Medical Education

Informatics technology in health care in India

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INTRODUCTION

Human thinking processes and decision-making have been aided by several important breakthroughs. The first of these was writing which gave man the memory to perform mental tasks. The second was the Arabic numerical system using zero and positional notation and the third, analytical geometry and calculus which permitted the solution of complex problems. The most recent has been the use of computers.

Present-day digital computers combine the advantages and attributes of all these breakthroughs. They have an enormous capacity to store and speedily retrieve and process data. In the 1980s the low-cost desk-top 'personal computer' (PC) appeared in the market and since then its use has become widespread. In the 1990s, low-cost interfacing with modern communication devices has become feasible. Text, data, integrated pictures and voice can now be selectively processed and transmitted almost instantly to any part of the world via satellite and earth linkages. Such interfacing of computerized information with communication devices is called 'informatics technology' (IT).

Decision-making is a process of selecting the best course of action from various available choices. In medical science, where a number of uncertainties arise from biological, socio-cultural and personality factors, appropriate decision-making is a difficult task. What is required is a 'quick' and 'correct' decision. Any error or delay can be catastrophic. These decisions in health care can broadly be categorized into the following somewhat overlapping functions:

1. Patient care (diagnostic and therapeutic decisions);
2. Medical education, training and research; and
3. Administration of health care systems at various levels.

Information technology is playing a vital role in holding together and coordinating the increasingly complex system of medical sciences. The important role of computers in biomedical research was recognized three decades ago,[1] but the dominant role of IT in all activities of the health sector is a recent development.

PATIENT CARE

The foremost aim of any medical system is to provide effective patient care. Modern information and communication technologies are capable of performing miracles in the medical care system today. An event reported in 'A letter from the publisher' in *SPAN* magazine[2] illustrates this point very aptly: 'One morning three-and-a-half years ago I felt a stabbing pain in my chest, indicating the onset of a heart attack. I immediately reached for the telephone, and dialed 911. This is the standard number throughout most of the United States for summoning emergency help, be it the police, the fire department or medical rescue squad. When the woman who answered my call told me that help would be on its way, I was a little surprised that she did not ask for my address. I did not know at the time that the telephone line was connected to her computer which displayed my address and telephone number the moment my call came in. Her computer keypad had buttons for various emergency calls. She pushed the one for heart attack, and my address popped up on the screen of a small computer in a rescue squad vehicle close to my residence. Within five minutes of my call, four professional medics arrived . . . . The fact that I am alive today is due in no small measure to having received immediate help in a life-threatening emergency.'

This probably represents a near-ideal health care system in an emergency situation. In the West, PC-based solutions are being extensively used for centralized cardiac monitoring through cardiology management networks.[3] By these systems a cardiologist is networked to computers both at his residence as well as hospital, making it possible to be constantly in touch with patients. In India, the process of acquisition of new technology, upgradation of existing techniques and effective utilization of information systems is gradually taking place. This trend is more evident in the private sector institutions. Some hospitals in Delhi have launched a hotline for ECG evaluation. They have a trans-telephonic device for instant evaluation of ECGs round the clock via a telephone line. The device is connected to the patient which, through his telephone, passes the ECG to a central location. The cardiologist receives it on his computer, interprets the reading and offers appropriate advice over the phone.

Expert systems

Computer-based medical decision-making reduces reliance on memory, augments expertise, saves time and helps both in diagnosis and treatment. With an ever-increasing pool of information, it is difficult to assimilate all the useful information required for optimal decision-making. An interactive computer system which helps doctors and health care professionals with clinical decision-making is called an 'expert system'. Such systems essentially consist of a software that has the ability, when provided some basic data, to suggest possible courses of action.This has two components—a knowledge base and an inference mechanism. The knowledge base is a collection of encoded knowledge in a particular area of medicine and the inference mechanism is an algorithm that, given a case description, uses the information in

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the knowledge base to generate decisive information about the case.

An expert system can provide a diagnosis if the symptoms, history and results of investigation are available. It can also suggest a particular examination or investigation if this has not been done. A 'successful' expert system derives its strength from a large knowledge base compiled after consultation with a group of experts in the field. Thus, the experts' knowledge becomes available to the user—a general practitioner. By providing a list of required investigations, the system reduces reliance on memory.

An expert system supports but cannot replace doctors. The human brain can store 50 000 pieces of information, but the database of medical knowledge contains around 40 billion pieces of information.[4] Thus an expert system can elevate the level of expertise of a general practitioner to that of a specialist. When required IT can help to instantly transmit images such as the ECG and sonogram to experts and obtain their advice.

There are some misgivings regarding IT. The fear that a machine can replace a doctor is unfounded. Firstly, a computer cannot feel, touch, sympathize or express emotion. A doctor as a healer has a pre-eminent role in these activities which are important for patient care. Secondly, an expert system can only suggest possible courses of action. The physician remains the decision-maker accepting or rejecting 'advice' offered by the computer. In course of time, computer-aided diagnoses and therapy through standardized softwares may become acceptable.

No serious effort has yet been made in India to develop expert systems. However certain health care packages are available in the market. The system *Ekalavya*[5] is an attempt at evolving a comprehensive health care delivery system for children between 2 months and 5 years of age. It is intended to be used by the health worker to monitor, screen and refer children. Another system on obstetrics and gynaecology has been created at Trichy (A. M. Raghavan, personal communication). This system can be used for antenatal record keeping, diagnosis of ectopic pregnancy and neural tube defects. 'Hompath' is a programme, which can be used by practitioners of the homoeopathic system of medicine to select the 'right medicine, right potency and right repetition' (J. J. Shah, personal communication). A system has been developed for analysis of primary pulmonary hypertension, arterial blood gas interpretation and for electrical axis determination from an electrocardiogram (B. Radhakrishna, personal communication). A software has also been prepared for diagnosis and treatment of diseases of the ear, nose and throat (M. R. Bansal, personal communication).

The expert knowledge which makes up these packages needs to be evaluated thoroughly and modified suitably before they can be put to common use. The most common drawback in these systems is the meagre knowledge base incorporated into the system. It is probably for this reason that even well-known systems in the field of neurology, e.g. those for the diagnosis of symptoms such as headache have not become popular.[6]

Uses for the handicapped

Computer technology is being increasingly used to help the handicapped and disabled.[7] One such device is the speech synthesizer. When attached to a computer, it transforms written words into available electronic voices. It responds by either spelling out the words letter-by-letter or by pronouncing the whole word. 'Multiread', a PC-based multi-user, multilingual Braille library system and teaching aid has been developed by the Indian Institute of Technology, Kharagpur. It incorporates reading modules consisting of a tactile reading system, a 12-keypad keyboard and a reading device compatible with the Braille code format.

In India, The National Society for Equal Opportunities for Handicapped (NASEOH) conducts computer courses for disabled people. A similar facility is available at the Computer and Computer Communication Guidance Centre for the Disabled, Institute of Science, Nagpur.

Medical equipment

Medical equipment is being increasingly computerized to enhance efficiency and provide quick and highly accurate results. Computerized ECG machines, stress test equipment, computerized tomography scanners and magnetic resonance imaging machines are some examples. An additional advantage of such machines is that they can be linked to a computer network and the images and results immediately transmitted to the computers of doctors for their opinion.

The computer has also been used for the analysis of complex signals originating from the brain. Electrical activity of the brain measured by electroencephalography has been used for investigating diseases of the brain for many years. However, its analysis is complex. Computers have allowed the mathematical dissection of the waveforms by Fourier's transformations and spectral and power analysis to provide a better understanding of the normal and abnormal.[6] The storage and analysis of complex brain signals have been of great use in neuroimaging, monitoring the patient in the Intensive Care Unit and in electro-diagnosis. In the first-generation monitors, only signal storage and display were possible. Later, developments and technological advances have permitted signal analysis, and analysis of trends and relationships. The current third-generation monitors also suggest possible corrective action.

MEDICAL EDUCATION AND RESEARCH

Computer-assisted instruction

Computer-assisted instructions (CAIs) are gaining increasing acceptance as a supplement to the existing teaching methodologies. Artifical intelligence (AI) and CAI collectively have now provided the concept of intelligent computer-aided instruction (ICAI) or intelligent tutor systems (ITSs).[8]

The ICAI is based on the principle that teaching programmes should be comprehensive. They should also be able to provide solutions to the problems they set (if possible in different ways), and follow and criticize the students' solutions. They have a definitive edge in terms of flexibility, as the student controls the pace according to his or her requirement and can skip or repeat a lesson.

Virtual reality (VR), expert systems, multimedia (MM) and video-on-demand (VoD) make computers much more versatile, flexible and need-oriented than ever before. Visual information is desirable for imparting training in many fields of medicine, e.g. anatomy and surgery. A visual image is, in some situation, easier to understand than a long textual description. Voice-related data can be created for abnormal heart sounds, breath sounds and audio/speech therapy. A schematic diagram of a contracting heart, with opening and closing of valves, changes in the volume and corresponding variations in ventricular, atrial and aortic pressures can also be easily shown by computer animation. Low-cost multimedia kits can be used to integrate audio to explain animations as well as create special effects. Multimedia (MM)—a combination of audio, video images, graphics and data on the computer—is opening up new avenues for learning and training

in functional skills. Operative procedures can now be simulated. These can be used for planning operations and for patient education. Static and real-time images can also be stored and lead to 'filmless' departments.[9] VoD is yet another advance in computer-based training technology. Recently, in the USA, over 40 000 videos were made available to a cluster of 4000 households through a communications network and a mammoth video server that could store all videos and provide on-line access.[9] Virtual reality is a step further than MM, whereby human senses and response to human actions are simulated. It can even create a hospital on a computer screen and provide some facilities available in a hospital.[10]

In India, CAI could be effectively used in training medical personnel. Standardized modules distributed to different locations could provide similar training to a large number. These modules can be prepared in the form of a shell where local data or examples can be incorporated. A self-assessment process can be built into the system so that the trainees can evaluate their learning.

Local languages are important in all aspects of health informatics. While some word-processing packages are available for Indian languages there is a need to encourage development of more packages in different Indian languages.

Bibliographic services

It is becoming increasingly difficult to keep track of publications. Medical journals are expensive and libraries which subscribe to a large number of journals are few. This problem can be partially addressed by providing doctors with access to the latest world literature close to their workplace.

The computer-based Medical Literature Analysis and Retrieval System (MEDLARS) of the National Library of Medicine of USA is an extremely useful service. This system contains nearly 20 large bases of citations on international literature which are updated every month. The chosen citations can be scanned on the computer and the relevant ones copied to a disk or a print-out obtained. Besides a full reference to the text, the citations contain the abstracts as well. However, if the full document is required, it will have to be located and studied except those on ADONIS (Article Delivery on Network Information System). Under this system, full-length articles appearing in over 400 important biomedical journals are available on electronic media. This facility is available at the National Informatics Centre, Indian Council of Medical Research (NIC-ICMR) Centre in New Delhi since 1991. Laser print-outs of articles are supplied to users anywhere in the country on payment. The centre has also prepared a Union Catalogue of Biomedical Serials covering at least 170 medical libraries across the country. This is also available on NICNET which is a network of computers located in each district of the country. This catalogue helps in locating a library having the required journal close to the user. However, the actual beneficiaries of these developments so far have been research institutions. Professionals at the periphery are yet to take advantage of these facilities which are available in their district centre. Another drawback of the currently available computerized indexing and abstracting services is that only 30-odd Indian journals are included. Because of this, the world is deprived of information contained in most of the Indian literature. Also, even Indian professionals are seldom able to keep track of the developments in their own country as it is impossible to manually search through such a large number of journals. Efforts are on to computerize the Indian medical literature[11] and set up library networks.

Analysis of data and graphics

Biostatistical and epidemiological analyses are essential components of all health reporting. Such analyses help to improve the health care status by providing the necessary focus for taking action. The analyses are now so powerful that obscure factors accelerating or retarding a health process can be easily identified. This delineation can be made in quantitative terms, such as relative or attributable risks so that they can be compared and ranked. This, in turn, can help in devising suitable strategies to combat the problem.

Few researchers in India use advanced statistical methods such as logistic, discriminant, cluster, factor and MANOVA. The computer is able to take care of the computational portion of these techniques. However, the choice of the right method and correct interpretation of the results will continue to require a certain degree of knowledge of statistics.

Graphics sometimes help in understanding a problem which may otherwise be too complex. Visuals help to rapidly comprehend an overall situation. The graphics capabilities of computers are now enormous and include three-dimensional pictures. Various kinds of graphs can be drawn on the same set of data in a short time. These graphs can be compared and evaluated with regard to their efficiency in depicting a phenomenon.

ADMINISTRATION OF HEALTH CARE SYSTEMS

An health information system (HIS) is a process whereby health data (input) are recorded, stored, retrieved and processed for decision-making (output). Decision-making broadly includes managerial aspects such as the planning, organizing and control of health care facilities at the national, state and institution levels; and clinical aspects which can be subdivided into (i) providing optimal patient care, (ii) training of medical personnel to generate appropriate human resources, and (iii) facilitate research and development activities in various fields of medicine.

An HIS should ideally provide facilities for the fast flow of comprehensive and reliable information to administrators so that they can take quick and correct decisions on programme planning, implementation and monitoring; and of communication back to the field so that the impact of the decisions may be assessed. The problem of data on trauma and AIDS has aptly highlighted the deficiencies in the present system. While trauma, accidents and mass casualties have become part of life today, the exact magnitude of the problem is still not known.[11] Similarly, despite efforts, the estimate of the number of cases of HIV/AIDS in the country is based more on assumption than on fact.[12] An efficient HIS can help planners and managers to set priorities and distribute resources. For example, it can help to objectively decide the priority needed to be given to the control of AIDS in India vis-a-vis tuberculosis for minimizing the projected productive years lost.

The current HIS in India generates data mostly at the state level, that too for limited indicators confined largely to socio-demographic aspects, mortality and fertility. Except for some widely prevalent diseases such as tuberculosis and leprosy, no worthwhile data are available on the incidence or prevalence of various diseases or disabilities. No nationwide community-based estimates are available, not even at the state level, on coronary artery disease, diabetes mellitus, cancers and AIDS nor on common infections such as malaria, typhoid, diarrhoea and sexually transmitted diseases. Data are usually available after at least two years, and this delay naturally carries over to the subsequent stages of planning and implementation. Informatics can substantially reduce such bottlenecks.

Hospital information systems

A hospital is an intricate web where a patient may have to interact with several areas such as the outpatient department, wards, radiology department, laboratories, the pharmacy and the operation theatre. A department may be visited several times for the same episode of illness. A complete computerized record of the patient from entry to exit and re-entry could prove useful to the patients, treating physicians and hospital managers in a variety of ways.[13] Among them is quick response of the hospital functionaries to the diagnostic, investigative and treatment needs of the patient because of the instant availability of the patient's records to all departments on the local network. However, it raises the question of privacy and confidentiality. This can be ensured if a proper system of confidential passwords to authorized users is followed. In addition, programmes can be developed to lock the data on certain patients which can be opened by designated experts or managers alone. Files can be prevented from being copied or erased.

A computer-based hospital information system can bring about efficiency in material and manpower management by making it easy to monitor their utilization. Under such a system, patient records can be easily programmed to automatically accumulate and provide on-the-spot information on a particular activity. Computerized records can also help in hospital-based research as the follow up of patients is easy, a complete record is instantly available and cumulative information on patients with a specific disease can be easily obtained.

Most hospitals in developing countries need to use local area networks to improve their functioning. A start can be made by developing separate modules for each department of the hospital. Such modules can then be linked together to provide an integrated system. Once the hospitals computerize their operations, their linkages with one another for referral or mutual consultation is easy to achieve. An example is the network of the 111 Indian railway hospitals catering to a 10-million population (S. P. Satija, personal communication). Bharat Heavy Electricals Limited have started a computer-based occupational HIS (A. K. Ganguly, personal communication).

National health information system

Health is rightly viewed in India as part of the total development lattice. For fast communication of all developmental information, NIC of the Planning Commission has set up a satellite-based computer network linking more than 450 districts in India, and provided a 386-based PC machine. This network is called NICNET and is currently being put into operation. Monthly data on such diverse aspects as family welfare, child survival and safe motherhood, tuberculosis, malaria, blindness, disabilities and maternal and child health are to be collected from the villages. The data will only be aggregates. Thus privacy and confidentiality will be safeguarded. The information collected would be the minimum necessary to avoid burdening the grassroots worker. The staff position and inventory of drugs, vaccines and laboratory consumables will be recorded in some detail.[14] The information gathered will be manually compiled at the primary health centre (PHC) and district levels. Data on some aspects would also be collected from the government and private hospitals or nursing homes as well as health camps in the district. The transmission of selected data from the district to the state and on to the national level will be electronically available on the computer network. A feedback system is also planned. The system, which is called the Health Management Information System (HMIS) ver 2.0, has already started functioning in Haryana and is being implemented in other states in stages with the help of the World Health Organization.

The present plan is that data from the PHC level will reach the national headquarters every month within a week. The aggregated tables will go back to the district offices by the tenth day of the month.[15] However, there are certain disadvantages of this system. Firstly, the information being collected is not comprehensive. Detailed data collection by various agencies will, therefore, continue to be necessary. How efficiently this HMIS will work only time will tell.

Health databases

A wide variety of indicators are used to measure the health status of a population. At the community level, these include measures of mortality, fertility, morbidity, mental and social health and the availability of health services. Availability of all such data at one place will be a major administrative convenience since they can be easily distributed across the country in a uniform format. Such distribution can be easily done on a network, as mentioned earlier, and on diskettes to teachers and researchers who need such data but are not on the network. Also, all indicators can be simultaneously analysed. This can lead to sharply focused conclusions which at present are elusive in many cases. We have been building such a comprehensive database on Indian health indicators since 1970.[15]

Once a strong information base is available through various sources such as the HMIS, health databases and literature synthesis, systems analyses can be undertaken. This approach could be effectively used, e.g. in family planning and cardiovascular diseases.

PROBLEMS

The emergence of IT is relatively recent and the advantages are enormous. However, there are problems which are holding back its widespread use.

Cost-effectiveness

Information is an important resource, and IT is a basic infrastructure. The initial cost in setting up an informatics infrastructure is high, and its benefits are realized only after a long gestation period. The installation costs are, however, declining due to the emergence of more effective and less expensive devices. Satellites, dish antennae, modems, computers and good quality telephone lines are some of the basic prerequisites for an efficient IT system. The information superhighways have recently caught the attention of planners in India, but the concept has yet to catch the attention of the health sector.

Changes required

Transition in the health sector is necessarily slow. In case of IT, an additional problem is the lack of awareness of many physicians and educators in India of its benefits.

Individuals will have to learn to adapt their attitudes and behavioural patterns to constantly changing environments of IT. Total organizational change favouring IT can then be brought about by modifying the organization's structure, policies, procedures and techniques. If change is introduced systematically, computers which are now considered alien by some professionals in the medical and health sector would soon be fully accepted as a beneficial tool. If the present trends continue, informatics may one day be included in the medical curriculum in India. Till such

time, it may be prudent to organize short-term courses on IT for doctors and other personnel involved in the health sector in India so that the base of informatics-oriented professionals widens.

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Multi-cuisine restaurant—The pathology laboratory

Pathologists seem to love food. Various cell types, patterns and morphology are likened to edible items. Let us start by cutting cakes. You could choose between 'almond' (Hodgkin's spleen) or 'ague' (malarial spleen) cakes. We then have 'bread and butter' (rheumatic pericarditis), 'Swiss cheese' (metropathia haemorrhagica, adenoid cystic carcinoma, silicon granuloma and paraffinomas) and 'half-fried eggs' (oligodendroglioma or colonies of mycoplasma). The menu also has 'anchovy sauce' (pus of amoebic liver abscess), 'apple jelly' (base of lupus vulgaris), 'red currant jelly' (post-mortem clot or stools in intussusception) or even honey (chronic fibrotic lung diseases).

Among the cereals you could have a choice of 'sago' (amyloidosis spleen) or 'millets' (miliary tuberculosis). For vegetarians 'cauliflowers' (carcinomatous growths), 'carrots' (medulloblastoma), 'potato' (cut surface of seminoma testis) or 'onion peel' (Ewing's sarcoma or perineurium in leprosy). The non-vegetarian delicacies include 'fish-flesh' (nephroblastoma), 'fish-mouth' (rheumatic endocarditis) and 'fish-tapeworm' (*Diphylobothrium latum*). We also have 'chicken fat' (post-mortem clot) on our list.

Not much variety is available in soups—'pea-soup' (stools in typhoid) or 'rice water' (cholera stools). An assortment of fillers include a 'bunch of grapes' (hydatidiform mole or sarcoma botyroides), 'popcorn' (Hodgkin's disease—lymphocyte predominance—lymphocytic and histiocytic variant) and 'chocolates' (ovarian cysts). For beverages you can have 'coffee beans' (granulosa cell tumour of the ovary) or 'black water' (malaria) and to bid you adieu there are 'nut-megs' (chronic venous congestion of the liver).

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