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The Electronic Diabetes Medical Record. Purpose design of a human-computer interface

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Abstract. Innovation, design and development leading to proof of concept for a purpose designed diabetes electronic medical record is described. A matrix presenting data in a relevant context is described along with graphic representations. The possible impacts on clinical practice are discussed, with special reference to integration with the Danish national health care system. Details of utilities allow for comparison with other designs. A hands-on, electronic demonstrator will be available for testing.

1. Introduction

Transition from paper-based to electronic medical record (EMR) has not yet been made in any general sense. Efforts to develop systems covering the entire health care sector have been less than successful, individual accomplishments not withstanding [1,2]. This may reflect less on the infrastructure of the systems per se as the technological developments over the recent years have indeed provided open database structures, networks and CPU speeds quite sufficient for widespread application. Development of user interfaces that will support the specific needs of health care professionals are only emerging. This gap between technology and its application must be filled before any utility can be derived from an electronic version of the medical record.

1.1. Background In Denmark initiatives regarding hospital information systems (HIS) have been supported centrally by authorities and agencies that also financially oversee virtually the entire health care system. Such, however, has not been the case with regard to EMR, where development has been supported largely by industry - based on commercial concepts - and individual pioneers in the field, who as health care professionals respond to daily, unfulfilled needs. Our present stage thus reflects that efforts have been focused on other health care information technology applications than EMRs [3].

With this in mind, we - the users - reexamined the needs from a clinical point of view, to prepare for acquisition and implementation of an electronic diabetes medical record.

2. Materials and methods

A market survey identified current availability of products. Most were free standing (local) without capacity for large scale implementation. Two general purpose systems were identified, each having both technical and financial power to be implemented as a backbone in the Danish health care system. Strategically, this implies two options for EMR implementation namely independent, proprietary development of a local system or possible local adaptation to a nationwide system. In order to protect previous IT investments and to benefit from extended electronic communication through standardised systems, we explored the feasibility of custom designing a user interface with a view to implementation through integration into a general purpose system. Proof of concept was sought by designing an electronic demonstrator (i.e. a user interface without on-line database integration).

2.1. Setting Steno Diabetes Center serves a population approximating one million people. 5.500 patients, with an annual turnover of 1.000, make 25.000 visits to our outpatient clinic every year. Inpatient service, on-site eye and foot clinics, clinical biochemical and clinical physiology laboratory are other important activities along with clinical research. A collaborative effort is a prerequisite for success regardless of the use of IT. A human-computer interface explicitly designed for continuation of our multidisciplinary approach was thus a requirement. Our current practice, entails the use of a common paper based medical record and a single summary sheet (status sheet) by all health care professionals.

2.2. Innovation Review of current clinical practice highlighted areas where advantages might be obtained using IT. Instant availability and presentation of known clinical data is crucial in (life)long outpatient follow up. Subsequent ability to enter and document new clinical data at the point of care was considered a close second on the list of priorities. Graphical presentation of information may enhance the utility of the electronic medium.

2.3. Design Data presentation was separated from data entry. A textual screen was designed using a central matrix to depict results of current and immediate past clinic visits (i.e. core diabetes data), with a number of peripheral areas allocated to presentation of data and information regarding specialised areas of interest such as diabetes complications, medications and demographics. A separate screen presents quantifiable medical information graphically in a context of reference intervals and chronology. Navigation between screens as well as areas within a screen is by mouse. Data entry is accomplished by mouse clicking, choice from pick-lists or in a few areas by keyboard entry. Free text is supported but not encouraged. Data entered are presented on the screens instantly. Automated data transfer is not demonstrator supported, simulation, however, of such transfer is incorporated.

2.4. Development Macromedia Director® was used in the design of screen images. This tool has the flexibility to allow for schematic layout with both textual and graphical elements. At the same time, it provides the opportunity to demonstrate limited interactive properties, even without direct database access. Development was carried out using a Macintosh® computer. Because of the relatively high data and information density on the screens, design was made for a 19" or 21" monitor.

2.5. Implementation To allow for maximum utility of the demonstrator, a self contained PC version for Windows 3.x was derived. The only other hardware requirement to run the demonstrator is a screen resolution of 1024 x 768 pixels.

3. Results

The stage of an interactive demonstrator was reached late in 1995. Presentation of data elements and information is available as a textual summary presentation (ESS or electronic status screen) shown in figure 1 or graphically (figure 2, GSS or graphic summary screen).

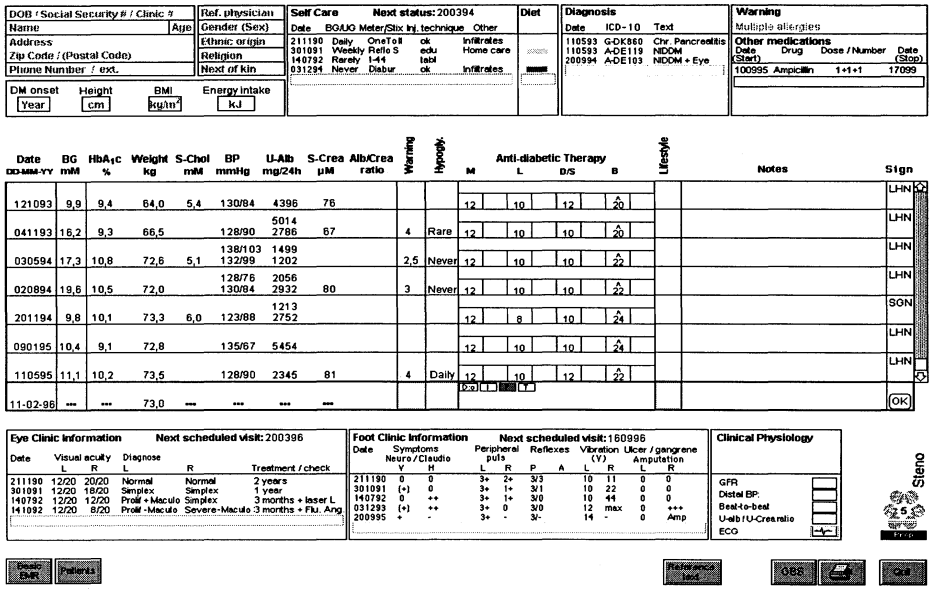

Figure 1: Screen 1: Textual summary presentation or Electronic Status Screen (ESS)

The ESS consists of a central matrix detailing mainly core, clinical data from a single clinic visit horizontally and corresponding information from a maximum of seven previous visits chronologically on the vertical axis. Key laboratory data, behavioral and therapeutic information relating to diabetes is found here. Satellites, consisting of domain-specific boxes, around the central matrix details demographics, baseline medical and diagnostic data along with information on diet, self care and clinical physiology. Results of eye, foot and neurological examinations are also presented in this manner. A clinic logo incorporates information on diabetes care team and clinical research affiliation relevant for the patient.

Data entry is accomplished by clicking the mouse on the first available blank line in the central matrix or any of the satellites. A pop-up sub-screen provides for detailed, structured data entry. Upon completion, leaving the sub-screen preserves the information for subsequent retrieval any time. Simultaneously, the essentials are mapped to presentation on the ESS proper, so as to ensure a continuously updated overview.

With all data elements in a central database, graphical presentation is straight forward. Figure 2 depicts design of a graphic summary screen (GSS). Core data are presented over time, with historic data (> 4 years old) compressed into visible trend curves. Simple scrolling reveals details. Individual graph boxes may be enlarged to full screen size clicking or restored by mouse-clicking. Consistent use of colour coding allows interpretation at a glance. White (or blank) signifies lack of data or information, while green gives recommended (age, sex and clinic specific) ranges or intervals. Yellow denotes items or areas of concern, while red highlights findings or behavior associated with known risk. Blue areas denotes individual target ranges such as interim goals.

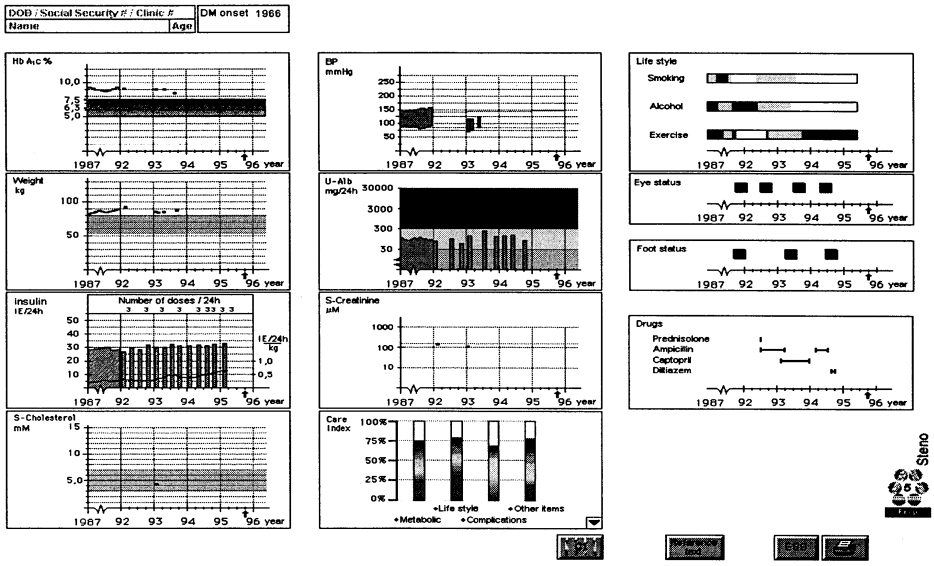

Figure 2: Screen 2: Graphic presentation or Graphic Summary Screen (GSS)

Build-in warnings appear if good clinical practice is about to be violated, reappearing if uncorrected by the time a new booking is requested on conclusion of the encounter.

Printing of screen images as either full screen or selected graphical views is possible from ESS and GSS alike simply by clicking the print icon. Gray scale or colour prints are fitted onto a standard A4 formats.

4. Discussion

Cost containment, longer life expectancies and improved medical interventions have changed the care of patients with chronic, lifelong diseases such as diabetes mellitus from a ward based process into an essentially outpatient managed service. Maintaining excellence in care under such circumstances requires rethinking of the entire care process.

Irregular or widespread clinic visits, increased patient mobility and multi-disciplinary health care teams make information technology immediately attractive to facilitate information flow. Instant access to all relevant information is highly desirable regardless of time and venue. In a national perspective, this requires an information structure to allow for unrestricted communication. Many initiatives including some within an EU framework deal with these problems including standardisation of the processes. Locally, however, the information needs to be provided in a manner facilitating and supporting good clinical practice. Key elements here are comprehensive and timely presentation of pertinent information for immediate comprehension of the complex issues relating to the individual patient [4], de-emphasizing whether the patient is previously known to the health care professional or not. Ability to completely document the care process, education and empowerment of the patient, and agreements reached are other key elements.

The prototype human computer interface developed by us for use in a diabetes setting has these abilities. Utilizing experience with a structured, problem oriented, paper based record, we have continued to rely on pattern recognition as the key to assimilate large quantities of diverse information quickly [5]. By enhancement with graphical depictions, we have purposely tried to strengthen this utility. Further details are available - at a simple click of the mouse in any specific area of interest - as is historic information, but all quantifiable core data are presented on the ESS and many are depicted on the GSS to allow for immediate strategic

planning of an encounter. An updated overview is maintained for final check of completeness before conclusion of the encounter. Essential warnings are added .

Thus the most obvious utility of this electronic diabetes record is individual patient management i.e. operational support. As important as such a tool may be, we are convinced that other applications may prove at least as rewarding in the long run. The fact that we are now able to record more pertinent details in a structured way, makes data available also for other purposes. Hospital information systems may incorporate limited health care related data. Such data may simply not be available in a usable form (database format). With an interface like the one we describe here, barriers between financial, organizational and health care data will no longer exist. This enables data and information management at an entirely new level. Using abstraction and aggregation personal identification is no longer possible, so health care data may now freely be used to support tactical and strategic decisions at any level desired. A whole new perspective is envisaged for epidemiological studies as well, providing a much more comprehensive basis for decision making.

5. Conclusion and perspectives

The human computer interface described enables data and information management at the level of the individual patient. This provides general support for clinical decisions. Versatility, timely availability and multi purpose utility are major advantages. The associated database created and maintained as a result of using the tool, in turn provides data for higher levels of abstraction supporting strategic decisions.

The general electronic medical record and any specialized human computer interface provides new opportunities for service to patients and colleagues. Wide area collaboration (telemedicine) between primary and secondary care providers as well as between regional or national centers may benefit patients and possibly serve to maintain or improve standards. Direct patient contact via telephone utilising mailed in test samples and downloaded values from glucometers also becomes feasible. Such activities may save time and lower cost without compromising the standard of care. Hopefully this may free up resources that may subsequently be redirected at populations and individuals at risk.

Providing high quality care, education and counselling continues to be our primary objectives. We feel, that IT solutions custom designed by and for a specific user group may help achieve this aim.

6. References

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