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Synopsis

Information Systems

The papers in this section share the common theme of "information systems." This compound term merits an informal definition. Information can be viewed as a set of symbols or logical processes that increase understanding or decrease uncertainty when making decisions. Systems are interacting entities united to perform a larger function. Information systems, then , can be defined as the set of facilities, language, and processes that support a synergy not realizable by individual components. Often, this synergy is realized by facilitating complex decisions (overcoming barriers of representation) and by facilitating communication (overcoming barriers of space and time). Rather than addressing information systems in the abstract, the papers in this section focus on the realities of health care delivery. Through a variety of techniques and a range of distinct domains, the authors of these papers are each in their own way are creating exciting functional definitions of what a medical information system is and what it can be.

Jean and colleagues [1]from the Broussais University Hospital discuss the open, integrated software systems necessary for effective medical workstations that can serve as mediators between the clinician engaged in a task and a series of complex and highly integrated information sources. Developing such systems requires a keen understanding roles played by various health care actors and by the current and future state of information technology. Software development, it is argued, is itself a collaborative act every bit as much as the health care delivery processes supported by the workstations. Jean and colleagues' discussion of software development, and their desiderata for workstation functionality, serve as a valuable framework for reading the other papers in this section.

Scherrer and colleagues [2] discuss UNIDOC - a system in use at the Geneva Canton University Hospital. At first glance, their paper appears to be a straightforward attempt at solving distributed information systems problems by allowing clerical and professional staff to use commercial document preparation systems sharing a single file server. This effort, when implemented in a large-scale clinical environment, is accomplishment enough, but there is much more to the system than creation of simple documents on personal computers and storage and access from a central source. Beneath the surface, UNIDOC is a complex collaboration environment in which documents have a clear and well organized structure and which data are retrieved into a document from multiple sources. The UNIDOC system allows one to examine both the issues that are raised in large scale systems development and the complexities experienced in providing ease of use to those who use systems to deliver patient care. Although some underlying technologies might be replaced by new operating systems, software architectures, and encryption algorithms, and digital signatures, the underlying needs articulated in this paper are generic.

Two papers, one by Cimino [3] and a second by Joubert and colleagues [4], approach another pressing issue. What, they ask, unites an information need articulated by a health professional with the information residing within an information system? Cimino's paper emphasizes the importance of medical vocabulary and provides valuable insights for information systems designers. His paper focuses on the medical workstation but, in contrast with Jeans software architecture discussion, addresses issues of medical vocabulary necessary for effective software systems. Those concerned with lexicons and medical language representation are confronted with system design choices every bit as critical as those encountered by software engineers. Cimino emphasizes the close relationship between the context in which a datum is collected and how it is represented. He advances a notion of "active" vs. "passive" knowledge and he reminds us that different forms of clinical statements will have differing present and future optimal representation. Cimino identified issues that must be addressed in a coherent way if systems are to be effective - issues like common data types, controlled vocabularies, general syntax, and common content. In

covering this ground, he charts an evolutionary path for information systems developers.

Joubert and colleagues take some themes emphasized by Cimino and examine them from the perspective of Sowa's conceptual graph theory. Conceptual graphs are bipartite knowledge structures composed of terms and relationships having some similarities with semantic networks. In this case, the latter type of data structures are used to transform hierarchical vocabularies into a format that supports logical inference. Queries and discharge data, when transformed into conceptual graphs, can be compared with existing conceptual graphs on the basis of their similarity. The greater the similarity between the conceptual graph formed by the query and that formed by the data, the more likely the data will satisfy the information need raised by the query. This methodology offers an alternative way of retrieving medical information and merits greater comparison with other techniques.

In a two-part article, Miller and Britt [5,6] discuss ways in which Australia and New Zealand have adapted the United Kingdom's Read Clinical Code system The Read Clinical Code system is a strictly hierarchical lexicon based on ICD-9 and OPCS 4 codes and encompassing diagnoses, procedures, findings, laboratory tests, and demographic information; mappings between Read Clinical Codes to ICD-9, ICD-9CM, OPCS 4 and ICPC enhance its utility. The overview and discussion of Australian implementation is led by Miller. It compares and contrasts Read Clinical Codes with other methods and touches on themes addressed in many reprints in this volume, including patient identification, ambiguity of terminology, and changes in health care delivery. A discussion of a more radical reform in health care underway in New Zealand is led by Britt and addresses the social and technical issues surrounding the introduction of any encoding system. A consideration of Cimino's discussion would be helpful in this effort. Read Clinical Codes could also serve as the substrate for the conceptual graph approach discussed by Joubert.

Engelman and colleagues [7] from the Deutsches Krebsforschungszentrum in Heidelberg carry the themes articulated by Jean and colleagues into the domain of digital radiology. Engelman's group, like Jean's, works on the European HELIOS system, placing particular emphasis on the integration of image processing into general purpose clinical information systems. Jean's group emphasizes an overall architecture and Engelman's paper shows how this architecture can be used to address clinical imaging needs. Several aspects of the Engelman paper are particularly notable. It provides an excellent series of illustrations showing how extremely complex systems can in the aggregate provide simplicity and ease of use to the information system user; it defines as "basic" an extremely comprehensive set of image manipulation and annotation capabilities. and it defines a scripting language that integrates image processing, image segmentation, and ray tracing capabilities a set of user-specific methods for visualizing complex images.

Information systems can be evaluated by their acceptance in the clinical setting and by their clinical and economic effects on health care delivery. Mosser and colleagues [8] address these issues in describing 20 months experience with a completely digital radiology system in Vienna's Danube Hospital. The results, both in sheer magnitude of effort and in impact, appear striking. Architectures, data volumes, technical problems, and acceptance are addressed. Their claim of increasing the quality of medical care, while intuitive and consistent with economic models, remains a matter of great debate. Certainly health care practitioners react favorably to the delivery of digital images to ward settings and it is hard to believe that this rapid delivery does not impact on length of stay. But increases in quality, particularly from the patient perspective, may not always be proportional to a decrease in length of stay. Although quality (from any perspective) and length of stay may be related, it investigators still experience great difficulty in identifying the extent to which radiographic image delivery impacts the discharge date, particularly in center of innovation like the Danube Hospital where many health care innovations are taking place simultaneously. Ironically, the more global the degree of innovation exhibited by a health care system, the more difficult it may be to demonstrate the contribution of any single component - even components of the magnitude and technical excellence of the PACS system described in this paper.

This same theme is extended in the paper by Becker and Arenson [9] from the University of California at San Francisco. After a brief overview of PACS systems, Becker and Aronson provide a brief summary of 12 papers addressing direct cost-analyses of PACS. (Direct cost analysis is defined as the measurement of expenditures hardware, film, space, personnel, networks and other factors directly involved in implementing PACS; direct costs do not take into account performance and ease-of-use factors measurable by observing user behavior. They point out the widely varying opinions on the direct cost-benefits of PACS and identify some of the factors that account for the wide variance observed. Cost of hardware and people, for example, seems to vary widely from study to study. Film costs are

space costs seem to favor PACS, and although the cost of technicians to support PACS may be higher than that required to support conventional radiography, it is difficult to calculate the net cost since even the true direct personnel costs may be defined differently in different institutions. Where indirect costs and benefits are concerned, Becker and Aronson's discussion of several University of Pennsylvania studies reinforces Mosser, Urban, and Hruby's claim that PACS systems - particularly when deployed in intensive care units - can result in meaningful shortening of length of stay without adverse impact on the care delivered to the patient. The impact on personnel numbers in a radiology department is equally striking, although again, one may be replacing low-cost clerical workers with higher cost technicians. Most studies, however, emphasize the importance of user acceptance to the overall financial impact. User acceptance, critical to the benefits of PACS implementation, could also motivate the development of more sophisticated PACS systems; initial software development costs, while large, could be recovered quickly as a system is widely deployed. At least in the United States, return on investment (ROI) analyses are critical to the future development of information systems, and to the field of applied medical informatics.

Bellon and colleagues [10] from the Catholic University of Leuven, Belgium, examine in greater detail the barriers of time, space, and representation that can be overcome through the application to PACS of hypermedia-based electronic mail systems. They describe three fascinating prototype systems and report on preliminary observations. The first study involved multimedia links between previously dictated reports and subsequent addition of links to annotated images; these capabilities were deemed useful by physicians. The second study allowed radiologists to abbreviate and in other ways change the composition of their reports by allowing images to replace more verbose textual descriptions. (These studies showed that in some settings, adage a single image IS worth many words still holds truth.) The final study, employing what the investigators call a "slide presentation" metaphor, evaluated the use of a "guided tour" composed of a audio dictation and accompanying radiographic images; this technique was also deemed valuable in some settings. Bellon's work extends in creative ways traditional means of conveying complex information necessary for clinical decision-making.

When evaluating the impact of information systems on patient care, one must ultimately asses this impact over extended portions of a patient's lifetime and not solely over a single brief hospitalization or patient encounter. This problem is made extremely difficult by errors in patient data entry and different means by which government agencies and health care providers identify patients. The "unique identifier" problem has been a concern of researchers at RAND in California and is discussed in some detail in a paper by Bell, Keesey, and Richards in this series [11]. They describe in detail the many identifier variables that must be considered in even the simplest case of longitudinal health care analysis. From a categorical and statistical perspective, they define their use of terms like "match," "agree," "link," and "compare" and they provide a statistical scoring method that, when applied to a large and complex data set, provides promising results. While emphasizing the efficiencies gained by statistical manipulation, the authors also proclaim the need for human judgment where name agreement is concerned. The goal, then, is to identify the appropriate trade-off between automated merging and human-mediated merging. It may be difficult to come to a consensus on this technique because in some instances (e.g., patient bills) errors can be quickly corrected with little adverse biological impact where as in other instances (e.g., misdiagnosis based on inaccurately merged clinical data) the implications may be life-threatening. Resolution of these issues is central to the creation of clinical data warehouses.

The articles in this section address many of the complex issues that must be addressed to create useful clinical information systems. Although each topic must be understood and examined critically in isolation, it is the flexible and innovative woven tapestry composed of these individual components that determines their value to health care. Measuring the value of these innovations, then, become problematic, for these software systems in turn are a part of an dynamic human system designed for effective health care delivery. In examining these issues, it may be useful to make an analogy between health care and the sofa or chair in which one reads this work. How does one measure the benefit and aesthetic contribution of the furniture on which one is reading? H ow does one determine which features are more important than others? How does one decide which features are generic (and hence easily imposed by outside mandates), and which features are more a matter of individual preference? Information systems, it seems, represent a good part of the structural components and glue that hold the piece together. They are the framework, the fabric, and the glue of our health care delivery system and hence they deserve great attention.

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