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Synopsis

Information Systems

As health care organizations worldwide respond to the information demands of providing high-quality care in a cost-conscious environment, information systems are increasingly visible as critical enablers for adapting to these changes. Technical and non-technical challenges in collecting, storing, communicating, and using information still remain. Six papers were selected for this section on Information Systems.

Kahn [1] encourages leaders of academic medical centers to take the initiative to unleash the strategic value of information distributed in the multitude of desktop databases. Collura et al. [2] describe a workstation-based EEG viewer that allows neurophysiologists to review 5,000 pages per day of EEG data. Brooks et al. [3] link environmental data with data from health-care databases to explore associations between air pollutants and hospital discharge diagnoses. Marr et al. [4] provide interesting data that challenge a common rationale for adopting bedside terminals, revealing the need for studies of work flow and work practice. Wong et al. [5] discuss archiving digital images and some of the issues involved with high-volume storage and communication requirements as well as the requirement for 24-hour reliability. Finally, Pangalos [6] describes database security policies that balance the need for access with the need to protect patient privacy.

In Kahn's paper on *The Desktop Database Dilemma* [1], he describes the information sitting in hundreds of desktop databases as a "priceless asset." Indeed, they are, provided appropriate technologies and visionary leadership are marshalled to unfetter their value. Kahn discusses the reality that limits optimal use of these voluminous data: lack of sharing, and lack of quality control over data. Lack of sharing causes redundant work of data entry, and prevents gaining leverage among different potential beneficiaries of the data. Sharing of data, however, places an added premium on data quality. Data validation and data quality assurance must be performed to ensure that only high-quality data are stored. Data validation ensures that the variables selected are the appropriate metrics for the desired effects. Data quality assurance ensures that data is entered accurately. Computers enable the uninitiated to produce flattering printouts of dirty data. Decision makers may be misled by high-resolution renditions of unreliable data. Technical and social impediments are only part of the problem. Kahn concludes his paper by emphasizing the need for strong leadership to guide academic medical centers toward the benefits of shared databases by using open systems and cooperative policies regarding data quality.

One use of databases is to enhance the efficiency of health care professionals in a single department. Collura et al. [2] describe their EEG viewer, EView, that supports the review of EEGs generated in two four-bed epilepsy monitoring units. Neurophysiologists review large volumes of EEG data in epilepsy monitoring units. Two minutes of EEG data per hour per patient translates into 288 10-second pages of EEG per day. Among the challenges is a data stream of 6 Mbytes per minute. Collura et al. set out to provide data-viewing tools that support rapid review of EEG data by neurophysiologists. Drawing operations of high-resolution tracings required special hardware and code to allow rapid scrolling through the EEG files. A montage editor/reformatter with a montage library was developed to accommodate large, unconventional electrode arrays. Other tools, such as digital filtering, record annotations, digital calipers, and educational tools are included in their system. Currently, all EEG records are reviewed on the workstations in a networked environment with records on over 1000 patients stored in the archive.

The next paper in this section, *Linking Environmental and Health Care Databases: Assessing the Health Effects of Environmental Pollutants*, by Brooks et al. [3], demonstrates the potential value of linking databases across different organizations in a discovery process to uncover associations that might warrant further study. The collaborators linked data from two government-administered databases, the Medicare database and the Environmental Protection Agency database in Ohio. The geographic region covered by a zip code was used to form the small area for analysis. The authors report that levels of total suspended particulates, a measure of air pollution, had some effect on the complication rates of interstitial lung disease, chest trauma, and pneumothorax. Previous investigators had similar findings, but their methods were more labor-intensive, requiring surveys, follow up, and manual examination of paper-based documents. Linking information from electronic databases proved easier, and could be generalized over a larger population, such as a state or country.

Timely and complete capture of data is a goal of computer-based information systems. Placing the data-capture device close to the source of the data, in many cases the patient, was a popular notion in the 1980s, and led to the promulgation of bedside terminals for nursing systems. Marr et al. [4] provide evidence in their paper, *Bedside Terminals and Quality of Nursing Documentation*, that question whether bedside terminals actually improve the quality of nursing documentation. Most studies fail to separate the benefits of bedside terminals from the benefits of computerization. Quality of documentation, in Marr's study, was measured by the timeliness and completeness of the documentation, using hospital standards. The investigators studied medication administration, daily charting, physical assessments, and the admission note. In a controlled before-after study, they compared the quality of documentation when terminals were available only at the nursing station versus after terminals were installed at the bedside. The results showed that, when nurses who are experienced with using terminals at the nursing station were offered terminals at the bedside, most of the time (64-70%) the documentation studied continued to be entered at the terminals located at the nursing station. The authors claim that "a positive relationship between the presence of bedside terminals and completeness and timeliness of nursing documentation was not supported." Several reasons for these findings are offered. For the predominantly narrative charting tasks studied, it may be true that terminals located at the central nursing station provide the most convenient and suitable environment to enter that type of data. Seating opportunities, collaboration with colleagues, and "[needed] time away from the patient" are all contributors to this preference. Too often, studies of user needs ignore work flow and work practice considerations. Computer systems unforgivably codify what designers think is going on, only to find that implementations fail when perceptions turn out not to be accurate. On the wards, nurses might understandably batch their data entry on multiple patients and sit at the nursing station for a more prolonged session with the computer so that their time with the computer is used more effectively. Other reasons for having a bedside terminal, however, must also be considered. This study concentrated on data entry of nursing documentation. The terminal also acts as a data retrieval device. Accessing patient data from terminals in patient rooms may be important to nurses and physicians in support of patient care decisions. Lest this seemingly rational assumption be adopted without further study, however, Marr's study reminds us to look more carefully at work flow issues.

Fail-safe reliability and wide-spread availability of information, in this case: images, is the topic described in the paper, *Digital Archive Center: Implementation for a Radiology Department*, by Wong et al. [5]. The authors describe their success to date of providing a fault-tolerant archive center that stores all digital images from three MR units, four CT scanners, selected images from three computed radiology systems and two laser-film digitizers. In total, the center archives 1.5 to 2.0 Gbytes per workday. The optical disk library can hold up to 100 disks, each offering a capacity of 6.8 Gbytes. In order to maximize performance for the end user, current images are sent to the display station immediately upon arrival at the archive center. Requested images not otherwise cached, may take up to 3 minutes to retrieve (for a 20-Mbyte CT scan), but prioritizing algorithms may shorten that to just under a minute. During peak-demand hours, performance may be compromised (by 2-3 times). At the time the article was written, the system had been in operation for six months without any downtime.

As the network of shared data and databases grows, administrators should develop explicit database-security policies and use advanced security technology. Pangalos' paper [6] describes database authorization policies that govern the rules for disclosure and modification of information in the database. Security concerns for medical databases are always a tradeoff between availability of data and protection of the privacy of the patient. The author considers three proposals for medical database security policies: (1) a multilevel or mandatory security policy, (2) a discretionary security policy, and (3) a personal knowledge database security policy. The multilevel policy has multiple access classes from public to highly confidential. Access classes apply to both the user and the data. The most general policy would require the ability to individually classify atomic facts in the database. Access control can be applied to both read and update privileges. A number of technical considerations must be addressed when implementing a multilevel policy. For example, entity polyinstantiation arises when multiple identifiers (with potentially different access classifications) are assigned to the same patient. Attribute polyinstantiation occurs when unclassified data are entered by an unclassified user with the same key value as an existing classified one. Multiple protocols have been developed to implement the multilevel security policy, and these are briefly discussed in the paper. Discretionary database-security policies permit changing user access, typically based on access control lists. These policies are usually implemented by tables of subjects (e.g., users, processes) versus objects (e.g., files, programs). Granting, revoking, and denying authorizations to users or groups pose special challenges. Security policies need to consider each of these and define a position for the organization that is implemented in the system. For example, when users belong to multiple groups, are the privileges a union of all the groups, or does a user operate with privileges of only one group at a time? Granting access is a special privilege, which may be revoked. Upon revocation, the system should propagate the revocation to dependent users as well. The personal knowledge approach favors privacy as the primary goal. Access (read and update) is granted only via an object (person) representing him. The specific proposals for security policies in several European medical systems are discussed. Access control is an important technical consideration for implementing security policies -- policies which must balance the need to deny access to protect patient confidentiality against the need to guarantee access to relevant data for caregivers with a need to know. The effectiveness of the access mechanism is based on three assumptions: (1) correct user identification, (2) physically secure system, and (3) protected privileged information. Distributed heterogeneous databases add complexity to security as network security must be considered as well.

In summary, making optimal use of information contained in various computer-based systems depends on accurate capture, sharing, communicating, presenting, archiving and securing of data. Nontechnical and technical challenges remain to be solved before information systems effectively support the decisions and work flow of health care professionals in routine patient care, education, and research.

The papers in this brief section present a glimpse of some of issues that must be addressed by researchers and practitioners of medical informatics in the years ahead.

References

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