Electronic Forms: Benefits and Drawbacks of a World Wide Web-Based Approach to Data Entry

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It has long been realized that, compared to paper-based records, electronic record systems provide many advantages in the healthcare environment, including increased availability, improved legibility, long-term accessibility, (potentially) greater completeness, data encoding, and automated decision support and analysis. In spite of these recognized benefits, collection of patient data at the point of service generally does not occur, in large part because each such effort usually requires application-specific software and hardware, and, most significantly, provider time. Given the presence of WWW browsers now available on nearly every desktop, the support and access concerns for data entry applications can be substantially lessened. Despite these advantages, there are also downsides to the use of the WWW for data entry, including user interface issues and security. At CPMC, we are currently using web-based forms to gather patient charge data from physical and occupational therapists. Benefits of this approach have included a 98.2% user compliance rate for at least weekly data entry, and the reduction of charge posting from an average of 24.3 days to 2.3 days following the date of service. Drawbacks to WWW-based applications have included increased security exposure and persistent human tendencies to enter data in batches rather than at the time of service. A final conclusion was that, in the absence of a strong central mandate, providers must perceive a clear benefit in order to be willing to learn and use a new technology.

INTRODUCTION

The Internet and most especially its graphical component, the World Wide Web (WWW), have been recognized by many in the medical informatics community as a means by which to integrate and present data from a variety of clinical systems, to rapidly develop prototype efforts, and to share resources with others who have similar interests and information needs. Many examples of clinical information made accessible via the WWW already exist.[1-3] These reports help to illustrate the potential of using the WWW to address the issue of data capture.

One of the greatest challenges to the full development of electronic medical records (EMRs), web-based or otherwise, is the need to have providers enter information directly into the system. User interfaces have been studied extensively over the years by many in the informatics community, and several developers have demonstrated successful systems for data entry using a variety of media, including graphical user interface (GUI) - based forms.[4-6] In our effort to bring the benefits of electronic data entry to Columbia-Presbyterian Medical Center (CPMC), we have found web-based forms to be a highly practical medium for development.

DESIGN CONSIDERATIONS

An advantage of the Internet approach to application development is the widespread accessibility of the WWW via a variety of browsers. Indeed, our primary motivation for choosing the web-based route was the CPMC environment itself. Our institution has taken the Integrated Advanced Information Management Systems (IAIMS) initiative to heart; access to a variety of clinical and administrative information systems is provided to the medical center faculty, staff, and students via over 6500 workstations of varying age, manufacturer, and operating system.[7] This heterogeneous environment has admittedly placed some limitations on the design of our web-based forms. For example, older workstations running Lynx (University of Kansas, Lawrence) can not take advantage of forms designed with Java (Sun Microsystems, Inc., Mountain View, CA). Also in favor of the web is the relative ease of user

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data-entry screen development; it takes little time to create these prototypes with HTML.

Another potential obstacle to work in this new medium, however, is concern about the confidentiality and security of patient data which is accessible via the internet (or intranet). This has now been exacerbated by electronic data entry applications (eg. forms), in part because of worries about improper additions or modifications to the clinical database. Although the standard issues of authentication and authorization exist for any software application, the knowledge that the information is potentially accessible to the entire world has heightened, in a positive way, the need to address security issues.

We have thus paid close attention to each security feature of our application. For example, one recognized limitation of Lynx is the fact that it does not (as of this writing) support secure socket protocols for encryption, normally a very desirable security feature.[8,9] This means that passwords (and other data) are transmitted in an unencrypted format over the internet when the user accesses our (or any other) system via a Lynx browser; this is not the case for Netscape (Netscape Communications Corp., Mountain View, CA) or Explorer (Microsoft Corp., Redmond, WA). We have therefore incorporated other browser-generalizable security measures in our application, including password protection, session keys, timed logouts, domain restriction, and audit trails.

We were also driven by concerns that the authentication and authorization features we implemented be efficient, in the event that we someday have large numbers of simultaneous users of the application. Finally, we had to take into account the fact that, in a sizable institution such as ours, the user population and the number of electronic forms are both potentially very large and dynamic. It is crucial to have a readily maintainable database of those who should have access to each type of form.

User interface issues in the WWW are also a natural concern. For example, data entered in an electronic form must first be validated by a common gateway interface (CGI) following its submission, rather than checked dynamically at the time of entry. Because of this system structure, it is then necessary to notify the user that there is an error with the submission, and provide an opportunity for it to be corrected. These issues are more readily addressed with tools like Java, but not with standard HTML.

IMPLEMENTATION

Our partners in the development of the initial electronic forms have been therapists in the divisions of occupational (OT) and physical (PT) therapy in the CPMC Department of Rehabilitation Medicine. The therapists revealed that a great documentation challenge for their group has been the capture and timely posting of patient charge data, so this eventually became the focus of our initial work. As a secondary agenda item, we also wished to use this new record of the therapists' activity to ensure that designated critical pathways were being followed (e.g., did a therapist visit each patient on the first day following total hip replacement surgery?).

With this plan in mind, a variety of forms were developed in HTML, and displayed via CGIs written in C. Current forms include those needed for logging in to the application, presenting the list of other forms available to a given user, and looking up patients in the hospital ADT system by either MRN or name. Separate patient service forms were created for the physical and occupational therapists, since charge codes and cost centers vary by specialty. Data entered in the patient service form is passed on to a CGI that checks to ensure that the date of service entered by the therapist is valid for a given patient account number, and that a cost center code is always selected. The CGI then passes the information on to a separate summary form, which was created to provide the therapists with an opportunity to check all of their entries before final submission. A separate review form allows therapists to look up their previously submitted charges by date of entry. Other forms available to all users include on-line help, comments, and a summary of features recently implemented in the application.

While work was proceeding on the actual forms, efforts were also underway on the back end of the system. To provide a basic means of authentication, each therapist was assigned an ID and password on a production unix platform. However, further levels of access and privilege needed to be defined. Ideally, we would have a single directory which securely defined access privileges across multiple applications. As this was not in place, we had to settle on an application specific solution. For simplicity and ease of implementation, we opted for a system that defined user access and privileges by membership in various unix groups. Our own

authorization server acted as a mediator between these groups and the CGIs, determining the appropriate read/write privileges for a given user on query from any CGI. As another security measure, the access domain of our application was restricted to our campus.

More than 100 therapists were trained on the system (usually in group sessions lasting no more than 30 minutes apiece). In order to take full advantage of our application, and increase the specificity of the information being captured, the financial services group at the hospital revamped the recognized procedure codes (from 5 nonspecific categories to greater than 45 CPT-based identifiers) with the goal of being revenue neutral, and arranged for electronic processing of the captured data via batch HL7 files. All components of the hospital financial systems were tested extensively to insure that the charges were uploaded, processed, and printed properly before the forms entered production.

RESULTS

The web-based patient service (a.k.a., charge capture) form has been in routine use since February 1, 1997. One objective measure of user compliance with the system is the fact that, over the course of the initial 4 months of use, the therapists who were expected to enter data in any given week did so 98.2% of the time. We have been able to measure several other variables, including the total number of charge submissions in a given month (> 6500) and the average monthly charges ($957,210). Of note, this latter figure is consistent with rates of the prior paper-based system and codes.

The most significant result to date, however, was the change in the time from the date of service to the date of data entry, which dropped from an average of 24.3 to 2.3 days. Also measured were variations in the delays in the posting of individual charges. These ranged from 2 to 66 days during the final 4 months of the paper-based system, and from 0 to 10 days in the first 4 months of use of the new electronic system.

An additional benefit of direct user entry has been the elimination of keypunch errors. With the paper-based system, operators were required to key in the therapists' charge data; given the tens of thousands of charges being entered manually, opportunities for errors were bound to arise. We noted in one month's data the entry of over $10,000 in charges with an obviously wrong date of service (due to the fact that these codes were not available in our electronic system for the keyed month of service, and thus could not have been entered via the forms). The electronic forms also eliminate the possibility of charges being ascribed to the wrong division (e.g., PT versus OT), because the cost centers for each division are defined on the respective patient service forms for these divisions. We have noticed OT charges appearing in PT cost centers, and vice versa, with manually keyed data.

Another feature previously unavailable to therapists is the ability of an individual to check submissions made earlier via the forms. Because the data have been entered and stored electronically, we can provide a detailed on-line log of prior activity. Therapists are thus able to identify overlooked bills, avoid duplicate submissions, and, on occasion, catch previous mistakes (e.g., date of service). Since there is no direct interface currently available to the hospital billing system, the only mechanism at this time for correction of errors is (ironically) a paper form.

One other financial benefit has been the elimination of the need to print the paper forms previously used by the therapists to document their charges. Not only is there a monetary saving, but this electronic medium permits the immediate modification of charges being used. When CPT codes are updated or new supplies are added to the standard inventory, it is now no longer necessary to modify, print, and distribute new paper charge forms.

Furthermore, supervisors can see who has or has not entered charges in a timely manner and can easily track down and verify disputed charges.

The physical and occupational therapy staffs are enthusiastic about the use of these electronic forms. Of note, only a handful of over 100 therapists had had any contact with the WWW prior to their training for this project. Many have commented that it is quicker and easier to enter the data in our application (even using Lynx) than on paper. Also, several have expressed satisfaction in knowing that their work now no longer risks being lost during processing; their supervisors can see the evidence of their labors in weekly reports which detail each therapist's activities.

DISCUSSION

The Internet has proven to be a very viable medium for application development in medical informatics, and, based on our experiences to date, HTML-based forms are clearly useful tools for both data

collection and presentation. Our electronic forms application has shown that data entered directly by clinicians can be beneficial in terms of charge capture and measuring treatments provided. This work has also demonstrated (via the initial high compliance rate) that providers, even those completely unfamiliar with the WWW, can be willing and even eager to use it as a means of recording data. Because there are a variety of browsers available for the WWW, the application is accessible from every workstation connected to our hospital's network; no special software installations or upgrades are required. Since HTML forms are easy to create, it is possible to rapidly prototype potential interfaces and get quick feedback from those destined to use them, thus potentially cutting overall development time.

There are, of course, several drawbacks to the capture of patient data via the WWW at this time. There are definite limits to plain HTML interfaces; some of these are being addressed by more powerful versions of HTML, browsers, Java applets, and commercially available form creation tools. Security issues will continue to be a concern, even with the more widespread availability and consistent use of features like secure socket layers. Maintenance of authentication and authorization mechanisms, especially critical for an application residing in a widely accessible medium like the WWW, will require constant attention.

It is also clear that willingness to enter patient data did not necessarily translate into an eagerness to complete the forms in a timely fashion, as evidenced by the 2.3 day average delay in recording patient treatment sessions. This tendency to postpone data entry thwarted our desire to use this mechanism as a means of decision support for critical pathways, which requires more timely data updates. However, the drop from 24.3 to 2.3 days is a vast improvement over the old paper-based charge posting. In addition, since inpatient accounts are normally closed five days after discharge, charges arriving after that time (for non-DRG patients) may well be lost as a source of revenue for the hospital; this new system may help address that problem.

We also learned that sometimes data entry features can be a little too user-friendly. For example, many of the inpatients are routinely seen by the same therapist and provided with the same treatments at each session, often on a daily (or more frequent) basis. Part of the reason for the delay in entering patient data turned out to be the fact that many therapists prefer to enter several days' worth of data on individual patients all at once. After entering data on one patient visit, the therapists then make use of the "back button" feature of the browser, and simply take advantage of the option we provided to change the date of service from the current date (the default setting). If the charge codes on the patient service form are unchanged, then the therapist simply resubmits the form with the new date. This saves them the daily effort of logging in to the application and then entering the patient's MRN for every single bill.

Perhaps the most important and generalizable lesson has been that one key to any successful information system is providing what the customer wants. We made several false starts on clinical forms which appeared useful for the occupational and physical therapists, but which in reality were much easier for them to continue charting in a traditional manner. More significantly, these initial attempts were for paper forms whose content, in an electronic format, would be of little obvious benefit in the therapists' daily patient care activities.

Clinical notes provide a tremendous challenge. They are enormously more complicated to build than a clearly defined entity such as a billing form. Something as simple as a quick diagram or drawing can be very difficult to capture electronically. Beyond the complications of user interface, in coding non-standardized concepts we must address some complicated knowledge management issues.[10-12] While desirable for many reasons, including decision support, critical pathways, and superior legibility and availability, computerized records can be seen as more trouble than they are worth by the providers who must make the transition from writing a daily note to entering it into the computer. In the absence of a strong central mandate, the providers themselves must see some benefit to working on the development and deployment of an electronic system. The potential advantages of electronic charge capture were immediately obvious to all involved in this particular effort, and this helped to rally support that was a critical factor in the project's ultimate success.

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