1 ICT in Day-to-Day Clinical Practice

Abstract: The practice of evidence-based medicine is immensely information-intensive and knowledge-intensive hence the need to make full use of Information and Communication Technology (ICT) and its automated information management tools to achieve high quality of health care – promotive, preventive and curative, for each and every individual. To achieve this goal the first step is the creation of a life-long Electronic Health Record (EHR) and Electronic Medical Record (EMR) which allows integration of the individual's data with decision support system in the form of alerts, reminders, suggestions and constraints against erroneous decisions, thereby ensuring optimal care. Unlike paper-based medical records in which a lot of information remains buried unexplored, EMRs lend themselves to "data mining" which can lead to the discovery of new knowledge such as genetically inherited diseases and gene-drug interactions.

Computerized prescriptions will eliminate many hazards of hand written prescriptions and will make drug treatment safer for the patients. By combining drug indication data (automatically recorded when the prescription is generated), adverse drug effect data, usage patterns and reasons for stoppage of drugs (problems solved/failure to achieve result/adverse reactions / availability of better drug) a valuable data base is created for pharmacovigilance.

Patient education is the most neglected aspect of current clinical practice. EMR can be integrated with e-mail and web-based information resources for patient education and teaching self-management of chronic illnesses such as diabetes, hypertension, asthma-COPD and arthritis, which accomplish more effective care at much reduced cost. ICT is available and affordable to the Indian clinicians, who need the vision and initiative to utilize it forthwith.

INTRODUCTION

In managing a patient's illness the clinician must continually make complex decisions under conditions of uncertainty – first for establishing the diagnosis and then selecting appropriate therapy. The clinician must make the diagnosis with a degree of certainty that exceeds a definite *threshold value,* which is the function of the losses resulting from diagnostic errors and the gains associated with a correct diagnosis, and treatment. For example the threshold will be low for the diagnosis of malaria or B12 deficiency in which conditions (1) losses due to missing the diagnosis are exceedingly high, (2) gains of treatment are also high and (3) the cost of treatment is relatively very low and (4) the harmful consequences of unnecessary treatment are also negligible.

In contrast, in the diagnosis of cancer / HIV infection/CAD the threshold for diagnosis has to be *very high* since apart from (1) and (2), cost of treatment and harmful consequences of unnecessary treatment are also very high.

Another threshold value is the probability below which one is willing to state that a disease is not present.

CLINICAL DECISION MAKING

Clinical decision making in the management of the patient is a highly intellectual activity which involves (a) the clinician's skill in gathering and evaluating new information about the patient (b) the clinician's ability to readily recapitulate the information already logged in the patient's record and (c) his ability to effectively utilize the large body of medical knowledge, which expresses the relationship between the data describing each individual's problems and the diagnostic, prognostic and therapeutic options available for the optimal management of the patient's problems.

The experienced clinician needs close to two million pieces of information to practice high quality evidence–based medicine. These include the following:

1. *Understand the causation of illness:* Physical, mental and psychosomatic.
2. Pathophysiology and natural history of thousands of disease entities, common as well as rare.
3. Availability and cost of various laboratory tests and imaging procedures with their sensitivity, specificity, positive and negative predictive value and cost-effectiveness.
4. Availability and cost of surgical procedures with assessment of their benefits versus risks.
5. *Patient variables:* Age, sex, race, family history, allergies; attitudes, fears and anxiety; perception about illness and expectations from treatment.
6. Financial and social implications of illness and its treatment.
7. Knowledge about thousands of drugs and formulations, along with their dose, route of administration, frequency and duration of administration, undesirable side effects, toxic effects and drug-drug interactions.

The vast amount of existing medical knowledge and the continuing "Information explosion" makes it increasingly difficult for the doctor to assimilate and recall all the information essential for proper decision-making. It is not surprising that several studies have shown that clinicians do not always make optimal decisions. Human memory-based medicine is increasingly unreliable and can do harm to the patient. An important publication of the Institute of Medicine (IOM) USA in 1999 – entitled "To err is human" indicated that 100,000 deaths in USA alone occur each year due to errors in medical management – "*Most of them are Preventable*".

The human brain is unsurpassed in its ability to perceive, focus, analyze, imagine, think and create concepts, but it is greatly limited in its ability to store vast collections of facts and their relationships permanently, to recall them instantaneously and precisely when needed, and to handle multiple variables at one time. It is in these areas that the computer power will supplement (not supplant) the human brain and vastly improve Clinical Decision Making, and ensure the clinical competence of each individual clinician.

The practice of evidence–based medicine is immensely information-intensive and knowledge-intensive, hence the crucial need for making full use of ICT (information and communication technology) and its automated information management tools to achieve high quality of health care – promotive, preventive and curative for each and every individual. A follow-up report of IOM 2001[1] emphasizes that ICT can play a particularly important role in ensuring high quality of care – the Electronic Medical Record (EMR) and Computerized prescription being the two essential ingredients.

CREATION OF ELECTRONIC MEDICAL RECORD (EMR)

History taking is the most important activity of the clinician. There is tremendous variation in the performance of clinicians in this regard which is more due to lack of adequate time they are willing or able to spare for this activity, rather than lack of competence to ask the right questions. Computer programmers have captured the clinician's skills in history taking and designed programs for automated history generation through direct patient computer interaction. The program gives a summary of the positive history findings (Instant Medical History. Allen Werner 1994).[2] Using Bayes' theorem, it suggests diagnostic possibilities.

Bachman (2003)[3] has stated that the patient computer interview is a neglected tool that can aid the clinician. Smith and Grossmic (2004)[4] have observed that computer interview with the patient is more complete than the traditional oral history taking by the clinician. Patients are more willing to reveal sensitive information such as alcohol and drug abuse, suicidal risk, sexual problems and adolescent sexual behaviour. Patients are ready and willing to use computer interviews conducted in the waiting room itself while they are waiting. Since March 2003, Open SDE, an open source for structured data entry is available for international use (van Ginneken AN et al 2004).[5] Details of the methodology of history taking by computer and creation of a structured data base including history, physical examination and laboratory tests are given in my

book "Computers in Medicine : Progress in Medical Informatics" (2005 McGraw Hill, 2nd reprint 2007).[6]

Electronic Health Record (EHR), Electronic Medical Record (EMR), as exemplified by the Personal Health Record (PHR 2000, a registered product pioneered by Dr NG Rao from Hyderabad India can be carried on a 3½" floppy or CD or smart card which is in the custody of the patient, to be presented to his family physician or specialist or hospital where it can give all the information needed to provide care. It can be created in any International or Indian language. Further details about PHR 2000 can be found at www.personalmd.com

EMR allows integration of decision support systems with the patient data, to guide optimal management, through automated alerts, check lists, suggestions and reminders and constraints against erroneous decisions. For example Clement McDonald's web-based Action-oriented Decision in Ambulatory Medicine (55 pages of computer print-outs) have shown positive impact on patient management, both preventive and curative.[7]

KNOWLEDGE DISCOVERY FROM EMRs

The conventional paper-based medical records have a lot of buried information in the form of free text (discharge summaries, histopathology reports, imaging reports) which could be explored to seek relationships hitherto unknown. The most spectacular example is the Framingham study which revealed the inverse relationship between HDL levels and the risk of Coronary Artery Disease. Women had higher HDL and lower incidence of CAD. Natural Language Processing (NLP) systems can extract useful information from EMRs. Bates (2003)[8] reviewed 22 studies that reported the utility of NLP tools to detect certain types of adverse drug reactions from free text clinical databases. Medical data sets have thousands of variables. Bayesean Local Causal Discovery (BLCD) is a new algorithm which can explore hundreds of records of measured variables per second. (Mani and Cooper 2004).[9] Association of genes to genetically inherited diseases has been established by data mining (Perez Iratxeta et al 2002).[10]

COMPUTERIZED PRESCRIPTION

Medication is an important therapeutic tool in the prevention and care of illness. However, the entire medication process – from the determination of the patient's need for a drug, through the clinician's decision to prescribe the drug, the actual hand written prescription, its communication to the pharmacy, dispensing by the pharmacist and the eventual administration of the drug to the patient and the patient's compliance with the instructions – is extremely complex. Many providers are involved in the process and opportunities for error abound.

Prescription errors often occur because the prescriber does not have immediate access to information relevant to the patient's condition (especially hepatic and renal function) and the drug (especially toxicity profile and interaction with other drugs being taken by the patient, known or unknown to the prescriber). With the deluge of new drugs in the market and the deplorable practice of using the trade names instead of generic names in the prescription, the physician's memory can no longer serve as a bridge between advancing knowledge and clinical practice which involves tremendous individual patient variables.

There are several key areas in which computerized prescriptions will transform the care process and treatment outcome. Computerized systems containing rules to prevent incorrect or inappropriate prescriptions increase the safety, and transform quality of care (Nightingale, et al 2000).[11]

The computerized prescription system design has 3 components:

1. Drug Database and drug dictionary
2. Patient data base including age, sex, weight, drug allergies, genetic data, e.g. G6PD deficiency, diagnosis, relevant laboratory results (esp. liver and kidney function)

3. Scientific drug information reference and guidelines such as treatment protocols for particular conditions.

For instance if a clinician diagnoses a patient with gonorrhea, the system will help him with the recommended updated guideline (e.g. CDC-STD Rx). The patient database will direct him to the already known allergies (e.g. penicillin) which helps him to select an alternative drug such as doxycycline recommended by the system.

The laboratory data can interact with the pharmacy data: examples: the most recent digoxin and serum potassium levels before renewing a prescription for digoxin; or to question the propriety of a vancomycin prescription for a patient who has no blood culture, or one positive for a methicillin – sensitive organism. Adjustment of drug dosage in elderly patients with impaired renal function (even if serum creatinine may be in the normal range) is incorporated in the computer program for prescribing drugs eliminated by the kidneys. Computerized prescription eliminates dosing mistake which are the most common and preventable type of medication error. Dose calculations and automated checks on drug toxicity (e.g. fatal agranulocytosis during cancer chemotherapy) and adding time dimensions including out-patient scheduling ensure safety. Barcoded medication administration (BCMA) eliminates transcription errors. Patient instructions are given in the form of clear legible statements in his own language regarding how to take the medicine (with meals – cimetidine, corticosteroids; on a full stomach – aspirin, NSAIDS; on an empty stomach – one hour before meals or 2 hours after meals for most antibiotics); not to take antacids and antibiotics together etc. Simple as these instructions are, it is amazing how many patients have never been told about them. The patient is also alerted about possible adverse reactions which should be reported immediately (bleeding on anticoagulants, hypoglycemia on insulin or sulphonylureas). Just as pilots and ground engineers are expected to check a list of potential problems before taking an aeroplane back into the sky, the computer check list, completed by a patient while waiting in the clinic (or on-line on phone from home) enables a clinician to check for any drug problem before renewing a prescription.

By combining drug indication data (automatically recorded when the prescription is written) with adverse effect data, usage patterns and the reasons for discontinuing therapy (problem resolved/failure to achieve desired result/adverse reaction/availability of a more effective alternative), a valuable data base is created for post-marketing surveillance of newly introduced drugs, which has eluded the FDA for decades viz – *pharmacovigilance*.

DECISION SUPPORT INTEGRATION WITH LABORATORY REPORTS

Decision-oriented laboratory testing strategies are increasingly used as part of physician education programme in laboratory test utilization.

The mission statement of the American Association of Clinical Chemists (1995) envisaged built-in expert systems which gives, advice on test selection, test logic and test interpretation e.g. Alkaline phosphatase and amylase isoenzyme patterns.

Pro-MD, a diagnostic expert system shell for clinical chemistry test result interpretation has been found to be very useful. Clement McDonald (2003)[12] has given a five year update on LOINC (Logical observations, identification names and codes), a free for use database maintained by the Regenstrief Institute Indianapolis, USA, for more than 6300 clinical chemistry test observations. www.loinc.org.

CONTINUING MEDICAL EDUCATION (CME)

The CME programme developed at the Massachussetts General Hospital (MGH) Boston, USA covers at present more than 20 different clinical management areas, providing self-paced interactive learning based on computer – simulated patient encounters. Cases are designed to convey the essentials of efficient diagnosis and effective patient management in regard to

priority, safety, cost and temporal sequencing of decisions. These programmes meet the criteria for category 1 of the Physician Recognition Award of American Medical Association.

More and more such programmes are available on micro discketts for use on PCs and laptops and their increasing use can be predicted.

The internet offers several libraries of images—radiology, dermatology, pathology including hematology etc. which are useful for training as well as CME.

Clinical cases: A number of web-sites feature clinical cases on a regular basis. The user may be presented with a simple discussion or alternatively work progressively through the clinical history, examination findings and investigation results before coming to a diagnosis.

Examples: Case of the month. www.med. connect.com/hourcas.html

Medical rounds: www.uchse.edu.sin/pmb/medrounds/index/html

Reuters clinical challenges : www.reuterhealth. com/clinical

COMPUTER AS AN EVALUATOR

The National Board of Examinations USA has pioneered the application of new techniques of computer-based testing (CBT) in examinations for licensure, certification and self assessment.

CBX- patient simulator provides interaction with the physician who is required to exhibit characteristic behaviors similar to "real life" actions in the care of patients. By evaluating, diagnosing and treating the simulated patient the physician demonstrates a variety of problem – solving and patient – management capabilities that can be reviewed and evaluated. CBX can become a valuable methodology for CME and the assessment of clinical performance. Is the patient's state at the end of the simulation optimum, acceptable, marginal or unacceptable ? How much did this encounter cost the patient ? How did the cost compare with the optimum cost for safe and effective care ? How much unnecessary cost was incurred ? Were healthcare resources used judiciously ? To how much risk, was the patient exposed due to the physician's decisions? How many contraindicated tests, procedures or therapeutic techniques were ordered? How logical were the physician's sequences of decisions? Were decisions made in a timely and logical sequence? Did the physician accumulate the necessary clinical information and data to justify the selection of a particular course of action? CBX provides the answers. Apart from CBX, Conventional Multiple choice Questions (MCQ) can also be delivered via computer. Maximal savings are realized by eliminating printing and shipping cost of paper and pencil MCQ tests. The technology is now available and by collective action can be made affordable. We need vision, initiative and sustained effort to do something which is long overdue.

IMPACT OF THE INTERNET

The advent of the Internet and the world wide web (www) in the 1990's have made a revolutionary impact on the practice of medicine in the 21st century. "Death of Distance" is a dramatic way of describing the achievements of the Internet. Today a doctor with a desktop or laptop PC can access any necessary or relevant medical information at any time, at any place at the cost of a local telephone call. Patients are equally interested in seeking health related information. 40% of the internet queries are health and illness related. Today the practising doctor will have to know at least as much medicine as his patients know through the Internet! The Internet provides low-cost global access to expert advice through Telemedicine and Tele Health Care. The recent launch of Edu-Sat, the Indian Space Research Organizations' (ISRO) newest satellite exclusively dedicated to education is a wonderful opportunity to introduce Computer-Assisted Instruction (CAI) in our medical and nursing education as well as health education in remote rural areas.

Web-based decision-support tools are now available as a free public resource. The National Guidelines Clearing House (NGC) sponsored by the Agency for Health Care Policy Research,

American Medical Association and American Association of Health Planners, aims at improvement of the quality of healthcare and reduction in the cost of healthcare through evidence-based clinical practice guidelines, the full text of which is available at www.guidelines.gov.

Prescribing information is available on the Internet in an authoritative and accessible form

Clinical Pharmacology (Gold Standard Multimedia Inc) www.gsm.com/resources/cponline

PharmaInfoNet (Vir Sci Corp) www.pharminfo.com

Physicians gen Rx (Mosby Year Book Inc) www.mosby.com

Web pages now exist for virtually every clinical speciality and subspeciality. Web-based directories and search engines are also useful for locating speciality sites. The Cochrane Collaborative Review Groups provide the most reliable information on medical intervention and their effects in health care www.update-software.com

Retrieval of computer-based medical information is a skill which should be taught to every medical student similar to the use of the stethoscope. Data from USA indicates that novice clinicians searching the web retrieve only about 27 percent of the relevant literature which would help them. No Indian data is available. An organization in India –Q Med Foundation founded by a medical librarian with long experience of medical data retrieval from the Internet, has provided a solution to Indian doctors and health care professionals, which will substantially improve their ability to retrieve high quality relevant information. More information is available at www.qmedin.com email info@gmedin.com

PATIENT EDUCATION

Patient education is the most neglected aspect of current clinical practice since the clinicians are too busy to spare some time for this important professional obligation. The Internet now provides unlimited access to health care information for which patients have an insatiable need.

In 1998 the American Medical Infomatics Association (AMIA) issued guidelines for the clinician's communication with the patient via email, a cost effective and medicolegally sound practice. Health connect, a web-based patient –doctor communication tool is available at any time from any Internet connected device. To ensure patient's confidentiality, both parties to the email must have compatible encryptation-decryptation software on their computers (e.g. Pretty Good Privacy-PGP) which is freely available and can be downloaded by anonymous FTP from many places including ftp.ox.ac.uk/pub/crypto/pgp. A digital signature is a means of authentication.

EMR can be integrated with e-mail and web-based information resources. This will facilitate patient monitoring, particularly in situations like diabetes, asthma and COPD, chronic rheumatoid arthritis. This results in better patient care as well as a substantial reduction in cost of management of chronic illness. Health Insurance companies should actively promote the creation of EMRs and self-management programs such as Arthritis Self Management Program (ASMP) downloaded by Stanford University and disseminated by the Arthritis Foundation in USA. Self-management education for chronic illness should become an integral part of high quality primary care (Bodenheimer et al 2002).[13]

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MULTIPLE CHOICE QUESTIONS

1. **An available Indian product whereby patient's clinical data is available in floppy or CD is:**
   A. Open SDE
   B. Personal Health Record (PHR 2000)
   C. McDonald's web based programme
2. **Pharmacovigilance means analysis of:**
   A. Drug adverse effect data
   B. Usage patterns and reasons for discontinuing
   C. Availability of a more effective alternative
   D. All of the above
3. **Pro MD is:**
   A. A web based programme that fights for doctors rights
   B. A computer programme that provides guidelines for prescribing drugs
   C. A diagnostic expert system shell for biochemical test interpretation
4. **Doctors and paramedics in rural areas can be easily educated using:**
   A. Organizing CME lectures in all the villages
   B. Postal newsletters
   C. Computer - Assisted Instruction (CAI) via the ISRO's new launch Edu-Sat
5. **In today's world along with use of stethoscope the medical student must be taught:**
   A. How to manage his bank account
   B. Art classes to be able to submit impressive laboratory notebooks for assessment
   C. The skills of retrieval of internet-based medical information
6. **Web-based patient-doctor communication tools must essentially use:**
   A. Encryptation – decryptation software to maintain patients confidentiality
   B. Very advanced, multistepped interaction platform
   C. None of the above

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1. B 2. D 3. C 4. C 5. C 6. A