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Medical informatics—the state of the art in the Hospital Authority

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Abstract

Since its inception in 1990, the Hospital Authority (HA) has strongly supported the development and implementation of information systems both to improve the delivery of care and to make better information available to managers. This paper summarizes the progress to date and discusses current and future developments. Following the first two phases of the HA information technology strategy the basic infrastructural elements were laid in place. These included the foundation administrative and financial systems and databases; establishment of a wide area network linking all hospitals and clinics together; laboratory, radiology and pharmacy systems with access to results in the ward. A major push into clinical systems began in 1994 with the clinical management system (CMS), which established a clinical workstation for use in both ward and ambulatory settings. The CMS is now running at all major hospitals, and provides single logon access to almost all the electronically collected clinical data in the HA. The next phase of development is focussed on further support for clinical activities in the CMS. Key elements include the longitudinal electronic patient record (ePR), clinical order entry, generic support for clinical reports, broadening the scope to include allied health and the rehabilitative phase, clinical decision support, an improved clinical documentation framework, sharing of clinical information with other health care providers and a comprehensive data repository for analysis and reporting purposes.

Keywords: Hospital information systems; Clinical information systems; Hong Kong

1. Introduction

We enter the new millennium faced with rapidly changing, increasingly complex health care systems. The traditional paper medical record is no longer adequate for today's health care environment, with its multidisciplinary, cross-setting care, requirements for quantitative indicators of quality and effectiveness and increasing demands on information from patients, purchasers and other third parties. The problem is well recognized;

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the Institute of Medicine has called for a concerted effort to develop computer-based record systems to meet these new demands [1] and countries have developed national initiatives on health information [2,3].

In Hong Kong, the Hospital Authority (HA) has devoted considerable resources to develop its clinical information systems. This article describes the history of this development, the current state, and future plans.

2. Background

2.1. History of IT/IS in HA

When HA was established in 1991, there was very low information system penetration, with only isolated pockets of computerization. A three-stage IT/IS strategy was formulated [4].

- Stage I. Establishment of the key corporate databases of patients, staff, finance and assets and the wide area network.
- Stage II. Clinical systems at the front line and at the clinical departments.
- Stage III. Integrated Healthcare Information Systems: informational databases integrating clinical, financial, costing and management areas and information sharing with third parties.

The early phases of the strategy put the basic infrastructural elements into place. These included the patient master index, administrative and financial systems and databases, establishment of a wide area network linking all hospitals and clinics together; and laboratory, radiology and pharmacy systems with access to results in the ward.

2.2. The clinical management system

The clinical management system (CMS) began in 1994. CMS provided an integrated clinical workstation, giving single logon access to all the available clinical information from either the ward or clinic setting. The original functionality included discharge summary generation with ICD9-CM coding, discharge and outpatient prescription ordering with electronic transfer to pharmacy, clinical notes and appointment booking. The CMS provided demonstrable operational benefits [5], and over the next few years the system was gradually extended and implemented in all 14 major acute hospitals and their associated clinics. Today there are some 2000 CMS workstations being used by around 19,000 staff to enter or retrieve clinical information.

In 1999, with the rollout of CMS phase I nearly complete, our attention turned to developing the next phase of CMS.

3. CMS phase II

Although the use of clinical data has expanded far beyond the realm of direct patient care, the clinical care processes still lie at the heart of clinical information collection and usage [6]. The key focus of CMS phase II is to provide better support for the clinical care processes, while ensuring that good clinical data is available for quality initiatives, management, planning and research. We embarked upon a lengthy consultative process, soliciting extensive input from clinicians, informaticians, managers and technologists, and eight key areas were identified for CMS phase II development.

3.1. Electronic patient record (ePR)

With computerization some benefits, such as legibility and accessibility, are easy to achieve. However, the more advanced benefits of health information systems, including efficient data presentation and clini-

cal decision support, are predicated on a properly designed electronic record [7]. The Institute of Medicine, in its landmark study, *The Computer-Based Patient Record: An Essential Technology for Health Care*, emphasizes this point by defining the computer-based patient record (CPR) as 'an electronic patient record that resides in a system specifically designed to support users by providing accessibility to complete and accurate data, alerts, reminders, clinical decision support systems, links to medical knowledge and other aides' [1].

In CMS phase I, patient data is distributed widely across multiple systems and locations, and although the clinical workstation can access any appropriate information through the intranet it is difficult to provide efficiently a complete overview of the patient for viewing by clinicians, let alone provide clinical data to drive decision support systems.

There are two parts to the ePR. From the clinician point of view the key feature is the provision of an integrated view of all the important clinical data for a patient. This view will span both functions or disciplines and settings. The second part of the ePR is the clinical repository. This repository will contain all the clinical information at a summary level, and the ePR will enable clinicians to 'drill-through' to the complete details contained within the source system.

The ePR lies at the center of CMS phase II. It moves CMS from function-centered to patient centered, making the CMS a window onto the patient record, rather than a series of functional modules which can act upon patient data. Since the ePR repository consolidates all the important clinical information, it will serve as the information source against which patient-specific clinical decision support functions can work and will also form the basis for information sharing with other health care providers.

The initial development of the ePR will consolidate the information which is currently being captured. These include laboratory, pharmacy, radiology, diagnoses and procedures. The ePR will then be extended to include images and multimedia, as well as the other clinical data being developed in CMS phase II.

3.2. Generic order entry

To fully realize the benefits of clinical information systems, they must be integrated with and directly support the care processes [6,8]. Entry of orders by physicians is one of the most direct ways of integrating the information system into the care process, and physician order entry has demonstrated benefits in 'process improvement, cost-conscious decision making, clinical decision support, and optimal use of physician time' [9]. It has been shown that if the care-giver directly enters requests and orders then alerts and reminders are of greatest value [10] and that clinical guidelines are much more effective when coupled with physician order entry [11]. A study of the CMS found improvements in the process, time savings and a reduction in errors resulting from the online entry of prescriptions [5].

From its inception, CMS included direct physician entry of prescriptions for discharge and outpatients. In CMS phase II, we aim to dramatically increase the order entry functionality by developing a generic order entry engine, which will be capable of handling any clinical orders, including referrals and consultations. The system will be developed with protocols, guidelines and care plans in mind and will interface with departmental systems as required.

A laboratory order entry prototype is already in operation in two hospitals and this year the prototype will be extended to include radiology orders.

3.3. Generic results reporting

CMS phase I supports laboratory and radiology results. CMS phase II will extend the scope of results reporting by developing a generic results system, which should support any type of results.

A three-phase approach is being adopted:

1. a simple text based system will be developed first;
2. a structured reporting system will allow templates with user-defined fields. Data captured in this format will be amenable to analysis and reformatting;
3. interfaces with measuring instruments and equipment will automate a lot of the reporting process, and allow capture of raw data which can be presented in graphical or tabular format.

3.4. Rehabilitation (outcomes) module

Clinical information systems have tended to focus on physiological, biological and demographic data, with little attention to health status and outcome measures [12]. CMS phase I was no exception to this rule, as it was targeted to doctors in acute care institutions. The rehabilitation module will extend the clinical coverage of CMS phase II to include the processes and outcomes of the rehabilitation phase of patient care. The target user group will be nurses and allied health professionals, who will use the system to document problems, interventions and outcomes. Information entered into this module will be synthesized into a rehabilitation report, which will provide an integrated perspective on the various aspects of patient outcome including the biomedical, functional and psychosocial.

The rehabilitation module will be an integral part of the CMS—the information in this module will be included in the ePR, it will leverage the technology of the clinical data framework (CDF, see below), and the outcomes will be an important part of the analysis and reporting system.

3.5. Information sharing

One of the key tenets of health care today is that care delivery should be integrated across the various settings, from acute care to community care, from public to private care. Health care today in Hong Kong is still compartmentalized [13] with poor communication between sectors.

In CMS phase I, the printed and codified discharge summaries represented a partial step to redressing this problem. The explosive growth of the Internet and the availability of technologies such as the public key infrastructure (PKI) [14] coupled with the patient-centered ePR means that CMS phase II will be able to share patient information more securely and in a timely manner.

3.6. Clinical data framework and clinical vocabulary

One of the breakthroughs of CMS phase I was the ability to produce discharge summaries with automatic coding into ICD9-CM. Unfortunately, the need for physicians to participate in the coding process also produced many complaints. This is unsurprising, because ICD9-CM is poor at capturing clinical content [15]. In fact, none of the major clinical coding systems are able to capture all the elements of a clinical record [16]. The capture of the medical narrative in electronic medical records has been a major area of research for the past 30 years. The two approaches, which today seem to be most promising are natural language processing or dynamic structured entry, both of which need a controlled vocabulary [17].

CMS phase II will focus on the dynamic structured entry approach through CDF. CDF aims to increase greatly the expressiveness of the electronic record while maintaining a structure amenable to analysis. It employs a disease-specific approach where each disease can contain different 'axes', or attributes. A trial implementation showed that CDF enables the capture of more clinical detail than is possible with ICD9-CM codes, and does so in a clinician-friendly way.

Underlying the CDF will be our vocabulary table, the hospital authority clinical vocabulary table (HACVT). HACVT is the successor to the hospital authority master disease coding table (HAMDCT) [18]. Whereas HAMDCT was basically an extended ICD9-CM coding table, and thus code-based, HACVT will be terminology based. This means HACVT can accommodate a broader range of clinical concepts and is no longer tied to any particular coding system structure. The development of the CDF and HACVT will be an ongoing collaborative effort involving clinicians, informaticians and the CMS development team.

3.7. Medical decision support system

Enabling the computer to support clinicians in diagnosis and treatment has always been one of the major goals of medical informatics. Although the heady optimism of early artificial intelligence research, including some groundbreaking clinical applications [19,20] which showed success in limited domains, has long since been sobered by the realization of the sheer difficulty of the task, progress has been made. Many studies have shown that computerized decision support for clinical tasks can be of benefit, especially for reminders and guideline adherence [21,22] and in reducing the incidence of medication errors and adverse drug effects [23–25].

The first major clinical decision support application in CMS phase II will be alerts for drug allergies, adverse drug reactions, drug–drug interactions and drug dosages. As the ePR and order entry functions are developed, guidelines will be embedded into the system and protocol alerts and reminders can be generated.

3.8. Data analysis and reporting

Clinical data which is captured routinely represents a potential goldmine of information for research and management. However, analysis of observational databases is fraught with difficulties including bias, ambiguous terminology, and incomplete data. It is impossible to predetermine all required data elements so the database model must have a means of accommodating unforeseen data. Creating query tools on such databases is difficult [26]. Our own experience has been that clinicians are more willing to put effort into entering good quality data into the system if they know they can derive useful information for their own research and management efforts.

The Hospital Authority is developing a data warehouse to meet these challenges. The development of query tools to enable access to the data in the warehouse is an important part of CMS phase II.

4. Conclusion

Despite massive technological advances and increasing efforts in the arena of CPRs, significant barriers to their development and implementation remain. These barriers include (1) the lack of a detailed definition of the CPR; (2) creating effective user interfaces which meet all the needs of the users; (3) standards in content, vocabulary and format

of data; (4) legal and social issues; (5) costs and demonstrating benefits to justify these costs; (6) leadership and commitment to the CPR from the top of the organization [27].

CMS phase II addresses many of these barriers. The project is being driven and funded by top management. The ePR will provide our definition of the CPR. Meeting user needs is at the very center of CMS phase II. The CDF and HACVT are major efforts at standardization of vocabulary and clinical data format.

The past 6 years have seen HA move from a prototype clinical workstation to full deployment across all the major acute hospitals. The use of information systems in the clinical setting is now the norm rather than the exception. The next few years should see further dramatic increases in the use of clinical information systems as CMS phase II is developed and rolled out.

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