integrator and Computer).

In 1946 Eckert, Mauchley, and von Neumann issued a design report on which all modern computers are based. It allowed for the actual operation instructions—that is, the program[1]—for any particular procedure to be numerically coded and stored within the machine itself. Since then progress in design has been fantastic. The first stored-program computer (known as EDSAC) was completed in 1949 in Cambridge University. It was followed in 1951 by UNIVAC 1, which was used by the American Bureau of the Census, and in 1953 by a modification of EDSAC, which was installed for office work in Lyons's Electronic Office (LEO) (Laver, 1965).

In these early days computers were large, fragile, and erratic. Just before 1960 they were followed by "second generation" machines, which were transistorized and were three times as reliable and 100 times as fast. "Third generation" models appeared about 1965: they were characterized by their modular design, and were 10 times as fast again, which made possible the facility of time-sharing.

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[1] Spelling defined by the British Standards Institution (1962).

The speed of performance of modern computers is measured in nano (10^{-9}) seconds and pico (10^{-12}) seconds. This above all is why they are unique, for they can observe and analyse the characteristics of a machine system so fast that the resulting conclusions can be used to modify that system *before its characteristics have significantly changed*. This is the concept of on-line real-time computation, on which modern space exploration depends, and which makes possible the automation of any machine system, automation being defined (Payne, 1966) as the partial or complete instrumentation of information for decision, adjustment, or control purposes.

Present State of Hospital Medical Records

In the past 30 years a tremendous growth of scientific knowledge has revolutionized medical and surgical treatment. Patterns of illness have consequently changed, and the medical records of individual patients now often relate to illnesses which last for many years and which may be treated at different times, even within one hospital, by clinicians of various specialties. Most British hospitals have now adopted the unit file system, which means that each patient in any given hospital has only one file, in which are housed all his medical case records originating within that hospital. Unfortunately, in many large hospitals even this modest attempt at record linkage has begun to defeat its own ends by presenting clinicians with overwhelming and ill-assorted masses of heterogeneous information which are fast becoming impossible either to store physically or to assimilate mentally.

In hospital practice we have now reached a communications barrier, which must, as a matter of urgency, be broken through (Levitt, 1969). In fact, I strongly believe that the most serious obstacle to the efficient practice of clinical medicine today, both within and outside hospital, is the difficulty of rapid and accurate communication of known facts about individual patients between one doctor and another.

Computers in Hospitals

Electronic computers are already being employed in hospital clinical practice in various ways (Taylor, 1967 ; Healy, 1968). Firstly, as arithmetic calculators they can, for example, rapidly determine optimum radiotherapy dosages for different patients (Payne, 1966). Secondly, they can analyse and process outputs from recording devices: thus in electroencephalography they can be used to demonstrate the presence or absence of wave forms which have major diagnostic and prognostic significance in psychotic illness and after strokes (Walter, 1969), and if problems of pattern recognition can be overcome computerized E.C.G. diagnosis may soon be possible (Favello and Giolito, 1969). Thirdly, they can be used to automate physical and biological systems: there are interesting possibilities here in laboratory work, anaesthesia, renal dialysis, and intensive-care monitoring.

As data banks of general clinical information, however, the place of computers is much less well-defined. Efforts to replace conventional paper records by a computerized "total information system" are being pursued in several centres, notably in the Karolinska Hospital, Stockholm. It is claimed there that the present medical records clerks will become both the secretaries *and* the computer operators of the future, and that case records in current use will be held on computer file, and will be efficiently displayed to, and updated by, staff of all departments concerned by means of peripheral visual display units (Hall, 1967). It remains to be seen whether such fantastically elaborate and expensive schemes to record current clinical data will be successful. The whole idea seems to me rather (as the Irish say) like buying a Rolls Royce to take the pigs to market.

Retrospective computerization of *selected* clinical data is an entirely different matter. It has been practised for hospitals throughout North America for the past 17 years on a fee-for-service basis by a large organization[2] in Ann Arbor, Michigan. Statistical analysis on a hitherto impossible scale has proved valuable for clinical research, medical audit, hospital planning, and so on. A somewhat similar though very much more limited data processing system is, of course, operated in our own Health Service by the Department of Health and Social Security in England, and the Home and Health Department in Scotland. Unfortunately, hospital activity analysis abstracts require a great deal of preliminary clerical work to select and process data in order to make them suitable as computer input. In these days of grave financial and staff shortages in our hospitals I question how economic this information processing really is, especially when so much of the initial data is itself so vague and unreliable.

Some doctors are now seriously suggesting that clinical diagnosis could eventually be partly or even fully automated (Card, 1967 ; Hall, 1967 ; Masturzo, 1969). Data input, in the form of symptoms derived from a standard questionary, and signs derived from a standard physical examination, would be collated with information already stored in a computer about previous patients. On the basis of pattern recognition a diagnosis and prognosis (and perhaps even advice about treatment) would be supplied as data output.

I believe, however, that diagnostic perspicacity cannot so simply be translated into machine logic (Mitchell, 1969a). It depends too much on the doctor's subjective reactions, on his skill in editing each case history as he elicits it, and on his designing each physical examination accordingly. Above all, a case history is accurately described only in space-time narrative, which cannot be *comprehensively* reduced to numerically coded computer input in fixed field/length format.

Conclusions

What, then, *is* the relevance of the electronic digital computer to hospital medical records at present ? As a result of several years' personal research into the factors necessary to make and keep good medical records in hospital (Mitchell, 1969b) I have come to the following definite, though admittedly controversial, conclusions:

(1) The case papers within unit files of patients who have not attended the particular hospital for, say, six consecutive years should be destroyed, except for items of correspondence (including operation notes) and details of blood groups, drug sensitivities, and radiation dosage. These latter documents should be kept in *paper* form indefinitely.

(2) Provided that letters about patients are composed in hospital with this arrangement in mind, there is no reason why they should not serve adequately as full case summaries, nor any reason why they should not be composed in variable field/length format—that is, normal English prose.

Now, these arrangements immediately solve the present problems of the size and readability of case papers within unit files: they are basically simple to operate, and they do *not* involve computerization. They were adopted in the Western Infirmary, Glasgow, in 1968 (Mitchell *et al.*, 1967).

(3) Hospital patient indexes of all kinds (master, diagnostic, operation, and so on) should be integrated on computer file. The data are immediately suitable for computer input, and the resulting data bank could be used and expanded for current control purposes, such as for outpatient clinic and admission booking and registration, and for centralizing waiting-lists. Any computerized clinical data processing services should exist *in parallel with*, and not replace, the long-term condensed unit files which remain in paper form.

The present problems of handling and storing hospital case records do *not* depend on computers for their solution, but because this fact is not widely appreciated these problems are

[2] The Commission on Professional and Hospital Activities.

diverting attention from the many invaluable uses to which computers might be put in other areas of clinical activity.

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OUTSIDE EUROPE

America's Unhealthy Twins

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Medicare and Medicaid, the American federal government's two recent sorties into the financing of medical care, had their third anniversary during the summer. But instead of celebrations cries of woe filled the air. President Nixon and his health advisers spoke of a "massive crisis" and of the danger of a breakdown in the country's system of medical care. In Congress the Senate Finance Committee opened hearings to discover why the financial burden had proved so unexpectedly heavy, both for the federal government and for the states.

The two programmes are parts of the same Act, but they serve different, though partly overlapping, groups. Medicare is a federal insurance scheme financed by a tax on pay-rolls which goes into a trust fund to pay for hospital treatment and aftercare for the 20·5 million people who are 65 and over; it also offers a voluntary insurance scheme for doctors' fees to elderly people willing to pay a premium of $4 a month, which the federal government matches. Everyone in these two schemes is entitled to the same benefits wherever he lives.

Medicaid is an assistance programme run by the states within guide-lines laid down by Washington, under which the federal government pays from 50 to 83% of the costs, with the poorest states receiving the most help; 40 states and four other jurisdictions (the District of Columbia, Guam, the Virgin Islands, and Puerto Rico) participate and the rest must join by next year.

Before Medicaid the federal government paid part of the local costs of providing medical care for four classes of poor people: the blind, the disabled, the aged, and families where there are fatherless children. All these are eligible for Medicaid, but the legislation also allowed the states to include people who were above the poverty line but were unable to meet their doctor's, dentist's, and hospital bills—the so-called medically indigent. How to define this group was left to the states, as were the services that were to be provided above a basic minimum. Rich and progressive states like New York have been generous, poor ones stingy, with every possible variation in between. But in all cases it is the state which sets the spending pace, with the federal government paying the bulk of the bills.

Rising Costs

What the two programmes have in common is galloping inflation. Year after year estimates of what they would cost have proved too optimistic. Early on there had to be an increase in the tax payable to the Medicare hospital trust fund; even so, it is estimated that the fund will be bankrupt by 1976 unless additional revenues are found or benefits are restricted. The fund for medical insurance is running an accrued deficit, and a rise in the premiums next year seems unavoidable.

As for Medicaid, it has gone through the roof and is costing over twice as much as was expected. State and local medical expenditures for the needy, which were $764 million in 1965, have risen to about $3 billion in the current year, in addition to a federal contribution of similar size, and the end is not yet. Medical care now absorbs nearly half of the states' spending on assistance, and one state—New Mexico—tried to leave the scheme when its funds ran out with two months of the financial year yet to go. But this is not permitted by federal law. Until July, when Congress altered the law, it was not even possible for a state to restrict services once they had been offered.

Sensational Figures

Not surprisingly, Congress is concentrating on the outright frauds which have come to light and the rich pickings of some doctors and nursing-homes. Sensational figures abound. Illegal and unethical practices are said to be costing California alone some $6–8 million a year. In the country as a whole over 8,000 doctors drew at least $25,000 each from the two schemes last year, and this may be an underestimate; until recently such incomes need not be reported to the tax authorities by the bodies making the payments. Even this is peanuts compared with the $375,000 a year received by two doctors for treating patients in nursing-homes which they owned. How ironic the doctors' violent opposition to Medicare looks today; for many it has proved a gold mine. Nursing-homes, which absorb about one-third of the money dispensed under Medicaid, provide some of the most flagrant examples of abuse: charging twice for the same service, indenting for expensive shoes for the completely bedridden, overprescribing medicines, and exacting rake-offs from the suppliers.

All this makes excellent copy for the Senators and for the press. But officials of the Department of Health, Education, and Welfare insist that fraud accounts for only a small share of the escalation of costs. The trouble goes much deeper. Long before Medicaid and Medicare doctors' fees and hospital charges were rising faster than the cost of living; at present hospital charges are going up by about 15% a year compared with an exceptional bulge of almost 6% in the consumers' price

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