Medical Data Capture and Display: The Importance of Clinicians' Workstation Design

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ABSTRACT

The Department of Veterans Affairs is developing, testing and evaluating the benefits of physicians' workstations as an aid to medical data capture in an outpatient clinic setting. The physician's workstation uses a graphical user interface to aid the clinician in recording encounter data. Various input devices including keyboard, mouse, pen, voice, barcode reader, and tablet are available on the workstations, and user preferences will be examined. Access to general services such as electronic mail and reference databases is also available. The workstation provides a wide variety of patient specific data from the hospital information system, including image data. The single data collection process by the clinician will also provide data for the cost recovery process.

INTRODUCTION

The Institute of Medicine's study of the computer-based patient record (CPR) identified the development of a technology that is sufficiently powerful and appropriate to the needs and preferences of health care professionals so that they can -- and will -- enter medical and other health care data directly into the computer as the single greatest challenge in implementing the CPR. It further noted that significant new technologies such as the graphical user interface can now support data entry by practitioners [1]. The VA is undertaking a project to evaluate the use of windows-based workstations with various input devices for clinician data capture. This study will be looking at user preferences for data entry technology and will compare workstations with other technology such as scannable encounter forms.

Others have reported work on clinical workstations. Some workstations were designed to present existing data, generally from networked hospital information component systems, to clinicians in an integrated manner, without allowing data entry [2,3]. Other workstations allow physician ordering for the Regenstrief system [4], clinical note entry for PEN&PAD [5], and problem list entry for the HELP system [6]. Recently several institutions have developed portable pen-based medical data entry systems for outpatient encounters and progress notes [7,8,9]. Results of this work is directly applicable to workstations performing the same functions. Various techniques have been tried in these studies to make the data entry process simpler and less time consuming. These include creating lists of input choices based on the context of the interaction [5, 10] and allowing multiple keyboard methods for choice selection [6]. These workstations generally use a keyboard and mouse or pen. Text data from the HIS may be displayed, but not images.

CLINICAL DATA CAPTURE WORKSTATIONS

Image capture and display workstations have been used by VA clinicians since 1990 [11]. They run the VA's hospital information system (HIS) with extensions that provide medical images as an integral part of patients' online medical records [12]. Over three years of experience has shown that physicians are willing and even eager to use the workstations in order to insert images into the patient record. The images included in the integrated online record seem to provide valuable information not adequately recorded in the traditional patient chart.

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The entering of verbal descriptions is still a time consuming process, so more efficient methods of data capture are being examined. The automated data capture project described here has developed a graphical user interface to provide data entry capability in outpatient clinics and enhance existing imaging workstations in use at some V.A. Medical Centers.

There is ongoing discussion about appropriate metaphors for user interaction in a windows environment. Some prefer a user interface which imitates the paper chart, while others feel this is "not adequate for all aspects of clinical information processes" [13]. The user interface developed in this project is based on a main outpatient encounter window which summarizes all of the data to be collected for the visit (see Figure 1). Data entry occurs in dependent windows, and data then appears on the summary screen. This approach is similar to the Rooms metaphor [13] and was used by Nowlan et al [5].

The triage nurse enters the vital signs, chief complaint, and nursing note. The physician enters the type of visit, the procedures performed, the diagnoses or problems, and the narrative comments. Electronic signatures are used to verify all information.

A variety of input devices are available on the clinician workstations including: keyboard, mouse, pen, digitizing tablet, recorded voice, scannable forms automatically converted to ASCII data and

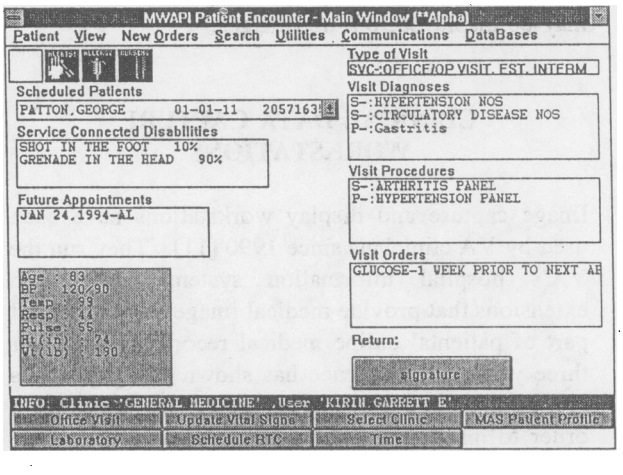

Figure 1: Outpatient encounter summary window

imported into the HIS database, and captured images. A clinician may use a single device for all interaction, or change devices during data entry, for example to make a diagram, handwrite a note or dictate.

INCENTIVES FOR CLINICIAN WORKSTATION USE

Clinician capture of data can be encouraged through the benefits obtained from the greater availability of data, the variety of patient data views, the range of data types available (structured and free text, images, electrocardiograms, anatomical drawings), and access to reference databases. Additional benefits are obtained by the institution due to availability of more accurate data for cost recovery and management.

The workstations access a variety of data from the hospital information system, including standard reports such as the patient's medication profile, health summary, progress notes, medical procedures reports, radiology reports, and laboratory results. These reports are often multiple pages and are therefore displayed in a window which can scroll or page for ease of review. Data presented at the workstation must be up-to-date and reflect the data in the main hospital system.

Images are available for review on the workstation using the "visual chart" option (see Figure 2) at some sites. Users may view all images pertaining to a particular patient, regardless of the hospital service that originated the images. For example, during a single hospital visit, a patient may have an endoscopy study, a biopsy read in pathology, an xray, an electrocardiogram and surgery. Image abstracts ("thumbnail" size images) will appear on an image menu, similar to that shown in Figure 2 and the user may select images to be viewed in full resolution. Images are displayed chronologically, and create a longitudinal record, including multiple hospital stays or outpatient visits.

Another benefit to workstation use is the availability of electronic multimedia mail from the graphical user interface workstation. Users may send and read mail conveniently. Mail messages may incorporate image, waveform, scanned document or voice data. This capability is being tested in a referral patient evaluation project between two test sites.

Finally, clinicians can access reference and other data sources from the workstation. Sources such as Medline, Micromedix, and CD-ROM data are being

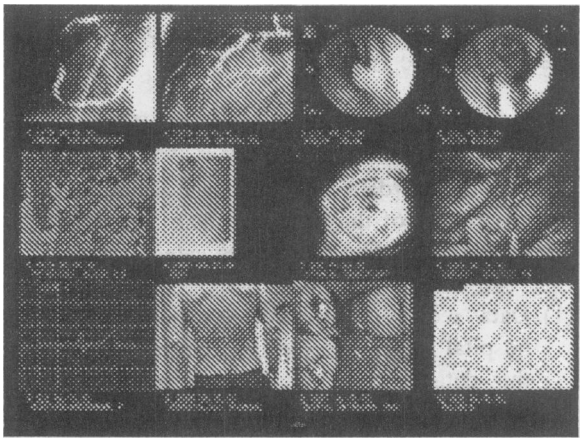

Figure 2: A true color Visual Chart summary of images for a patient is used to select images for full resolution viewing.

will be provided, depending on availability at the medical center.

REQUIREMENTS OF THE DATA CAPTURE PROCESS

The development process has followed the "VA structure model" where prototypes are developed and reviewed by a group of physicians and clinical users [18]. This has first been done by users at the initial test sites informally; it will be followed by more formal review. Suggestions are made for modifications. The resulting system is tested at alpha and beta test medical centers which provide feedback to the developers. Logging of system usage as well as user interviews will provide direct feedback and guide future development, as has been done for imaging workstation development [11]. There will be a formal evaluation of workstation use at the beta test sites, performed by an outside evaluation team.

Based on experience and the work of others, an automated data capture process must meet a number of requirements in order for physicians to willingly participate. These include:

- Data capture must be rapid. A typical outpatient visit may last only seven minutes. Data capture operations must be measured in seconds to avoid slowing physicians' work.
- Workstations must be simple to operate. Physicians cannot spend time figuring out how to do what they need to do. In many institutions, physicians rotate periodically, so training must be quick and easy.
- Input methods must be customized to the user. Different users prefer different input devices and screen layouts. Typing ability varies so different users will prefer keyboards, mice, and scannable forms.
- It must be possible to record various types of data. For example, some data is best recorded as structured text, others as captured images or annotated anatomical drawings.
- Finally, the record must be valuable to clinicians. Useful data must be collected and presented in a functional format; and data retrieval must be rapid.

IMPLEMENTATION OF SPECIFIC DATA CAPTURE METHODS

The use of a pointing device, such as a mouse or pen, for data entry requires that short to medium length lists of input choices be provided for user selection. These lists include the most commonly used terms for a specific clinic. We will examine whether the clinicians data capture task can be made easier if lists are created dynamically using patient specific information stored in the HIS. Users also have the ability to enter choices not on the lists. It is important to use the terms preferred by the clinician, but these must be mapped to standard terms for retrieval. The VA uses a standard clinical lexicon, which is updated as new terms are used. The clinician's own terms are recorded in addition to the standard terms so they can be displayed for the clinician reviewing the record.

Many clinicians prefer to dictate their narrative comments. The workstation allows voice dictation and records the audio data as a digital file. The digital voice file is stored on the network server and a transcription service directly accesses these audio files. These are transcribed to produce ASCII text files placed back on the network server and are linked to the patient's record automatically. They are then verified by the clinician before removal of the audio file.

Image data capture, including video capture of true color and black and white medium resolution images, is done using the workstations. Network interfaces have been developed to allow image acquisition directly from radiology PACS systems [14], image scanners, or electrocardiogram systems [15].

Another input mechanism to be tested at some sites and compared is the scannable form. There are commercial forms packages which allow automatic recognition of data entered on scannable forms [16]. These scannable forms allow entry of checkbox data, alphanumeric optical character recognition data, and scanned image areas. The same lists of commonly used diagnoses and procedures as described for the workstation may be used on these forms, and the same generic interface file may be used for input to the hospital information system. Check boxes are used as much as possible because of their greater reliability, however, alphanumeric recognition is used for entry of items not included in the most commonly used list. Scanned forms are printed individually for each patient scheduled for a clinic visit. This allows the inclusion of demographic and other data related to the patient and the customization of the lists to the clinic and even to the individual patient.

SYSTEM ARCHITECTURE

There are several alternative methods for creation of the graphical user interface. The VA has a policy of using standards that are hardware and software independent. The VA's hospital information system is written using the ANSI standard M language. M has developed a standard graphical user interface applications programmer interface (API) called the M Windowing API (MWAPI) [17]. Software for Microsoft Windows, Mac Windows and X Windows is identical from the programmer's perspective, and the software can be moved from one platform to another. The advantage of this approach is that the existing backend hospital information system software can be called directly in response to user actions. It is not necessary to write separate backend processor software.

An alternative choice is to use a non-M front end tool such as a platform independent windows code generation tool. The front end can be implemented using platform specific software such as Visual Basic for Microsoft Windows. User interface software must be written for each platform to be supported. This approach requires the writing of new backend and frontend software to incorporate the workstation functionality and enforce the VA's business rules.

The first phase of the VA's data capture workstation development uses the MWAPI approach. This approach was chosen because it could be implemented quickly and would allow the gathering very valuable user feedback. The approach will be evaluated after about a year, and decisions will be made for future versions.

DATA STORAGE MECHANISMS

Storage of the data that has been captured is an important part of the process. Data entered on the workstation falls into two access categories:

(1) Data requiring immediate storage within the hospital information system because changes to this data must be immediately available to all users. Examples of data which requires such a "live link" is vital signs, chief complaint, and nursing notes data. This is collected by the triage nurse, often within seconds of the time the physician sees the patient and needs to access the data. Problem list data is also shared by providers, the up-to-date problem list information must accessed for referral during the visit and changes must be rapidly updated following the visit. It is necessary to prevent multiple users from updating the problem list simultaneously through the use of locking mechanisms. It is difficult to meet these requirements with input mechanisms such as scannable forms.

(2) Data which may be processed in the background because only one user needs access at a time. This data is generally going to an HIS module which does not interact much with other modules or processes. Billing data can be processed in this manner.

We have implemented two mechanisms for transferring data to and from the data capture workstation. The first is the use of silent application programmer interfaces to the HIS modules. These are entry points in the software modules which may be called by the workstation to access or update data.

The second mechanism uses a generic interface file structure, which is a temporary file in which collected data is placed for processing by a background job. Any HIS module which needs data collected on the workstation will provide processing software to extract the data from the generic interface file and store it in package specific data structures. Therefore, the generic interface file is independent of the packages, and use of data can be extended to additional modules without modification to the user interface or interface file.

Data collected by the workstation is currently used by the following hospital information system modules: vital signs/nursing package, outpatient visit file (Patient Ccare Encounter module), billing package, radiology, pharmacy and laboratory packages (orders), and scheduling package (return visit).

CONCLUSIONS

We believe that technology now available will assist in clinical data capture by making the process easier. Proper design of a data capture workstation and its flexibility to satisfy clinician's individual preferences is critical to its clinical use. Other devices may be required to meet the needs of other clinicians. Clinician data capture will improve the quality of data for clinical care and billing because it is done by the person who knows the most about it. Use of the same data capture process for billing and statistical data assures more accurate accounting and management information.

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