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Electronic medical records

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Historical overview

The importance of medical records in health care delivery has been recognised for a long time. Its relevance to patient care and health administration was documented by Florence Nightingale in 1873 a book entitled *Notes on a Hospital*. Health care is a continuous process in which data is progressively accumulated, therefore the record must function as a 'pre-birth to post-death system that meets the requirements for any clinical setting-whether intensive care or primary care (Hammond 1993).

Ideally the medical record should be the primary repository of all information regarding patient care, provide decision-support, and be a tool for supporting and maintaining ancillary health care activities such as administration, quality assurance, research and epidemiology.

Shortliffe has defined medical (health) practice as medical decision-making, (Shortliffe 1990) and it is recognised that there is an integral relationship between medical decision-making, the accumulation of clinical data, health care costs, patient outcomes, and the quality of care (Johns & Blum 1973, James 1989). The delivery of quality, cost-effective health care requires efficient decision-support tools based on the medical record system if these end points are to be achieved.

Traditional medical record systems

Current medical record systems are predominantly hard copy paper-based models with or without variable components of electronic data such as laboratory results and X-ray reports. The paper chart can be read by only one person at a time and they must have it physically in their possession. It is difficult to store and retrieve, requiring space, time and effort. It can be organised in one format at a time yet the demands of the users of the record require it to be in a multitude of formats to meet the individuals needs. To reorganise the record into a variety of formats requires major time commitments and the schematic format is easily corrupted. The paper record is not always legible, is often inaccurate, lacks clinical sensibility, and is not compatible with specified data standards or other information stored in the record (Tierney &Hannan 1992). Poor indexing of data makes the finding of information difficult or impossible (Brennan et al 1991, Leape et al 1991).

Reproduction of the manual record by transcription and photocopying adds to the costs of health care services without any corresponding proven benefit. It was recently calculated in the U.S.A. to cost an additional $15 billion per year to manually reproduce the medical record by transcription (Frawley 1993). Use of the paper chart as a medical record impedes efforts to monitor and improve health care by the inherent difficulty, time, and expense required to access individual charts(Payne 1990).

Technology and health care delivery

Since the 1960s there has been a rapid growth in the technology used to support medical care (Blum 1986, Orthner & Blum 1989, Shortliffe 1990), and this has resulted in the creation of enormous volumes of **data and information** that is available to assess and manage the delivery of health care. Weed estimated that an individual patient can generate up to 50,000 data items during their life (Weed 1989), and to support good decision-making individuals who provide health care require timely integration of this data. New and evolving technologies continue to produce and store large volumes of data and information for patient care (Blum 1986, McDonald 1989a, McDonald 1992a), but there only a few systems that provide **information processing tools** which support clinical decision making (Blum 1986, Orthner & Blum 1989, Shortliffe1990).

It is recognised that information processing capacity of the human brain is limited in its ability to accurately decipher this clinical data and information in a timely manner without errors (Miller 1956, Pryor & Clayton 1991, McDonald 1976). Errors in decision making are further increased when there is **random noise** data, for example, with unexpected data input in stressful situations, a common occurrence in health care.

Consequences of using manual-based record systems

The use of predominantly manual, non-integrated medical records systems has led to increasing costs in patient care (Johns & Blum 1973, Blum 1986) and administration (Woolhandler & Himmelstein 1993), decreased compliance with health care standards (McDonald 1976, Gardner & Schafner 1993), inappropriate variation in health care delivery (Wenneberg & Gittelsohn 1973), and possible negligent behaviour by health care providers(Brennan et al 1991, Leape et al 1991). A Harvard study into the incidence of adverse events during hospitalisation led the authors to conclude that, ‘Lawyers generally believe that investigation of substandard care only begins with the medical record; that in many instances the medical record even conceals substandard care; and that substandard care is not reflected in, or “discoverable” in the medical record’ (Brennan et al 1991, Leape et al 1991).

Concept of electronic medical record (EMR)

What is the Electronic Medical Record (EMR)? It is the storage of all health care data and information in electronic formats with the associated information processing and knowledge support tools necessary for the managing the health enterprise system.

In the early 1970s several institutions investigated the concept of creating an EMR to improve patient care. An important feature each of these projects was the concept that the medical record should be the cornerstone for all information systems within the health care environment, (Blum 1986, McDonald et al 1992a, Safran 1990, Enterline et al 1989, Kuperman et al 1991) and that the data supporting ancillary patient care activities such as administration, pharmacy, laboratories, etc., could and should be generated as a by-product of the patient care process (Blum 1986, Slack 1990, Bleich et al 1985).

One of the earliest successful implementations of EMR functions was at the Regenstrief Institute, Indianapolis. Using the Regenstrief Medical Record System (RMRS) McDonald demonstrated that the use of computer-generated reminders based on patient-specific laboratory data resulted in a reduction of physicians errors in the detection of life-threatening events, and also confirmed that busy physicians were often unable to detect many of the critical abnormalities occurring in the patient record. He concluded that, ‘the amount of data presented to the physician per unit time is more than he can process without error. The computer *augments* the physician’s capabilities and thereby reduces his error rate....It is very likely that the physicians in these studies were simply unable to detect all the multitudinous conditions specified by the standards.’ (McDonald 1976) Computer-generated reminders are now used as standard tools for patient care in the RMRS and other EMR systems used in hospitals and ambulatory care environments (McDonald et al 1992a, Safran 1990, Safran et al 1992, Enterline et al 1989, Kuperman et al 1991).

The Institute Of Medicine study into electronification of the patient care record

In 1992 the Institute Of Medicine (Dick & Steen 1991) of the American National Academy of Sciences, published the results of its study into computerised medical records, their functionality, and how technology could bring the benefits of these records within the reach of all those within the health care system. The recommendations from this study are summarised in the following list:

- Health care professionals and organizations should adopt the computer based patient record (CPR) as the standard for medical and all other records related to patient care.
- To accomplish Recommendation 1, the public and private sectors should join in establishing a Computer based Patient Record Institute (CPRI) to promote and facilitate development, implementation, and dissemination of the CPR.
- Both the public and private sectors should expand support for the CPR and CPR system implementation through research, development and demonstration projects. Specifically, the committee recommends that Congress authorise and appropriate funds to implement the research and development agenda outlines herein. The committee further recommends that private foundations and vendors fund programs that support and facilitate this research and development agenda.
- The CPRI should promulgate uniform national standards for data and security for facilitate implementation of the CPR and its secondary databases.
- The CPRI should review federal and state laws and regulations for the purpose of proposing and promulgating model legislation and regulations to facilitate the implementation and dissemination of the CPR and its secondary databases and to streamline the CPR and CPR systems.
- The costs of CPR ststems should be shared by those who benefit from the value of the CPR. Specifically, the full costs of implementing and operating CPRs and CPR systems

should be factored into reimbursement levels of payment schedules of both public and private sector third-party payers. In addition, users of secondary databases should support the costs of creating such databases.
- Health care professional schools and organizations should enhance educational programs for students and practitioners in the use of computers, CPRs, and CPR systems for patient care, education, and research.

Publication of this report has resulted in wide range of activities directed towards standardised EMR developments. In North America, the US. Department of Health and Human Services, has implemented a national policy on a health information communication infrastructure based on automation of the patient record.(US. Department of Health and Human Services) This group sees a national interconnected communication network linking all participants in the health care system via their own **'computer-based patient record system** -an information system that would have the ability to create, store, retrieve, transmit and manipulate patients ' health data in ways that best support decision making about their care.' These record systems would be linked to reference bases of aggregated patient data and computerised knowledge-based systems which use decision support logic and practice guidelines to help caregivers make better decisions about diagnosis and treatment options (Safran et al 1990, Kuperman et al 1991).

Software applications providing decision support in EMRs

No complete EMRs currently exist however standards for software functionality and decision-support have been defined and are seen as core elements for future EMR developments (Dick & Steen 1991). The basic software components necessary for future EMRs as defined by McDonald are shown in Table 12.1, and a description of these terms is outlined in the following text (McDonald 1988).

- Maintain a data dictionary
- Orientation
- Introspection
- Selectivity of data input
- Query languages

In systems which maintain a *data dictionary*, all data and observations are stored in records, which include fields that link or point to the dictionary files. This means that the data is stored in coded formats which provides for more consistent recording and ease of data entry. They also provide facilities for declaring the data entry fields prior to the recording and storage of data, without the need to define in advance the space to be occupied by the recorded data, thus providing a much more economical use of computer storage space, and more rapid access to the data.

Orientation provides the facility to produce an array of time-oriented flow sheets from the stored data. Figure 12.1. shows summary flow chart of clinical data taken from a patient on chemotherapy for leukaemia. The capacity for displaying clinical data in user-defined, time-oriented formats, is a decision support tool fundamental to good clinical practice (Blum 1986, Orthner & Blum 1989, Hannan 1991).

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CCCIS CLINICAL INFORMATION SYSTEM              HISTORY NO: 808080
                                               NAME: MARROW,BONE
                                               DATE: 30/10/88
FULL FLOW
:-----------------:-------:-------:-------:-------:-------:-------:-------:
: CURRENT         :04SEP87:05SEP87:07SEP87:08SEP87:09SEP87:10SEP87:11SEP87:
:PROTOCOL/CYCLE --:-------:-------:-------:-------:-------:-------:-------:
:525              :       :       :       :DAY   1:DAY   2:DAY   3:DAY   4:
:           CYCLE :       :       :       :C2D1   :C2D2   :C2D3   :C2D4   :
:737              :DAY  24:DAY  25:DAY  27:DAY  28:       :       :       :
:           CYCLE :C1D24  :C1D25  :C1D27  :C1D28  :       :       :       :
:CHEMO    --------:-------:-------:-------:-------:-------:-------:-------:
:ARAC     MG      :       :       :       :    220:    220:    220:    220:
:DAUNORUB MG      :       :       :       :    110:    110:       :       :
:VP-16 IV MG      :       :       :       :    165:    165:    165:    165:
:HAEM.    --------:-------:-------:-------:-------:-------:-------:-------:
:WBC      10^9/L  :    4.1:    5.1:    7.8:    8.4:       :    5.7:       :
:RBC      10^12/L :   3.88:   4.15:   4.23:   4.13:       :   4.74:       :
:HGB      g/dl    :   11.7:   12.2:   12.8:   12.7:       :   14.6:       :
:HCT      %       :   33.3*   36.5*   37.8:   37.1:       :   42.7:       :
:MCV      fL      :   86.0:   88.0:   89.0:   90.0:       :   90.0:       :
:MCH      pg      :   30.2:   29.4:   30.3:   30.8:       :   30.8:       :
:MCHC     g/dl    :   35.1*   33.4:   33.9:   34.2:       :   34.2:       :
:BAND FMS %       :       :       :      2:       :       :       :       :
:NEUTROPH %       :     30*     36*     44:     45:       :     68:       :
:PLATELET 10^9/L  :     67*    103*    214:    247:       :    200:       :
:BLASTS   %       :       :      7:       :       :       :       :       :
:MYEL     %       :      3:       :       :       :       :       :       :
:METAMY   %       :      2:       :       :       :       :       :       :
:EOS      %       :       :      1:       :      5:       :       :       :
:TOX.GRAN         :     SL:       :     SL:     SL:       :       :       :
:LYMPH    %       :   43.0:   46.0:   42.0:   36.0:       :   23.0*       :
:MONO     %       :   22.0*   10.0:   12.0*   14.0*       :    9.0:       :
:ANISOCYT         :       :       :     MO:       :       :       :       :
:OV.POIK          :       :       :     MO:       :       :       :       :
:POLYCHRO         :       :       :     SL:       :       :       :       :
:RNDMACRO         :       :       :     SL:       :       :       :       :
:CHEMSTRY---------:-------:-------:-------:-------:-------:-------:-------:
:SODIUM   MMOL/L  :    144:       :    139:       :       :    138:       :
:POTASS   MMOL/L  :    3.5:       :    4.3:       :       :    3.5:       :
:CHLOR    MMOL/L  :    105:       :    103:       :       :    108:       :
:CO2      MMOL/L  :     26:       :     25:       :       :     26:       :
:UREA     MMOL/L  :    6.3:       :    5.5:       :       :    6.3:       :
:CREAT    MMOL/L  :   0.08:       :   0.09:       :       :   0.08:       :
:GLUCOSE  MMOL/L  :    5.6*       :       :       :       :       :       :
:BILI.T   UMOL/L  :       :       :       :     18*       :     14:       :
:AST      U/L     :       :       :     53*       :       :     34:       :
:ALT      U/L     :       :       :    131*       :       :     86*       :
:GGT      U/L     :       :       :    114*       :       :     83*       :
:ALK.PHOS U/L     :       :       :    198*       :       :    143*       :
:TOT.CALC MMOL/L  :       :       :   2.26:       :       :   2.16:       :
:PHOS     MMOL/L  :       :       :    1.3:       :       :    1.2:       :
:T.PROT   G/L     :       :       :     74:       :       :     66:       :
:ALBUMIN  G/L     :       :       :     39:       :       :     34*       :
:-----------------:-------:-------:-------:-------:-------:-------:-------:
                                        (C)ONTINUE OR (Q)UIT
(C)URRENT   (E)ARLIEST   (D)ATE   (B)ACKWARD   (F)ORWARD   (P)RINT   (Q)UIT
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Figure 12.1 User defined flow chart of clinical data

Introspection is a decision support tool where the computer is able to examine data and information stored within the EMR database using pre-defined clinical rules, and identify certain conditions that require attention (McDonald et al 1992a, Kuperman et al 1991, Safran et al 1990). These record systems automatically produce drug-alerts, warnings, protocol-generated reminders and are able to detect significant alterations in data elements which complement the medical decision making process. (McDonald 1976, Kuperman et al 1991)

The users of EMR systems must decide on the *selectivity of data input* and how it will be entered into the medical record, manually, electronically, or by other processes (McDonald 1990a). Quality data input can be expensive to maintain because it requires disciplined, well-trained staff. (Orthner & Blum 1989, Enterline et al 1989). However, once data are stored the users have access to the computers powerful report generator functions that provide useful data and information displays and reports that support all components of health care delivery (Enterline et al 1989, Safran et al 1990).

It is now possible to access these large volumes of clinical data stored in electronic formats using *medical query languages* for the purposes of research, epidemiology, health care planning, and for producing reports based on data analysis. The collection of information on large numbers of patients to answer specific problems is expensive, time consuming and personnel intensive and is often restricted to small numbers of patients for a limited range of conditions (Tierney & Hannan 1992). For example, to answer the question whether the postmenopausal oestrogen use protected women against cardiovascular morbidity and mortality, Stampfer and others had to receive regular mailed reports on specific clinical events from more than 48,000 women for 10 years (Stampfer 1991). These tasks could have been performed more easily and cheaply if the data were available in a single EMR database or accessible over a range of standardised EMR systems.

Computerised clinical decision support tools

Specific decision support tools for use within EMRs have been defined which provide benefits to health care, and these are as follows: (Clayton & Pryor 1991).

- Alerting
- Interpretation
- Assisting
- Critiquing
- Diagnosing
- Management

Alerting automatically provides decision makers with data and information in situations where rapid, sometimes life threatening, decisions are required. Examples are abnormal laboratory values, vital sign trends, failure to perform nursing procedures and medication contraindications. These clinical situations often have episodes of unpredictable *random noise* data which impair the decision making process leading to errors in patient care.

A system of alerts is used routinely in the HELP (Health Evaluation through Logical Processing)(Bradshaw et al 1989) and Regenstrief Medical Record Systems (RMRS) (McDonald et al 1992a). Established benefits from the use of alerts are a reduction in physician and nursing errors in patient management, increased compliance with predefined standards of care, (McDonald et al 1984) decreased length of stay in hospital and time spent in life-threatening situations (Kuperman et al 1991, Sittig et al 1989).

Using automated alerts in the HELP system during surgery for non-indicated and non-ordered antibiotics Classen demonstrated a fall in the post-operative infection rate from 13% patients per day to 5.5%, and a fall from 35% to 18% in the percentage of patients receiving antibiotics late for surgery. As a consequence there was a reduction in the number of patients receiving antibiotics for an excessive time post-operatively which produced overall savings of $59,000 in 6 months (Classen 1992). This system for recommending antibiotics has now been extended to primary and ambulatory care (Evans 1991, and 1993).

Interpretation is where stored clinical data is assimilated leading to an improved understanding of what the data means. Examples are ECG interpretation, blood gas data analysis and the interpretation of X-ray findings (Blum 1986, Orthner & Blum 1989, McDonald 1989, 1990b, 1991).

Assisting is where the use of decision-support tools speed up or simplify some clinical action. This technique is used in the production of clinical orders, nursing assessment of patients, and history and physical examination. Patient pre-printed encounter forms improve history taking and standardise data recording. Assisting also facilitates direct data entry onto computer terminals making the data immediately available to authorised users of the EMR (McDonald et al 1992a).

Where assisting is used in the ordering of blood samples the specimen is ordered ‘on-line’ and the EMR system indicates the tube type, laboratory to which the specimens are to be sent and when the last specimen was ordered. In this situation the system may also recommend how many times and on what dates a given sample is to be collected within a specified time interval (Enterline et al 1989, McDonald et al 1992a). At the Johns Hopkins Oncology Centre (JHOC), computerised protocol-directed care plans were used to manage blood-product facilities by recommending specific numbers of platelet units for thrombocytopenic patients who were at risk of bleeding. This produced cost savings of $250,000 per year, decreased the use of a limited resource (platelets), and improved patient outcomes (no increase in bleeding) (Enterline et al 1989).

Critiquing is where decisions are analysed within the EMR using defined knowledge rules to verify the appropriateness of those decisions. The system is able to recommends to the physician, nurse, etc., the most appropriate decision to make.(McDonald 1976) Examples of critiquing include clinical orders, protocol-directed care plans, diagnosis making and management plans (Blum 1986, Orthner & Blum 1989).

Diagnosing is where a specific clinical model is applied for the purpose of understanding a complex clinical situation. In these situations the computer may provide a probability list for a range of differential clinical diagnoses based on the data has stored within it (Miller et al 1982, Safran et al 1991). Currently these systems are limited to small clinical domains, such as intensive care, and are expensive because of the expertise needed to maintain the knowledge rules within them (Blum 1986, Orthner & Blum 1989).

Management is the generation of action oriented decisions designed to improve the functionality of the current system state. Examples include hospital operations, resource allocation (including personnel) and the current status of changing clinical disease patterns, either acute or chronic. In HELP the decision support system will recommend changes in FI02 (Fraction of Inspired Oxygen) with patients on respiratory support and suggest when to draw the next blood gases based on existing laboratory and clinical data (Kuperman et al 1991). Pooled data from HELP made available to surgeons performing uncomplicated prostatic resections resulted in reduced length of stay and costs of the procedure over a range of hospitals in the region (James 1989, Grandia 1994).

The Oncology Center Information System (OCIS) system uses nurse generated patient dependency ratings to allocate staff during hospital admissions, and patients are scheduled in outpatient clinics according to the procedures performed so that the doctor-patient encounters coincide with the availability of the clinical data.

Many decision-support applications coexist within EMR systems and they must be integrated to the continuously expanding database of individual patients and groups of patients. Data required for patient care must be available in a timely, reliable and complete manner with the user being able to extract data they require in the format that best suits their decision making (Blum 1986, Kuperman et al 1991). Timeliness of data retrieval is critical in patient care and it has been recommended that data recall times of less than two seconds should be achieved irrespective of the complexity of the decision support function (Clayton & Pryor 1991). An example of how access, storage, and manipulation of clinical data is able to assist all levels of health care is illustrated in Fig.12.2:

CCCIS CLINICAL INFORMATION SYSTEM
PRINCE OF WALES/PRINCE HENRY HOSPITALS
888888: WALKER, LUKE HEMATOLOGY PLOT FOR CYTOPENIC PATIENTS 03/11/89
WBC,PLATELETS,HGB,TEMP FOR CYTOPENIC PATIENTS

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        :---------------------------------------------------------:
   10.0W:                                                         :
        :                                                         :
   1000P:                                                         :
      8W:W                                                    wW  :
    500P: w                                                  W  w :
        : w                                                 w    w:
    250P: w                                               w  pPppw:
        : w                                               w pP   P:
    125P: w                                             wWpp      :
        : w                                           wWpP        :
      4W:  Pp                                        wpP          :
   50.0P:----P---P------------------------------------------------:
        :P  w  P     Pppp                         wWp             :
  31.25P:    Ww          Pp pppPp     pP      wPwWpP              :
    1.0W:------W-W---------P-----P-----------P---P----------------:
 15.625P:            WwwwWwWwwwWwWwPwwwWwPwP                      :
      0W:                                                         :
        :---------------------------------------------------------:
ARAC    : A A A A A A A                                      A A A:
DAUNORUB: D D D                                              D D  :
VP-16 IV: V V V V V V V                                      V V V:
        :---------------------------------------------------------:
   1987    AUG                                    SEP
DATE     12  14  16  18  20  22  24  26  28  30  01  03  05  07  09  11  13
(N)EXT  (B)ACK  (F)ORWARD  (D)ATE  (E)VENT  (R)EDO  (P)RINT  (Q)UIT
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Figure12.2 Daily plot of white blood cells and platelets with chemotherapy

This is a plot of white blood cells and platelets on a patient undergoing chemotherapy. The display shows user-defined levels (horizontal dashed lines) at which decisions relating to platelet or white cell transfusion, or prophylactic antibiotic therapy may be made. Using accumulated data from groups of patients based on the time interval in which they have a low cell counts, the length of stay in hospital can be predicted by treatment and diagnosis, thus aiding bed allocation and rostering of nursing staff based on patient dependency status. Resource utilisation such as the number of tests ordered, medications utilised and bed occupancy can be evaluated from the data accumulated during the patient care process, demonstrating how administrative and health planning data can be generated from the patient care record. The data displayed is linked to the complete medical record so complex interrelationships of data within the EMR can also be evaluated (Bleich 1985, Slack 1990, Safran et al 1990, and 1991, Grandia 1994).

Existing EMR models and confirmed benefits of EMRs

Complete automation of the medical record system has not yet occurred, however there are a range of EMR systems which provide information demonstrating the real and potential benefits of electronically stored medical information. Recent advances in technology relating to data and information storage, such as Compact Disks—Read Only Memory (CD-ROM), provide facilities for life-long repositories of medical data. There are functioning EMR systems storing in excess of 1 million patients on line, representing billions of data points accessible within seconds (Safran 1990, McDonald 1989a), and the ability to manage these large volumes of data is another area where the benefits of computerisation can be seen. For example;

- Fries and his co-workers, using the American Rheumatological Association Medical Information System (ARAMIS), showed that physicians using a computerised data flow sheet were able to find specified information twice as fast as physicians using the traditional paper record (Fries 1974). The physicians in this study were able to find the relevant information virtually all the time with the computer record but failed to find 10% of the information in the paper chart,
- Whiting-O'Keefe and his colleagues used the Summary Time-Orientated Record (STOR) to show that physicians were better able to predict their patients laboratory results when using the computerised record (Whiting-O'Keefe 1980).
- Computer-generated reminders used in the RMRS have improved compliance with practice standards particularly in the area of preventive care (McDonald et al 1984, 1989b, and 1990c, Litzelman et al 1990).
- HELP has an extensive alerting system based on data generated from laboratory auto analysers which has resulted in shorter length of stay in hospital, reduced costs and time spent in life-threatening situations (Kuperman et al 1991).
- Research using OCIS has confirmed the benefits of protocol-directed care plans by reducing resource utilisation and costs without reducing the quality of care (Enterline et al 1989).
- Use of the Beth Israel Hospital (BIH) system has improved access to medical records, provided decision support through rapid access to bibliographic databases and to cumulative patient data subsets via its medical query language (Safran et al 1990, and 1991).

The benefits from effective automation of health care delivery using EMR systems based on the IOM criteria can be viewed from different domains namely, patient care, quality assurance, costs, epidemiology, research, and administration.

Patient care

Preventive care is recognised as one area for providing major cost savings in health care delivery. The effective use of an electronic reminder system based on the patient record has resulted in the more effective implementation of preventive care protocols, immunisation procedures, better utilisation of vaccines, and a reduction in morbidity and mortality from infectious diseases (Fries et al 1993, Gardner & Schafner 1993).

Quality assurance

Effective quality assurance in health care requires a *reduction of inappropriate variation in health care delivery and adequate documentation of procedures* to improve the processes involved in health care delivery (Wennberg & Gittlesohn 1973, James 1989). At the Regenstrief Institute rheumatologists use the RMRS to identify patients with rheumatoid arthritis and other connective tissue disorders who are being treated with “second line” drugs such as gold, methotrexate, azathioprine, and penicillamine. The monitoring program detects whether the appropriate pre-treatment haematology and urine tests have been performed, if the results are abnormal and whether the drugs were held or given in reduced dosages. Patients whose records do not meet these standards have their outpatients charts reviewed and, if substandard care has been delivered, the providers are contacted (McDonald 1990c). The same system using data accumulated within the first 24 hours following admission, has been used to identify patients who are likely to have high hospital costs (McDonald et al 1990c). Tierney and others (Tierney et al 1993) demonstrated how the use of an electronic medical record system to control orders for inpatients significantly lowered patient charges and hospital costs. In this situation the ordering of blood tests, medications, etc, was performed at the computer terminal by the medical officers and the justification for requesting each test was prompted by reminders from the EMR.

Research

Research costs represent a significant component of the health care budget as the acquisition of accurate data is difficult and costly in both time and dollars (Tierney & McDonald 1991) Payne demonstrated the cost and time savings benefits of the electronic medical record system Computer STored Ambulatory Record (COSTAR) over the paper record when evaluating the effects of anti arthritic medications in hypertensive patients. The costs saving were in the tens of thousands of dollars and the time savings were measured in hundreds of person hours (Payne 1990).

Epidemiology

As chronic diseases become more prominent in modern health care, larger patient populations will need to be studied to detect variations in diseases and changes in health outcomes resulting from therapeutic interventions, and the size of these populations make it impractical to undertake studies using existing paper-based medical record systems (Tierney et al 1985). Effective studies of these large patient populations will require new analytical methodologies to be created so we can harness all the information they contain (McDonald 1989b).

EMR systems have been used to identify those patients with hypertension prescribed non-steroidal anti-inflammatory drugs who are likely to develop renal insufficiency (Tiernery et al 1989, Murray et al 1990), and identify clinical factors that predict which patients taking diuretics are likely to develop hypokalemia (Tierney et al 1985a,) and ventricular ectopy (Tierney et al 1985b).

Administration

Data stored within the HELP clinical system has been used in the Utah Intermountain Health Centre to evaluate the costs and quality of care for a variety of medical and surgical procedures. The EMR provided information on variations in length of stay, surgical procedure time and costs for uncomplicated surgical resections of the prostate. This information was relayed to the medical practitioners who performed the operations in a range of institutions and they co-operated in altering their surgical techniques and procedures to reduce the mean length of stay and costs of routine Transurethral Resections of the Prostate (TURP) (James 1989). In the evaluation process it was found that certain preoperative procedures such as chest X-rays, were unnecessary if a patient had an uncomplicated medical history. The same clinical data generated from the patient care process is being used to measure and evaluate the effectiveness of Diagnostic Related Group (DRG) studies, and has led to a reduction in DRG costings. Similar hospitals not using a patient-based EMR system have expanding DRG and other health costs (Gardia 1994). This confirms Howard Bleich’s observation that 90% of administrative cost data can be generated as a by-product of the patient care process (Bleich 1985).

To achieve these results EMR systems must provide standardisation of data recording so that data and information can be shared across institutions and internationally. Achieving the end points of EMR integration is not easy, however successful implementations have been completed and they provide answers to many of the difficulties faced and how they can be overcome (Martin 1992, Hannan 1994).

Conclusions

With the knowledge that established models of EMRs have been shown to improve the health care process, what is the recommended course for future EMR projects?

Developers, project directors and users of clinical information systems must begin to share the experiences, and use existing and evolving software tools to reduce implementation costs. This will result in the most effective delivery quality health care.

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