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Synopsis

Information Systems

The design, implementation and evaluation of medical information systems are still major challenges for medical informatics both as an engineering discipline and a science. Many institutions have developed excellent solutions for specific parts of medicine or for specific functions, but the distribution of high-quality systems that cover all aspects, or at least the essential aspects, of medical documentation and information handling, e.g., in hospitals, remains a distant goal. Important aspects, such as state-of-the-art data protection are seldom implemented. Basic questions, such as the proper balance between narrative and coded information are still open. Outcome analysis of medical information systems is in its infancy.

Given this situation, the selection of papers is interesting: all the papers address important topics: data protection, record linkage, and information presentation. The first paper [1] describes the implementation of the National Research Council (USA) recommendations for protecting electronic health information in a proof-of-concept manner for the communication between two hospitals. The security concept was implemented in one man month with standard components, costing under US $ 10,000. The concept seems well-planned and sound; one still wonders why data encryption and digital signatures are used so little in health care if implementation is that cheap. A real-life implementation was announced as "imminent" – the Synopsis writer did not have time to check for a new publication; and, apparently, the WWW page describing the system was not updated since the first publication. So we remain curious to know whether the data-protection problem can be solved that easily.

The second paper [2] relates the methods used and results obtained by linking two Scottish health registers for the same population of more than five million people. This is a useful paper whose practical hints, theoretical analysis and relevant references can be consulted for any similar task; and the proper linkage of records is a fundamental requirement for the electronic patient record.

The remaining two papers [3,4] deal with the problem of presenting complex information, in this case about the physiological state of the patient for nurses and anesthesiologists, respectively. The first paper [3] presents some new ideas on presentation and layout, but seems to be satisfied with a rather sketchy evaluation, asking nurses how they feel about a static example of the display. The second paper [4] compares a newly developed display with a traditional one in enabling anesthesiologists to quickly detect abnormal (simulated) events during anesthesia.

There is no paper about long-term analysis or evaluation of existing medical information systems, which, in my opinion, points to a weakness in medical informatics as a science. We have great difficulty to build a body of verified, established knowledge of medical information systems, and the same problems are addressed over and over again.

Halamka et al. [1] describe a WWW implementation of the recommendations for protecting electronic health information, which were published by the National Research Council (NRC) of the National Academy of Science [5]. The NRC recommendations are divided into two parts: practices for immediate and for future implementation. The practices for immediate implementation comprise individual authentication of users, access control, audit trails, physical security and disaster recovery, protection of remote access, protection of external electronic communications, software discipline, and system assessment. The second group of recommendations concerns practices for future implementation: strong authentication, enterprise-wide, access validation, expanded audit trails, and electronic authentication of records. The authors implemented all the recommendations of the NRC, including those for future implementation in the so-called Care Web architecture for two hospitals, the Beth Israel Hospital and the Deaconess Hospital in Boston. The two hospitals have different local information systems. A site server at each location translates HL7 requests from the outside into site-specific queries and generates HL7 responses. Access to health information is done with a standard Web browser. A query with HTML forms, specifying patient

IDs, is submitted to a "consolidator", which generates HL7 requests to the servers of both hospitals. The consolidator creates a uniform presentation of patient data from the answers of the two systems.

Enterprise-wide strong authentication is implemented with hardware tokens (Security Dynamics Server ID) with microprocessors that display unpredictable codes, which change about every 60 seconds. The Care Web user enters a user name, a memorized PIN-code and the currently displayed password. This information is checked by a security server which returns an encrypted "cookie" to the browser, which is used for the entire session.

The security cookie contains the job role of the user. The page scripts which assemble the medical record on the consolidator, tailor the delivered information according to the job role. Audit Trails. The audit trails are generated and stored locally on the servers of the hospitals, but may be queried in an integrated way to show the flow of information for a particular patient.

Protection of external communications is done by firewalls at the two hospitals. For communication between the browsers and the consolidator the Netscape Standard Secure Socket layer is used. Encryption of Public Network Transmissions uses RSA public key encryption for key exchange, session key cryptography for data exchange, and digital signature for authentication. Electronic authentication of records in Care Web is only guaranteed for public network transmission, but not for the data stored at the hospitals. Physical security and disaster recovery is also not part of the Care Web architecture, except for the consolidator, but is the responsibility of the participating institutions.

The status of Care Web at the time of the publication was that of a proof-of-concept system. The system was evaluated by 25 health-care providers and 25 information staff with real, but anonymized patient data. This evaluation did not reveal any serious problems and "initial reactions to the prototype appear to be positive". The security architecture was implemented in one man-month, using the standard Microsoft Windows NT architecture and Active X components. The evaluation in a live environment was planned for the near future.

In "best-link matching of Scottish health data sets" Kendrick et al. [2] describe the matching of two health registers for the same population. The National Health Service Central Register (NHSCR) is carefully maintained to contain one and only one record for each member of the Scottish population, but contains little operational information. The Community Health Index (CHI), on the other hand, contains a wealth of operational information, but may have duplicate records when individuals are registered with more than one Health Board.

The linking follows several steps. First, bring the relevant pairs of records together in an efficient way. Second, calculate probability weights based on levels of agreement of identifying items. Third, interpret the weights and make a linkage decision. Each CHI record could link to only one NHSCR record, either by a deterministic link – same NHS number, same soundex code, same date of birth and gender – or by probabilistic weight. Of the about 5.3 million CHI records, 4.6 million (86%) could be linked deterministically. The remaining 751,004 CHI records were given a probabilistic weight according to algorithms which had been developed over several years of linking data. The linkage thresholds were determined by clerical inspection of provisionally linked pairs; the criterion was whether the clerks were willing to accept links as, sufficiently accurate for administrative purposes involving direct patient contact. A subsequent check of 2,000 linked pairs failed to find an incorrect link; 98.8% of the CHI records could be linked to an NHSCR record. Only 0.6% of the individuals in the CHI system had duplicate records. The discussion shows that the probability for a correct match is greatly enhanced if almost all of the records of one file have one and only one correct match in the other (the master). In that case, the detection of duplicate records in one file is also best achieved by linking all the records to the master file.

"Design of a summary screen for an ICU patient data management system" by Ireland et al. [3] addresses the problem of the optimal screen content and layout to replace the hand-written charts in a digital system for ICUs. The study was conducted in two stages: a task analysis to identify the most common users and the extent of information they need and, secondly, the design and evaluation of the new display formats. During a ten-day observation period in an ICU in Sheffield (UK), nurses were identified as the most common users of a display with summary information on the state of the patient. They need this information for two tasks: the planning and implementation of the care of the patient and maintaining a record of the patient's status and the delivered care. To determine the required information, structured interviews were conducted with 18 ICU nurses, resulting in the determination of a set of priority parameters. For some of these parameters the most recent value is sufficient, for others also the trend or even the complete details of the time-dependent development are needed.

The screen contains five main sections with administrative details and summary information about cardiovascular, respiratory, fluid and temperature data. Depending on the importance of the temporal behavior, different formats are used, e.g., time-dependent curves for blood pressure and heart rate, or simple trend indicators like an arrow pointing upwards or downwards, or a pointer on a meter-like graph. The general layout is very simple, with few easily readable symbols that always have the same position on the screen and the same color.

In the evaluation one non-dynamic display containing sample data was shown on a 19" color monitor to 17 ICU nurses and after a short explanation, mentioning that more detailed information would be accessible through navigation buttons, a structured questionnaire was used to elicit the response of the nurses. The answers of the nurses indicated that they found the screen easy to understand and to read, giving an indication of the current physiological state of the patient.

The paper contains no indication, whether the authors planned to use the screen in any real-life system for further evaluation. The authors do not assess the validity and significance of this kind of evaluation or the possible shortcomings or alternatives to their design. Since the screen was intended to replace manual charts, one would expect at least an attempt to compare those two, asking groups of nurses to assess a patient's state from the manual charts and from the screen, for different conditions. An example of such a comparison is given in the last paper.

"An integrated graphic data display improves detection and identification of critical events during anaesthesia" is the title of the paper written by Michels, Gravenstein and Westenshow [4]. Their goal is to develop a new integrated anesthesia display which should enable detection of critical events earlier and more reliably than with traditional displays. Thirty monitored variables are shown on a single display with colored bars that indicate absolute values. "Normal" values are indicated by a black reference frame and deviations from normal are shown when the color bar extends beyond the reference frame. To evaluate the design, four critical events were simulated on a patient simulator (body simulation) and two groups of anesthesiologists were shown the patient, the anesthesia machine and the anesthesia record, generated by the simulator. The physiologic parameters were presented to one group on the display of the simulator and to the other group on the new, integrated display. Audible alarms were switched off. The two groups of each five anesthesiologists were randomly selected from ten faculty members of the Department of Anesthesiology of the University of Utah.

For all four events (blood loss, inadequate paralysis with spontaneous ventilation, cuff leak, and depletion of soda lime) the mean reaction time, i.e., the time between the start of the critical event and the time the observer saw a change from steady state, was markedly shorter for the group with the new integrated display than for the group with the conventional display (maximum difference about 2 min). For two events (inadequate paralysis and cuff leak) this difference was statistically significant. The same is true for the time to correctly identify the critical event, where the shortening of the time to recognize blood loss, inadequate paralysis and cuff leak was also statistically significant.

The paper contains a very relevant discussion of the possible advantages, but also of possible pitfalls (e.g., in detecting acute events, such as cardiac arrest, waveforms may be more useful) and open questions, such as the best definition of "normal" frames.

Given the ubiquitous nature of the problem of correctly reading and interpreting measured values under stress – this happens with aircraft pilots, with anesthesiologists, with operators of nuclear power plants, etc. – one is surprised, that there should not be an established body of knowledge about how to display this kind of information in a manner adapted to human cognition and how to test a display properly. Both last papers seem somewhat incomplete, the former in the evaluation, the latter in the screen design, where at least 30% of the screen is unused and, therefore, the graphs are unnecessarily small and cluttered. No wonder that the authors found (without comment) that one of the evaluators could not see some important yellow bar, even when it was pointed out.

In summary, the four papers do not give a coherent overview of the state of medical information systems, but they highlight important topics and illustrate the status of medical informatics as a science.

References

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