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Review Paper

The Requirements of an Electronic Medical Record to Suit all Clinical Disciplines

Abstract: The design of the electronic medical record is becoming increasingly sophisticated as techniques develop to improve the understanding of user requirements. Such techniques must develop as it becomes increasingly important to improve the use and uptake of such records. An outstanding question is whether the same electronic medical record can fulfil the requirements of users in different clinical disciplines. To evaluate such a requirement it is necessary to understand the different information management the needs of different clinical disciplines.

Only once these differing needs are understood, will it become possible to consider whether a common record is feasible in terms of both data modelling and the user interface. This paper describes the move towards a better understanding of user requirements. It outlines the differences between the requirements of various disciplines and discusses the implications. It concentrates on the differences between the requirements for hospital specialists and family medicine as an example of the problems.

Keywords: Electronic Patient Record, Shared Care.

Introduction

Automation of health care records has to fulfil multiple functions. The main requirements are:

- Improving individual patient care during the clinician - patient encounter.
- Improving individual patient care by increasing organisational efficiency, e.g. better communications between carers
- Improving administration of health care delivery - Billing, purchasing, cost effective care, planning health care delivery.
- Improving research and medical audit - collection of data, monitoring patterns of care.

Can all these functions be met within the scope of one common electronic medical record (EMR)? It has been shown that there are dangers in assuming one EMR can fulfil multiple functions [1,2].

The reported benefits of the EMR are increasing [3-5]. The case for hospital computers has not yet been proved, at least in the UK [6]. However, a recent report outlined the potential benefits (see box 1) [7]. These benefits could equally, with appropriate modifications, apply to primary care. Yet in primary care there is the beginning of evidence that computer systems do improve patient care [9,10]. Is it reasonable to expect that significant individual patient benefits can be achieved if we can improve the EMR? Do we need to have a co-ordinated, cross speciality approach to achieve such benefits?

2. The purpose of the EMR

The primary purpose of a medical record has been defined as for "direct patient care" [11,12]. The primary providers of "direct patient care" are clinicians and thus we need to understand their requirements before we can consider a multi-disciplinary EMR. One over-riding requirement is that clinicians need information resources at the point of care [13].

The term clinician encompasses many different specialities, medical, nursing and para medical. In the past these disciplines have been seen as

separate with similar but different requirements. However the boundaries between traditionally distinct areas of health care are becoming blurred. There is increasing use of team approaches to patient care. Shared care is often considered to be a cost effective way of improving patient care. This has been facilitated by the increasing trend to move care into the community where it is considered to be more acceptable to patients and cheaper than expensive use of hospital facilities.

Information infrastructures are a fundamental enabling factor in this change in health care delivery. Do the new paradigms mean that a common electronic medical record has to be produced which will suit everyone?

In the traditional model the medical records used by, for example, hospital doctors have significant differences from those used by primary care physicians.

I shall concentrate in this review on considering the differences between the requirements of hospital doctors and primary care physicians. However I believe the same principles apply to all clinical disciplines.

3. Understanding Various Needs

It is important to try to understand the nature of the work performed by different clinical users and the environments within which they function if we are to understand their requirements.

Technology can, of course, change the way in which people work. However, we will fail to provide appropriate systems if we assume that health care delivery and working patterns must change to fit what we design. In designing systems, false assumptions have been made about how people and procedures work [14].

We have not yet learned to represent computer based medical information in a form that seems intuitive to physicians [15,16]. There seems to be a tendency to investigate how users cope with existing interfaces or try to evaluate the individual tasks they perform without considering the holistic nature of their tasks. Much of the published work describes clinician's interaction with existing academic or service systems. Thus the results are often affected by the constraints of the interface. Most of the problems with clinicians use of coding [8] reflect the design of the system or the coding systems used. More appropriate implementations have elicited different results[17] Krushniruks paper tested a system that used formalised data entry templates for guiding the user through the data collection process. The results are well thought out and valid but only for a system that uses formal data entry templates. Do we know that such systems, logical to computer scientists, actually fit with clinicians needs? Would a more open structure [18] have produced different results?

Examples of classical design problems include [19]:

- Inconsistency: for example, a single key had variable functions depending on the context.
- Poor screen design: a common fault is the use of too many windows and too many menus causing user disorientation.
- Insufficient navigation control: users are often not given appropriate control over how to access various screens
- Important procedures are difficult to access: The difficulty in utilising important facilities illustrates a misunderstanding of user priorities and the importance of the concept of a narrative (see below).

Box 1 - Benefits of improved hospital information management

Clinical activity	Direct clinical benefits	Other benefits
Referral or attendance at accident and emergency department	• Easier access to history, drug interactions, current treatment	• Links to past attendances • Single entry of patient characteristics • Improved clinic organisation
Outpatient clinic	• Easier access to clinical records (history, drug interactions, treatment, old letters and summaries, radiology and laboratory results) • Easier production of clinic letters for general practitioner	• Reliable tracking of notes • Improved management of appointments, waiting lists • Faster response to patient's queries
Admission and inpatient stay	• Easier access to records • Support for practice guidelines • Faster reporting of tests and procedures	• Improved bed and waiting list management • Better management of resources (theatres, etc.) • Tracking of patients
Discharge	• Faster, easier, more structured discharge summary (benefits community health workers) • Reliable data for clinical audit	• Earlier discharge planning and documentation • Easier production of statistics • More efficient contracting

Adapted from the Audit Commission report by Wyatt J. [8]

4. Differences in User Requirements

There do appear to be significant

differences in the way hospital specialists work compared to family physicians [20-22].

4.1 Episodes of Care

In family medicine there is a reasonably clear view of a patient centred episode [23]. However, episodes often have different meanings within hospitals. For example, the finished consultant episode (FCE), is an administrative concept in the UK Health Service. Also there will be differences in the definition of an episode or a problem, according to the specialist involved. A surgeon is likely to look on an episode as being a fairly short-lived entity with a defined beginning and end. A geriatrician or a physician will consider a more long term, multi-faceted episode.

4.2 Problems

Specialists do not see the need for managing all of a patient's problems in the same holistic way as family physicians. They prefer the concept of a series of diagnoses, relevant to that attendance, some of which are problems and some of which are not. Thus they have less desire for a record that displays a POMR showing the context of each item.

4.3 Open versus Structured Data Entry

Specialists and their staff are much more used to filling in forms than family physicians who are more used to free text records. There is more emphasis on "rote clerking" in hospital activity.

4.4 Decision Support

Different expertise and experience require different methods of support. The benefits that come from Decision Support mechanisms for family physicians may be less appropriate to specialists. Some specialists may accept computer help for junior staff and for nurses, but they do not necessarily appreciate that they sometimes need help. Junior hospital doctors have more problems by not knowing who or how to contact someone to get a task done. The value of the experienced ward sister who tells the houseman/intern - "phone 2323 and ask for Imaging" is immense.

4.5 Mobility

One of the constraints to hospital clinical computing is the peripatetic nature of hospital work. Family physicians spend most of their time sitting in front of one desk, although they do carry out home visits. An EMR that is to be universally acceptable has to be available wherever users register, in their own default view (see below).

4.6 Order Entry and Tracking

Order entry is a more vital process for hospital doctors than family physicians. One of the main advantages in hospital has been the ability to track investigations. It shows where an investigation was at any point in time, and therefore saves the need to chase an investigation. All the results were available in an easily assimilatable form [24]. This is important to family physicians but less so.

4.7 Different Disease Patterns

Hospital doctors tend to see a highly selected group of patients and therefore the incidence of any particular condition is at variance with the incidence experienced by family practitioners who deal with an entirely different population base. Any system that relies on the problems of disease presenting to hospital clinicians will produce answers that are appropriate to the selected hospital population. This will be different to that experienced by clinicians in the community. For example, using the expert system QMR, the symptoms of cough, headache and jaundice suggest a possibility of Q Fever, a disease which is unlikely to be relevant to a family physician in the Netherlands.

4.8 The Differing Diagnostic Approaches

Family physicians deal with known patients, often with trivial complaints, on a frequent and recurring basis. Hospital doctors deal with selected patients, more likely to have significant disease, on a one off basis. Family Practitioners also have to cover the whole range of physical and psycho-social disease. Hospital doctors specialise in a particular discipline. As a result, family physician's are trained to work in a 'hypothetico-deductive' manner [25-27]. This allows for quick decisions based on a number of clues. These decisions, or hypotheses, are then tested to prove or disprove their validity. This proofing process can take place over repeated visits over a longer period of time. Hospital doctors tend to work according to predefined algorithms - exploring the problem in a logical and structured manner by eliminating possibilities to obtain a preferred differential diagnosis.

Hospital doctors will tend towards reaching a definitive working diagnosis. Family physician's are trained not to strive to reach a definite diagnosis, but merely a management plan that may not include an actual diagnosis.

4.9 The Scope of Medical Knowledge

EMR systems for family physicians will have to cope with the whole range of physical and psycho-social conditions. The emphasis will need to be on highlighting probabilities rather than confirming diagnosis. Hospital doctors will require more in depth, but speciality limited systems, which help towards arriving at a differential diagnosis.

4.10 The Differing Emphasis on Chronic Disease Management and Health Promotion

Hospital doctors are only concerned with the speciality in which they practice. Thus the neurologist will be interested in management of epilepsy, but would not be concerned, in the same

depth, about that same patient's problem of asthma. Family physicians have the need to simultaneously monitor all the diseases from which the patient may suffer. Their "gatekeeper" role produces the need to continually monitor the quantity and quality of care their patients are receiving from the health care system. Any health promotion offered by hospital doctors tends to be unstructured and patchy. Family physician's have specific responsibility for providing on-going health promotion concerning all aspects of the patient's lifestyle.

5. The Differences between Hospital Systems and Family Physician Systems

Reviews of hospital computing [28] described a different emphasis when discussing hospital and family physician systems. Hospital systems are described as relating to communicating between staff within the hospital and administrative activities. The family physician systems concentrated on describing an individual patient record. Indeed, much of the emphasis in published work is the communications potential for hospital computer systems [22]. The development of family doctor systems has been clinically led by the physicians themselves. Hospital systems have tended to be driven by the administrative functions

It is also true [29] that records kept by family physicians are less detailed and more pragmatic than those usually maintained by specialists. Therefore, because of the quantity of information involved, the step to computerised recording is much more difficult to take for specialists.

It has been argued that the wide range of definitions such as *record*, *chart*, *card* or *dossier*, reflect an actual difference in the way physicians practice. Perhaps the idiosyncratic view of different disciplines contributes to the frequently reported lack of success encountered when attempts are made to transfer a "standard medical record" from one environment to another [30].

The European Standards for the architecture of the healthcare record had to resort to vague descriptions such as "healthcare record complexes" to avoid the plethora of existing descriptions [31].

The individualistic nature of medical practice makes consensus hard [32]. Clinicians vary widely between themselves and between the way they function at various times under apparently the same circumstances.

6. Can One Record Suffice?

Considering all these differences it may be that one computerised patient record could not cope with such differences [33].

Computer systems that have been developed to help doctors have not been widely used, perhaps because they have not been developed to meet doctors needs [34]. It is common in Medical Informatics for a patient's medical record to be constrained either by a too rigid underlying model or by a supplier's workstation [2].

Techniques, such as cognitive computer based video analysis with "think aloud" protocols, have shown us much about the need to tailor data entry mechanisms to fit user requirements. [15,35]. In particular it seems to help us with the problems of combining controlled data entry using medical vocabularies to ensure consistency of data with the free format recording that feels more intuitive to clinicians [18]. Analysis of user requirements for data entry does seem to be cross disciplined [36]. However this work does not seem to have progressed towards issues related to data display.

The Institute of Medicine report [37] envisioned a virtual patient record that would encompass many providers and medical specialities in order to provide a multi-provider, multi-speciality longitudinal patent record.

The five levels of the Electronic Health Record as defined by the Medical Records Institute [38] describe the development of the medical record in terms of comprehensiveness and levels of functionality. It assumes that the structural concepts are common to all users. If this is to be the aim of a complete Electronic Health Record (level 5) then we need to ensure we understand all the requirements of all the potential users to see if one patient record structure will suffice. If not, we may well have a common underlying database structure but a user interface that may be radically different for different specialities.

7. The Story of the Medical Record

If the EMR is to be intuitive and not intrusive in the clinician-patient interaction it needs to represent patients as they are seen by clinicians, not just a list of data items. The manner in which the data items are displayed should represent disease and problems that are understood by the clinical user. The details of a patient's medical notes form part of a story. That is how clinicians know them and thus the record should "tell" the story. It is not sufficient for all the data just to be contained in various modules of the record. There needs to be a method of display which presents all the data in a meaningful way, as in a story. In a story, one does not expect to have to jump from chapter to chapter to cope with the flow of the narrative [18].

Narrative is at the heart of clinical decision making, medicine's relation to story is as old as the first case history [30]. A clinician may find it helpful for the EMR to prompt information or propose actions. However the

clinician's primary function is to assimilate the available information and then use their experience and intelligence to derive a conclusion for the benefit of the individual patient.

Clinicians deal in discourse [39]. However the differences between ordinary discourse, as used during the clinician patient interaction and scientific discourse, used for factual manipulation, have been ignored in many EMR designs. It may be true that opinion, belief and feelings can never be represented as data within the EMR. In which case we have to accept that the EMR will always be a mixture of standardised data and free text if it is to represent reality.

Is the story different for different clinicians?

- Do hospital clinicians see the story as a series of distinct types of information which they link via their thought process?
- Do primary care physicians look at the story as a cohesive, patient related, whole where every item is seen in its contextual and chronological place?
- Is it true that to a hospital clinician consultation notes (progress notes) are just another element of the record?
- Are, to a family physician, such notes the main story and the elements just appendages?

Although there has been much emphasis on the appendages in many systems all clinicians function by opinion and feelings, albeit informed by the factual appendages. We therefore ignore this concept of a story at our peril. Is there a danger that physicians will become used to just seeing a disjointed story and what will be lost if they do? Will it further the move towards impersonal medicine [40]?

8. The Data Model

Van Ginneken [41] describes how one model can fit for multiple specialities. However these are all hospital specialities that have the same basic needs. The underlying data model for specialists has been suggested as based on two main principles:

There must be a mother record that is easily extended with sub-records, each fulfilling the requirements of a specific domain.

The structure must support the flexible consultation, efficient data entry, data analysis and decision support. Even though every specialist has his domain he may always be confronted with findings outside his field of expertise.

Whereas the sub-records are designed to meet the needs within a specific domain or research protocol, the mother record is intended to provide the possibility to record any findings for which no explicit sub-record has been created.

There seems no reason why the work on data modelling across multiple specialities could not be extended to virtually all of medical computing. It will require additions such as mechanisms for handling the different meanings of concepts such as an episode.

8.1 Episodes of Care

Ways of coping with this multiple use of the term episode have been suggested [42]: The author describes the common elements of an episode wherever the term is used as:

- Episodes are chronological entities - periods of time with a start point and an end point
- Episodes may repeat
- Episodes delineate sections of larger concepts
- Within the context of the patient's record, episodes are a useful way to group notes and so subdivide (structure) the record.
- Episodes are made up of a number of *Patient Encounters.*
- The commencement of episodes is often an explicit event that is easy to capture on a computer. (The completion of an episode is often much less explicit).

He then describes a relationship that copes with multiple types of episode. An example is in Fig 1.

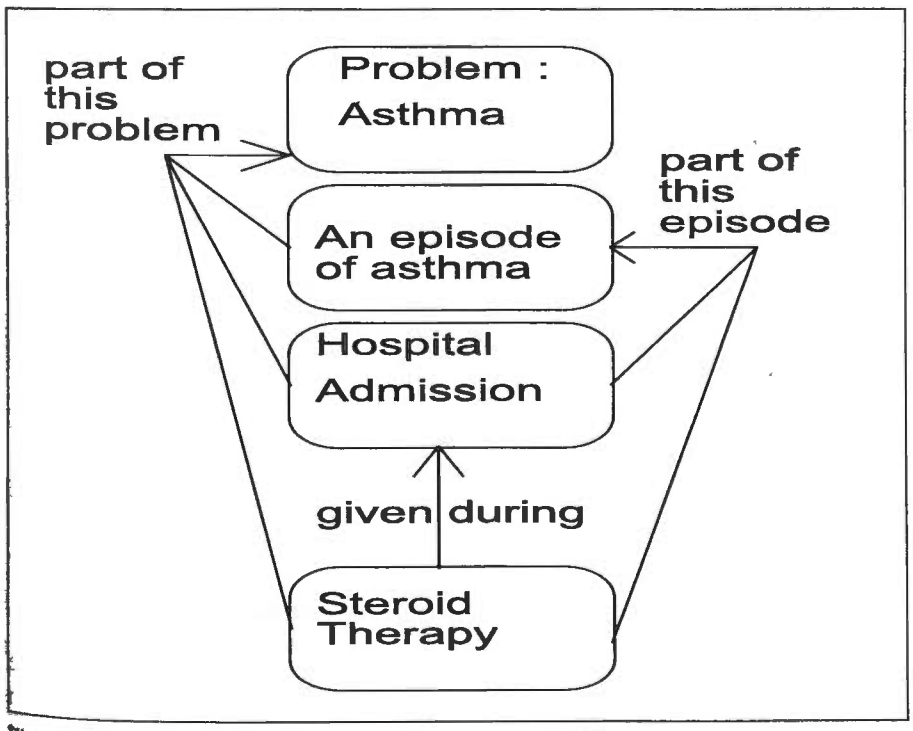

Figure 1 Illustration of many links between entries in the EMR

9. A Standard Approach to Data Entry

Many systems are designed to use structured data entry templates. These can be inflexible in the wide variety of user activities. However, unstructured data entry, particularly with extensive use of free text, can result in data that is of little value for analysis and processing. There is a tension between controlled data entry that suits the computer and free format data entry that suits the user [18].

Van Ginneken [43] describes part of this conundrum as using direct and indirect models. The direct model involves a direct mapping of items on the data entry and attributes in the tables of a relational database. The difficulty with this approach is that in medicine, with its variety of specialities and physician preferences, a huge number of screens and tables will be necessary to tailor applications to their users. The indirect model, often used with knowledge driven data entry, has screens dynamically created on the basis of a controlled vocabulary and user input. This can be achieved by storing findings as instantiations of concepts. However, retrieval in the indirect model is not as straightforward as patient data cannot be directly browsed in a meaningful way. The indirect model should only be used when the advantage of flexibility outweighs the disadvantages with respect to retrieval. The direct model would result in the building of large numbers of screens covering all possible findings for all specialities in detail. This would be cumbersome if it was the only means of data entry. Therefore, both approaches have their benefits and a combined approach within one system is more likely to be effective than either approach alone. The addition of free text input to cope with normal discourse provides a global model for all disciplines.

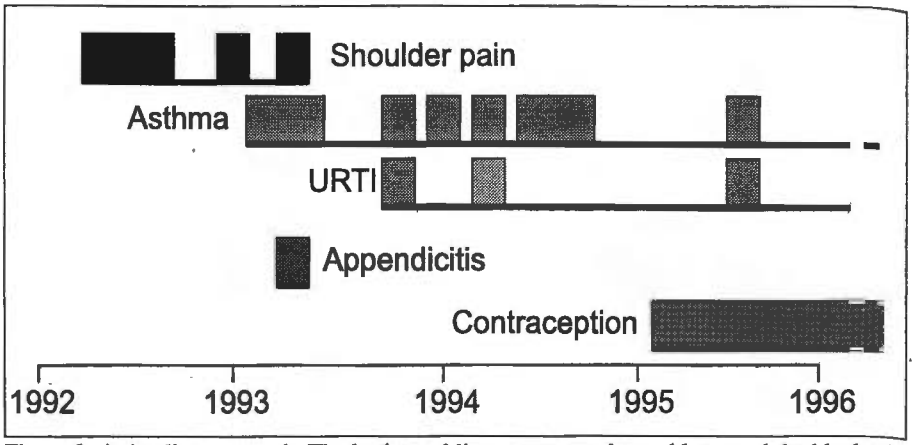

Figure 2: A timeline approach. The horizontal lines represent the problems and the blocks the episodes

10. Different Views on the Same Data

Nygren [44] made it explicit that it is important to present data in various views each suitable for performing one or more specific tasks. The EMR can never know in advance which clinical questions the physician wants to answer. Therefore the default view of the data should be based on the anticipation of what the physician is most likely to see. From there the physician should be able to call for other views efficiently depending on his needs.

The need for clinical data to have a consistent structure in the electronic record is becoming more widely understood. The clinician-information interface embraces the cognitive, analytical and decision processes that the clinician will need to undergo to capture clinical data in a structured, meaningful and analysable form [16].

It seems reasonable to assume that different clinical disciplines require different views of the same data. At its simplest level a hospital specialist will require extreme detail within a particular domain. A family physician will require a broader view of the total patient. However the underlying data is the same and what is required is a difference in the filtering mechanisms used for displaying such data.

It is not sufficient just to re-display the data in the form in which it was entered. The purpose of collecting data is to build a story of the patient record. That story cannot be told in only one way. It will be different according to the users needs.

- Sometimes a clinician will just want to be able to see type - specific data such as all laboratory results.
- Sometimes they will want to be able to examine the patient's problems with contextually linked data.
- Sometimes they will want to be able to see a chronological picture to determine patients' progress.

Data displayed as a long list is usually meaningless. Not only should the story be extracted in terms of linking textual items data together, e.g., the POMR, but it is also important to use the facilities of computer systems to display the data by graphical means. This allows two functions that provide "added value" [45].

The first is the graphical display of numerical data. This is fairly well described and can show patterns and trends within the patient's history. Thus it is possible to see changes in blood pressure level related to medication items. Even here it is important to take a holistic approach as a whole series of graphical charts does not necessarily provide a better picture. However there are problems with the mixing of graphed numerical information in one view that

still needs further exploration [46].

The other function that is just beginning to be explored is the concept of graphing textual information on a timed basis. This timeline/lifeline approach has been described in several papers [23,47]. Figure 2 allows one to see the inter-relationships between various problems that the patient has experienced. The suggestion is that if this is overlaid with numerical graphical information a better view of the patient's real experiences can be obtained. It is hoped that this will allow patterns and trends to be elicited visually. However there is still much more work to do.

Conclusion

The user requirements for different disciplines have significant similarities. A global data model should be possible. The user interface needs to be powerful and flexible enough to provide different views of the data for different users. This requires a balance between controlled and free form data entry.

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