The Implementation of a Personal Digital Assistant (PDA) Based Patient Record and Charting System: Lessons Learned

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ABSTRACT

Personal Digital Assistants (PDAs) offer many potential advantages to clinicians. A number of systems have begun to appear for all types of PDAs that allow for the recording and tracking of patient information. PDAs allow information to be both entered and accessed at the point of care. They also allow information entered away from a central repository to be added or "synced" with data through the use of a wireless or wired connection.

Few systems, however, have been designed to work in the client/server environment. Even fewer have been designed as point of care additions to already existing enterprise systems. This paper describes the issues encountered in deploying such a system for use in the University of Washington Neonatal Intensive Care Unit (NICU). The lessons learned could be applied to other institutions that will seek to add handheld technology to information systems in the future.

INTRODUCTION

After new technology becomes available, people quickly find a way to use it. Unfortunately, without proper planning and understanding, such use can lead to failure or lack of adoption. Many papers have documented a need for careful consideration and testing when employing new systems or components. [1-5]This is especially true in a medical environment, when there is little margin for error, and large implications for privacy concerns. Privacy concerns are particularly an issue for handheld technology as PDAs are portable, concealable, and able to store large amounts of information.

Many physicians already use personal digital assistants (PDAs) in clinical use.[6] Applications have been developed to record and store patient information, calculate appropriate drug doses, provide databases of important information, and offer other forms of bedside clinical decision support.[7] In fact, due to their low cost, portable footprint, and easily deployable hardware – unburdened by the need for space, PDAs have been used to fulfill some of these functions incredibly well. Past papers have described their successful use in documenting patient encounters,[8] delivering wireless alerts,[9] and accessing information at the point of care.[10]

We conducted a study of a patient record and charting system that used PDAs to input and access information at the point of care. We hypothesized that such a system would reduce the number of times that information would need to be transcribed, resulting in a reduction of documentation errors in resident progress notes. We described the building of such a system, and how we chose the tools involved, in a previous paper.[11].

This paper focuses on lessons learned during the deployment of the system to test our hypothesis. Implementing such a system required a number of changes both to the structure of work in the unit, and to the system itself. The issues we encountered during this implementation provide many lessons to those who would like to deploy handheld technology in the clinical setting.

SYSTEM DESIGN

The new patient record and charting system was built entirely from pre-existing software and hardware. The data repository was a Microsoft Access database housed on a Dell Inspiron 4100 computer. The PDAs we used were Handspring Visor Deluxes.[12] The system itself was built using the Access based Pendragon Forms.[13] All routines, queries, and data manipulation were written in Visual Basic or SQL. Although we elected to use Microsoft Access, any ODBC compliant database, would have been acceptable.

A number of factors specific to the neonatal intensive care unit (NICU) setting were taken into account when designing the system. Residents are responsible for recording, absorbing, and interpreting a great deal of information, and their time is limited. Some information, such as medications, remains relatively static from day to day, while other information, like vital signs, must be rerecorded at least daily. The system allowed for the daily creation of slots for dynamic fields like patient flowsheets, but kept the relatively static fields constant (edited as needed). By the time the system was ready for testing, we believed that we had developed an

integrated PDA based client server system that would streamline and improve care.

ALPHA AND BETA TESTING

Since our system was designed and built by three physicians (AC, PTH, and SS) with experience in the NICU practice setting, we felt that it had a better chance than most of being easily accepted into the NICU user environment.

Alpha Testing: One author (AC) was primarily responsible for building the system. Alpha testing consisted of two of the three designers (PTH and SS) using the system in an unstructured manner. Despite involvement in the design phase the alpha testers found: a) titles and categories were ambiguous, b) the use of the system was also not nearly as transparent as initially thought. We decided that a comprehensive instruction manual would need to be written before further testing commenced.

The manual itself required testing by an extended group. Initially the manual focused on using the system we developed, but through review by the extended group we determined that sections would need to be added to orient those who were not facile with computers, let alone a PDA.

Beta Testing: We began the second stage of testing a month before our go-live date. We devised a checklist for beta testers to run through, which we felt would systematically test the system. In addition we encouraged open-ended experimentation. Although these tasks were easily accomplished, unanticipated issues were identified. Even though we had been very thorough in our creation of pick lists (medication, line, problem, and lab), we had missed certain rare entries. Another flaw in our plans was the use of a checklist in beta testing. Though we felt that we had covered a wide range of broad tasks, the presumptive creation of a list gave our testers an artificially imposed focus and direction that live users lacked. Thus, the actual users turned up problems that ideally would have been caught in beta testing. Future testing would need to be less structured.

IMPLEMENTATION

On November 14, 2001 our system went live. A step we felt was invaluable in the initial adoption of the system was that we had pre-populated the database with all the patients in the NICU at that time. The residents were thus able to spend their time learning the system rather than scrambling to transfer information from one system to the other. Orientation to the system took about one hour monthly when residents rotated in the unit. Manuals were distributed to the residents at this time as well.

One of the authors (AC) was available by pager seven days a week, from 8AM to 11PM. The fact that technical support was immediately available went a long way in smoothing the transition from the old system to the new one. When problems occurred, residents became distrustful of the system, especially if it required the re-entering of information. Problems, both those foreseen and not, arose throughout the four months of the system's trial. These issues made clear the strengths and limitations of handheld technology in this inpatient setting.

PDA HARDWARE LIMITATIONS

Although PDAs have evolved in power and capabilities, they still have a number of important limitations. These limits are often misunderstood, to the peril of both the user and the developer. *(Table 1)*

Hardware Limitations
1. Screen size too small for text-intensive portions of medical record
2. Text entry still too difficult
3. Instability – fears of crashing

Table 1: Summary of Hardware Limitations

Screen Size: The first, and perhaps, most important limitation of the PDA is screen size. For the purposes of this paper, we will discuss screens on Palm OS PDAs (Pocket PC's having only slightly larger screens). A typical screen has eleven lines of possible text on it. With a maximum of about thirty characters per line, a full screen of text with no other buttons, links, or titles could not easily fit the information contained so far in this paragraph. Users were especially resistant to scrolling, and some found that reading large amounts of text on a palm-sized screen was difficult. Furthermore, the presence of a scroll button, or a chance to change from a record to a field view, did not guarantee that users would notice it, or utilize it regularly. Hence, users who were not cognizant of all their options may have overlooked information that was intended to be communicated on the palm device. Given these problems, a truly effective screen of information actually fit thirty to forty words, making the PDA a relatively ineffective tool for reporting large blocks of text. Most successful PDA programs are calculators, reminders, and simple databases, which do not abuse the scroll button, suggesting that other developers and/or the marketplace have come to the same conclusion. Even successful applications that replicate books for the PDA have had to discover ways to "package" information into small blocks.

Data Entry: Another limitation to the PDA is data entry. Although the "graffiti" text entry tool for the Palm OS is vastly superior to previous attempts at

handwriting recognition, it is still not as easy or fast as simple handwriting. The Pocket PC has made some advances on their system as well, but none approaches pen and paper. To overcome this, we offered two keyboard attachments for the resident to evaluate. The Thumboard[14] had keys that were too small, and residents complained that it caused thumb strain over time. The Stowaway keyboard for Handspring Visor[15] met with more success, but it was rather fragile and needed to be replaced almost every other month. Even with these attempts, a recurrent complaint was how difficult it was to enter large amounts of patient information over time.

System Instability: As we attempted to use the Visors for the complex task of patient data management, they were more liable to freeze or crash while in use or while hotsyncing. Although this was not a fatal error, it was a source of frustration. The Palm OS edits data in place in storage memory. Therefore, almost all data is kept in what is essentially a RAM disk, and will not be erased by a "soft" reset. This means that a crash rarely results in the loss of information. Even crashes requiring a "hard" reset, which would erase all information on the PDA, were not fatal if the resident had recently backed up their PDA through hotsyncing. This, of course, did require us to stress again and again the importance of frequent trips to the hotsync cradle.

PDA SOFTWARE LIMITATIONS

Although we discussed the limitation of database software currently available for use on the PDA in our last paper, they are worth briefly revisiting. It remains true today that no software exists that allows for the easy creation and management of complex relational databases that link between the handheld and server environment. The Pocket PC has seen great advances, but tools are still relatively complex, expensive, and somewhat foreboding to all but the very experienced developer. Those available on the Palm OS are somewhat more limited, but easier to use.

Difficulty altering tables: While Pendragon Forms was one of the most powerful tools available for such a system's development, it had constraints that made altering the system very difficult. (*Table 2*) To distribute a form to the PDAs, it had to be "frozen" first. This meant that the structure of the associated table had to be permanently fixed. Fields could not be changed or their order altered. Pendragon also named the tables through an internal function that was not possible to reverse engineer. An addition or change to a form necessitated a complete rebuild of the associated table. Since we could not retain the old table name, all associated queries had to be rewritten as well. This made editing and revising the system very difficult.

Software Limitations
1. Very difficult and time-consuming to alter the table structures
2. Simple software packages not suited for such large data manipulation
3. Difficult to maneuver between tables
4. Hotsyncing is asynchronous
5. Data entry effectively limited to either PDA or PC, not both

Table 2: Summary of Software Limitations

Not full-fledged RDMS: Although Pendragon Forms appeared to be a suitable product for our goals, we found that our use of the system taxed its capabilities to the limit. The sheer volume of data being passed left the hotsyncing process vulnerable to a number of problems. We found that if the Pendragon Forms manager was active at the time of hotsyncing, certain forms would not pass from the PC to the PDA. This left the PDA with incomplete information, and often led to the creation of duplicate entries. These difficulties in part are due to the design intent of Pendragon Forms, which was created primarily for data collection, and not for the bi-directional movement of large amounts of data. The software was, however, capable of functioning in that matter, even though its efficiency and utility was stretched in this role. Since we wanted to maintain as much information on the PDA as possible, hotsync times were long and cumbersome even for small changes to patient data.

Another limitation of Pendragon Forms is that, at heart, it is not a relational database. Therefore, although we could set up links to the PC based relational system, the information on the PDA was actually a series of forms linked together in one-way relationships. This limited the way that people could move through the data on the PDA. Often they had to back out and move forward through five or six screens to see the same data on two different patients.

Asynchronous Data: A critical PDA issue concerns the asynchronous nature of hotsyncing. Information on the PDA and information on the PC only match immediately after a hotsync. At all other times, each has no information as to the state in which the other resides. This leaves any system vulnerable to conflicting entries or duplicate data. If data was changed on both the PDA and on the PC, Pendragon Forms could not automatically resolve the discrepancy. Although we could have set rules to give one precedence over the other, when dealing with critical patient data, this is never an ideal situation. To compensate, we recommended that

residents not make any changes on the PC, but consistently enter and edit all data on the PDA. While this solved the problem, it eliminated the very attractive option of using the PC to work on text intensive parts of the record. The way in which Pendragon Forms is set up also precludes the creation of new records on the PC; they must be created on the PDA. Thus, an admission – the most text-intensive process – had to be completed on the PDA even if a resident would have much preferred doing so on the PC. This led to obvious frustration.

USER ISSUES

We quickly found that even with the best intentions and detailed planning, we could not predict what users would do with the system. The specifics we encountered often shed light on the use of PDAs in general. (*Table 3*)

User Issues
1. Some things must be done with pen and paper
2. Users require some data to be stored in ways not easily accomplished on PDAs
3. If the system is not fulfilling a need, users will do something else on their own. They cannot be forced to use the system.
4. Users have vastly different needs with respect to both the EMR and PDAs

Table 3: Summary of User Issues

We had initially intended the PDA system to completely replace all pen and paper in the NICU. Indeed, if used to its full advantage, nothing would need to be "written" at all. All signout, note writing, and long-term planning could be done with the PDA alone. Unfortunately, some tasks were just not possible to transition to the PDA. Specifically, interns did not like to give signout on the PDA. Signout consists of the intern staying overnight listening to reports about others' patients, and planning their work for the night. We had initially envisioned each intern deciding what needed to be done on their patients, entering those tasks onto their PDA, and then transferring that information to the intern on call. Residents, however, found this system too difficult to use on a daily basis. It required too many trips to the hotsync cradle, and information could not be easily and quickly reviewed. As we discussed their desires with them, we realized that there was no way that we could summarize the signout page and signout system the residents were used to on the small PDA screen.

This belied a much larger and important lesson. Some tasks are just not appropriate for the PDA. The ideal system the residents wished for required too many points of access, too much text, and too many updates for the current generation of PDAs to realistically handle. After multiple attempts, we decided to abandon out plans for PDA signout, and let the residents continue to handle it on paper.

Residents also wanted to have the ability to "jot" down information at various times. Pendragon's fixed forms made such additions difficult. We eventually added free text fields to every form, but remembering where the jotted information was placed frustrated the residents. Some savvy users began to use the memo function of the PDA, but the non-uniformity of style and use made this solution undesirable.

More disconcerting were the heterogeneity of requirements our users seemed to have. Since our users were from different experiences and backgrounds, they had very different needs and assumptions, both technologically and clinically. Many were so overwhelmed by the clinical work of the NICU that they had difficulty constraining their thoughts and ideas to the field sizes on the PDA. We also found that those working a given month frequently rejected the changes we made to address the requests of the prior month's interns. Finding a happy medium was almost impossible. We also found that while some technophobic users had accepted the necessity of computers in clinical practice, they had not yet done the same with PDAs. They viewed this technology as more of a toy than a tool.

DISCUSSION

While the PDA based client/server patient record and charting system developed for the NICU had limited success from a user perspective, the lessons learned from its design and implementation can help to forward the use of handheld technology with the medical record. Our work clearly identified a number of areas where handheld hardware and software need improvement for these types of ventures to succeed. (*Table 4*)

Future Advances
1. More sophisticated database applications with easy linking to enterprise systems
2. Synchronous data transfer without sacrificing security
3. Easier data entry, perhaps with voice recognition and dictation
4. Increased screen size

Table 4: Summary of Advances needed to make PDAs more useable with an EMR

While we were able to build the system using tools that were readily available, they were nowhere near perfect, and often difficult to use. Although there

have been recent advances in the sophistication of database applications for PDAs, especially the Pocket PC based systems, they are still requiring rather advanced knowledge to properly use and develop applications and systems.

Synchronous data transfer is a necessary component of any successful future system. This, by definition, will require some sort of wireless connection if handheld technology is going to be used in environments such as the NICU. Unfortunately, this raises a number of issues about security that will need to satisfy institutions, individuals, and HIPAA requirements.[16, 17]

Finally, some hardware and system improvements will go a long way to improving the acceptance and use of handhelds in conjunction with the EMR. Although the screen size of today's PDAs work well for address books and calendar planners, they are simply too small to review the amount of information in a medical record. Some way must be found to increase screen size without sacrificing the portability of handheld technology. A simple and easy way to enter large amounts of information must also be developed that surpasses methods in use today. One method that would likely be of use would be a voice recognition module that allows users to dictate information into the PDA. Although some systems in use allow the recording of dictation for later transcription, real-time translation into entered data would be much preferred.

Handheld technology has much to offer the electronic medical record in allowing users to access and enter information at the point of care. Advances must be made in the technology available, however, before its use and acceptance in such a setting becomes widespread. More importantly, acceptance is only the first step; this technology must also improve care. To that end, we are conducting an intervention trial to see if this system can reduce documentation discrepancies in resident daily progress notes by comparing the frequencies of such discrepancies before and after system implementation. We hope to present results from this study at AMIA in the future. Outcomes studies such as this are a necessary next step in the widespread acceptance of any system.

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