ARTICLE

Application of a Palm OS Patient Monitoring Tool in an Infectious Diseases Consult Service

Stephanie W. Ong, Sandra A.N. Tailor, and Scott E. Walker

ABSTRACT

Personal digital assistants (PDAs) and their application software must be evaluated to determine their suitability to either an individual's or a department's clinical services. In an infectious diseases clinical pharmacy service, accuracy, efficiency, and organization of documentation are required to ensure effective provision of pharmaceutical care to patients. The features and capabilities of PDAs can play an important role for the infectious diseases pharmacist. One of the objectives of this project was to assess the feasibility of incorporating an electronic patient monitoring form into infectious diseases pharmacy services. In 2002, a pharmacy resident, working with the clinical coordinator for infectious diseases, developed an electronic patient monitoring form for the infectious diseases consult service. The monitoring form was pilot-tested during the pharmacy resident's 5-week clinical rotation. During that period, a paperless system was used to track and monitor patients referred to the service. The electronic monitoring form reduced the pharmacist's clinical workload by consolidating patient information in one medium. Furthermore, data collected from monitored patients were directly synchronized and stored in a Microsoft Access database, which allowed for more efficient data retrieval and analysis. The development and implementation of a suitable electronic patient monitoring form for the infectious diseases consult service provided assurance of the benefits of a PDA in a specialized area of clinical practice by facilitating clinical monitoring and data collection activities.

Key words: personal digital assistants, pharmacy documentation, information technology

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RÉSUMÉ

Les assistants numériques personnels (ANP), ou PDA en anglais, et leurs logiciels doivent être évalués afin de déterminer s'ils conviennent ou non à une personne ou aux services cliniques d'un département. Dans un service de pharmacie clinique en infectiologie, la précision, l'efficacité et l'organisation de la documentation sont nécessaires à la prestation efficace des soins pharmaceutiques aux patients. Les fonctions et les capacités d'un ANP peuvent jouer un rôle important pour le pharmacien spécialisé en infectiologie. L'un des objectifs de ce projet était d'évaluer la possibilité d'incorporer un formulaire électronique de suivi des patients dans les services de pharmacie en infectiologie. En 2002, un résident en pharmacie, en collaboration avec le coordonnateur du service de pharmacie clinique en infectiologie, ont mis au point un formulaire électronique de suivi des patients pour le service de consultation en infectiologie. Le formulaire de suivi a fait l'objet d'un essai pilote durant le stage de cinq semaines du résident. Au cours de cette période, un système zéro-papier a été utilisé pour retracer et faire le suivi des patients adressés au service. Le formulaire électronique de suivi a réduit la charge de travail clinique du pharmacien en consolidant l'information sur le patient dans un seul et même outil. De plus, les données recueillies sur les patients suivis ont été directement synchronisées et mises en mémoire dans une base de données Access de Microsoft, ce qui a permis l'extraction et l'analyse plus efficaces des données. L'élaboration et la mise sur pied d'un formulaire électronique de suivi des patients approprié dans un service de consultation en infectiologie a confirmé les avantages de l'utilisation d'un ANP dans un milieu de pratique clinique spécialisé, en facilitant les activités de suivi clinique et de collecte des données.

Mots clés : assistants numériques personnels, documentation pharmaceutique, technologie de l'information

INTRODUCTION

Since the launch of the Palm Pilot handheld computer (Palm Inc, Santa Clara, California) in 1996, sales of personal digital assistants (PDAs) have grown exponentially.[1] With more than 700 medical applications available for Palm OS-based systems, the health care industry has definitely contributed its share to this rapidly expanding technology.[1] Available medical software ranges from drug information references, diagnostic tools and protocols, and patient-tracking and data management applications. Because pharmacy is an information-driven profession, pharmacists are faced with the challenge of evaluating the role of such devices and applications in their clinical practice. Recently published studies[2-4] evaluating the use of PDAs for documentation in pharmacy practice have identified several advantages, including accuracy, efficiency, and portability. Although Brody and colleagues[4] identified the common shortcomings of using a PDA-driven documentation tool, including the high maintenance requirements of the devices, economic and practical considerations, and incompatibility with existing programs used by clinical services, these technological drawbacks do not preclude adaptation of the tool to clinical practice today. Clearly, it is important to evaluate PDAs and associated software to determine their suitability for either an individual's or a department's clinical services.

The infectious diseases consult service at the authors' institution sees patients with a variety of medical conditions who are receiving complicated therapeutic regimens in departments throughout the hospital. The infectious diseases pharmacist plays a significant role on this team by providing several clinical services for patients. These activities range from providing therapeutic drug monitoring consults of antibiotics, monitoring patients for response or adverse drug reactions, making appropriate recommendations on therapy, providing drug information, educating other health care providers, and participating in research studies. The demands of the infectious diseases consult service require accuracy, efficiency, and organization in documentation to ensure effective provision of pharmaceutical care to patients. The features and capabilities of PDAs can play an important role in this regard, since they offer the capability of documentation at the point of care, portability of data, and enhanced organization.

The objectives of this study were to critically assess the features and capabilities of ePatient2000 and Pendragon Forms as patient monitoring and data management tools for the infectious diseases consult service; to design and implement a suitable electronic patient monitoring tool and patient database to track pharmacoeconomic data for the service using 1 of these 2 programs; and to assess the feasibility of incorporating an electronic patient monitoring tool into existing pharmacy clinical services on the infectious diseases consult service. It was anticipated that development of a PDA-driven monitoring tool for the service would enable efficient data collection for future clinical and research projects, including tracking of pharmaco-economic information.

ASSESSMENT OF PATIENT MONITORING APPLICATIONS

The first stage of this project was to become acquainted with features and components of the PDA. The device chosen for this project was the Palm m505 (Palm Inc, Santa Clara, California), which was the only unit with expansion capabilities available at the time the project was initiated.

Preliminary evaluation of several commercial patient monitoring and database programs determined that 2 software packages, ePatient2000 (IatroSoft Corporation, Houston, Texas) and Pendragon Forms (Pendragon Software Corporation, Libertyville, Illinois), were best suited for further investigation in the development of an electronic monitoring form and database for the infectious diseases service. In determining which of these 2 software packages was most suitable for this project, the infectious diseases pharmacist developed a list of program features that would be important in fulfilling a pharmacist's functions: ability to track patient information monitored by the infectious diseases pharmacist (i.e., patient demographic characteristics, present medications, history of present illness, infectious disease-related diagnosis, and relevant laboratory results), potential to track clinical and pharmacoeconomic data, flexibility (the tool should allows users to proceed without completing all fields), password protection to ensure patient confidentiality, generation of an automatic task list for downloading to a Microsoft Outlook calendar (Microsoft Corporation, Seattle, Washington), and compatibility with current Microsoft applications for data analysis.

Investigators gained expertise in using both ePatient2000 and Pendragon Forms. The nature of each program was analyzed with respect to its organization, configuration, and format. Investigators reviewed the capabilities of each program and compared each

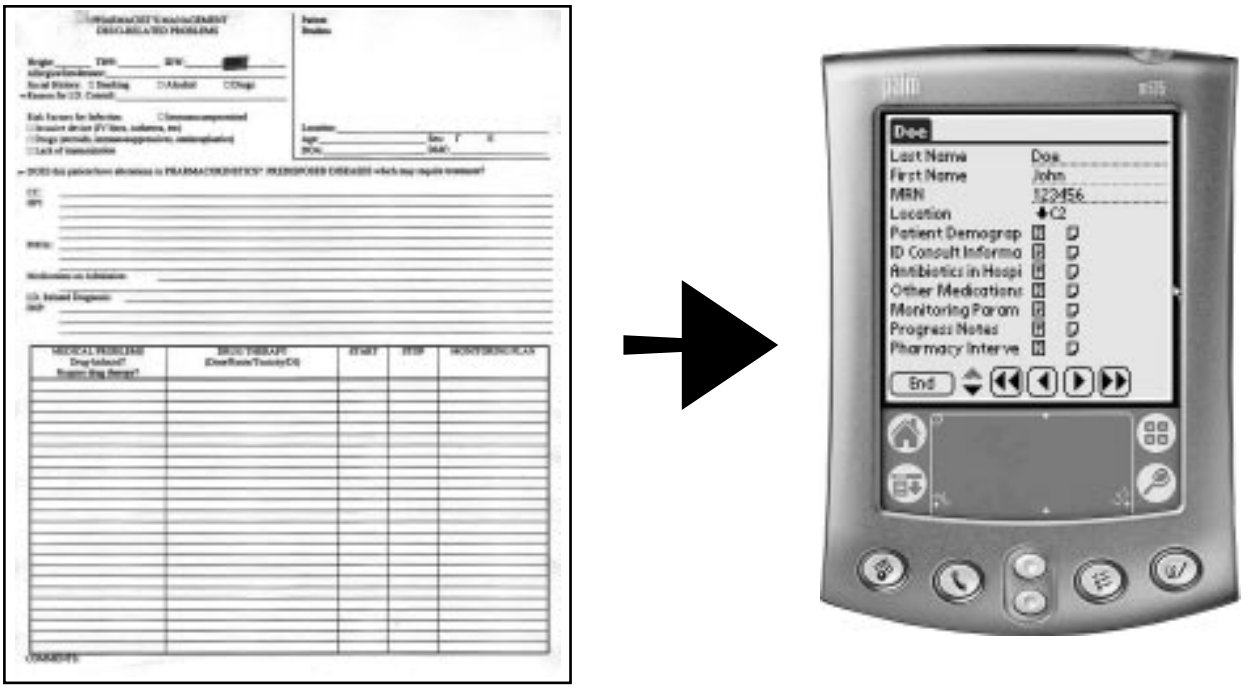

Figure 1. Pilot electronic monitoring form for infectious diseases (paper template and version for personal digital assistant).

program to the specific goals of developing an electronic patient monitoring form with capabilities for automatic downloading to a database.

ePatient2000 is a patient-tracking software application with built-in medical references (e.g., database of medications, microbiology information) and patient documentation forms.[5] Although it contains a comprehensive medical documentation form, its major disadvantage, for the purposes of this project, was lack of ability to directly link to personal computer (PC) databases. As a result, a user cannot directly transfer data that have been input through the PDA to his or her PC for storage and future analysis of data.

Pendragon Forms version 3.19 is a software package for creating forms, based on Microsoft Access (Microsoft Corporation). This software allows the user to create customized forms, which are transferred to the PDA for data collection. The data are automatically transferred to the user's desktop computer when the PDA is synchronized ("hot synched") with the desktop. Pendragon Forms is compatible with Microsoft applications and therefore the data can be transferred automatically from the PDA into a database application such as Microsoft Access. Because Pendragon Forms could perform the dual role of form creation and automatic data synchronization, it was selected as the software of choice for developing the electronic patient monitoring form for the infectious diseases consult service. While the electronic patient monitoring forms were being developed, the Pendragon software company launched an upgrade of the program (version 3.2).[6] The new features of this upgrade were incorporated into the electronic form developed for the consult service.

DESIGN AND DEVELOPMENT OF ELECTRONIC PATIENT MONITORING FORM

The electronic patient monitoring form developed through this project was based on an existing paper documentation template that had been used by the infectious diseases pharmacist to monitor patients on the consult service (Figure 1). To facilitate data entry, predefined fields such as calendars and "pick lists" for common medications, medical conditions, and infectious disease-related diagnoses were developed and incorporated into the electronic monitoring form. These aids decreased the need for the user to manually transcribe patient information onto the electronic form. In addition, formulas for calculating patients' ideal body weight and creatinine clearance were preprogrammed to enhance the clinical utility of the tool. These

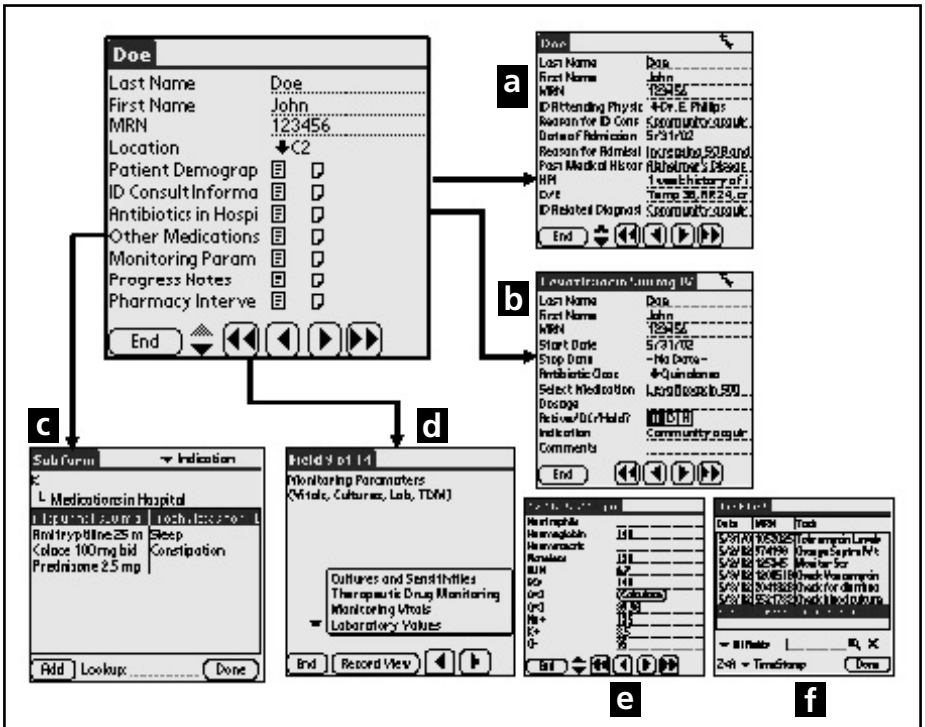

Figure 2. Pilot electronic monitoring form consisting of (a) summarized consult information, (b) antibiotic information, (c) other medication summary, (d) monitoring parameters, (e) calculation of creatinine clearance, and (f) task list.

calculations were beneficial for the infectious diseases pharmacist because dosage adjustment on the basis of renal function and weight are performed regularly.

The infectious diseases clinical coordinator (S.A.N.T.) and pharmacy students at various stages of their education assessed the ease of use of the electronic patient monitoring tool during patient rounds. For the tool to be considered valuable, the users had to be able to enter relevant information about patients while the infectious diseases house staff verbally presented the patient to the consult team. To ensure that the final version of the form was flexible and adaptable for use by different pharmacists, a variety of modifications were incorporated regularly, including enhancement of the esthetic appearance of the form, rearrangement of the data fields to ease navigation across fields, and verification that pick lists contained comprehensive information that users might need during their clinical practice. These changes were based on input from several pharmacy students, pharmacy residents, PharmD candidates, and the clinical coordinator.

Features of the Electronic Monitoring Form

The pilot electronic monitoring form encompassed a parent form, which branched out into several subforms (Figure 2), including the following:

- Patient demographic characteristics
- Infectious diseases consult information
- Antibiotics administered in the hospital
- Other medications
- Progress in the hospital
- Monitoring parameters (cultures, laboratory values, vital signs, therapeutic drug monitoring)
- Pharmacist interventions
- Daily task list

Information for new patients was entered through the main parent form, and all other specific information regarding the patient was entered using the respective subforms.

During this project, patient confidentiality was protected through several mechanisms. First, only the project investigators (a pharmacy resident [S.W.O.], an infectious diseases pharmacist [S.A.N.T.], and the research coordinator [S.E.W.]) had access to the PDA and the data collected via the electronic forms. The upgrade of Pendragon Forms (version 3.2) allowed password protection of specified forms, which ensured that only authorized persons would be able to use the PDA and access information collected through the electronic forms. The device was used

solely on the infectious diseases consult service for the provision and documentation of patient care and for research purposes and stayed in the hospital at all times. The dedicated Palm m505 was not used for personal purposes (e.g., as a day planner). Infrared beaming, to transfer data from one device to another, was not performed to transfer any patient documentation, because this feature is not supported by Pendragon Forms. During the documentation process in the data collection phase, patients were identified by name and hospital number; use of these identifiers facilitated patient monitoring and follow-up and the retrieval of information for patient care. However, in the database, for the purposes of data analysis, patient names and hospital numbers were omitted. Through these measures, every safeguard to maintain patient confidentiality was followed.

PILOT-TESTING OF ELECTRONIC PATIENT MONITORING FORM

During the pharmacy resident's 5-week infectious diseases clinical rotation, she used the pilot electronic patient monitoring form in providing care to patients assigned to the infectious diseases service. As medical residents presented new patients during daily bedside rounds, the pharmacy resident entered information about the patients using the electronic form. Patients' progress, antibiotic changes, laboratory results, and pharmacist interventions were also documented by means of the PDA as part of the daily clinical activities of the pharmacy resident. The PDA was synchronized daily with a desktop PC to ensure that data were regularly transferred to the database. Each day the pharmacy resident also reviewed the task list for each patient.

The total number of referrals to the consult service during the pilot period was 48. The pharmacy resident's initial target was to follow approximately 5 infectious diseases patients per week using the PDA. This target was selected because it was anticipated that this number of patients would provide sufficient experience in using the PDA, would allow collection of sufficient data for analysis, and would be manageable for a pharmacy resident. However, expectations for patient follow-up were exceeded, and a total of 32 patients were followed with the PDA tool during the 5-week pilot period. The remaining 16 patients were followed by a fourth-year pharmacy student, who used the manual documentation form that had been in use before development of the electronic form.

The PDA was well received as a documentation tool by the clinical coordinator, pharmacy students, and residents on rotation. There were clear advantages to using the PDA for documenting clinical pharmacy services. All individuals involved with evaluating the PDA tool agreed that consolidation of patient information with electronic references (i.e., ePocrates Rx and ePocrates Qid; ePocrates Inc., San Mateo, California) made the tasks of retrieving patient information and delivering services more efficient. Using the electronic documentation form, the pharmacists could easily review antibiotics (past and present) prescribed during the hospital stay. Furthermore, the daily task list enabled the pharmacists to efficiently retrieve and prioritize clinical activities. The use of preprogrammed formulas (i.e., for creatinine clearance and ideal body weight) ensured accuracy and decreased the need to carry another device such as a calculator.

GENERATION OF REPORTS THROUGH THE ELECTRONIC DATABASE

A Microsoft Access database was developed automatically as the electronic patient monitoring forms were being developed, since Pendragon Forms is built on Microsoft Access. Patient data collected during the pharmacy resident's infectious diseases rotation were automatically downloaded from the electronic patient monitoring forms to the database (on a desktop computer) and were then used to generate the following outcome-based reports for the consult service:

- Antimicrobial usage, including itemization of costs and indications
- Summary of specific diagnoses, treatments used, and cost of treatments
- Types and numbers of specific diagnoses
- Diagnoses, with organisms grown and antimicrobial sensitivity patterns
- Summary of pharmacist interventions
- Summary of "active" patients referred to the consult service (infectious diseases consult patient list)

One example of a cost analysis that can be generated by the database is a report that calculates the total cost of pneumonia treatment (Figure 3). The analysis is performed using an antibiotic cost table, which allows generation of summary reports for cost of treatment and antibiotic expenditure. This report breaks out costs for 3 different types of bacterial pneumonia, according to the indication for therapy when each antibiotic is prescribed. Within each type of pneumonia, the antibiotics used, the duration of therapy (average,

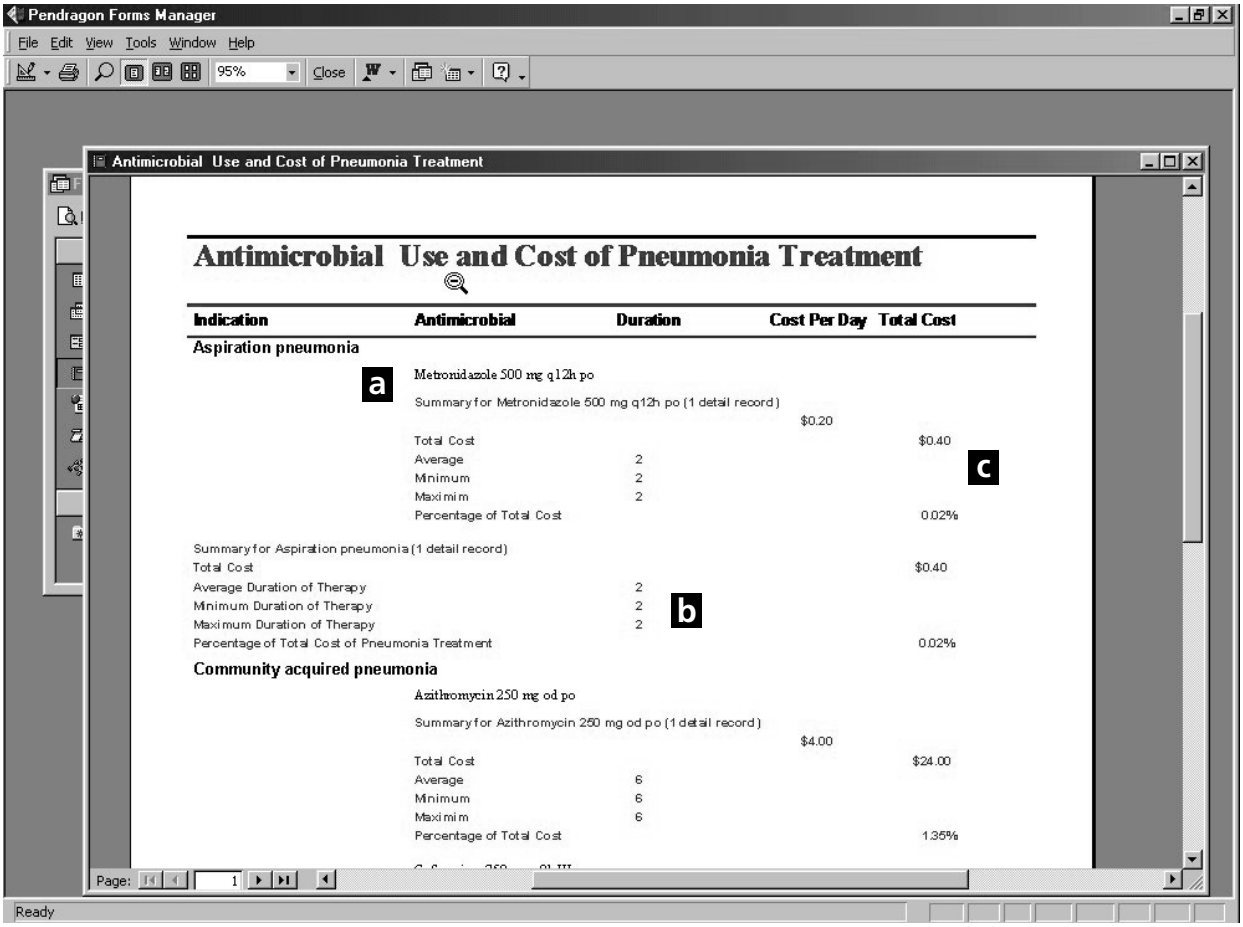

Figure 3. Cost analysis for treatment of pneumonia: (a) antimicrobials used, (b) duration of therapy, and (c) total cost of treatment.

minimum, and maximum), and the cost of therapy are itemized. The total cost of pneumonia treatment and the percentage spent on each class and each specific antibiotic are also reported ("cost of treatment" refers to approximate acquisition cost for antimicrobials used).

BUDGET

The total amount spent on this project was $1,865.64, including the cost of one Palm m505 unit, user licences for ePatient2000 and Pendragon Forms, and 2 Microsoft Access courses (Appendix 1).

DISCUSSION

The development and pilot-testing of an electronic patient monitoring form for the infectious diseases consult service provided assurance of the benefits of incorporating a PDA into a specialized area of clinical practice.

As has been the experience of other pharmacy practitioners using a PDA-driven documentation tool,[2,3] the authors found that the PDA helped to overcome many of the limitations associated with using paper documentation. Because of their portability and ability to hold and manage large amounts of information, PDAs can greatly assist pharmacists in day-to-day clinical activities by enabling efficient and standardized data entry through customized pick lists and by providing quick access to patient information and PDA-driven reference resources, right at the patient's bedside. The versatility and ease of use of Pendragon Forms software allows users to create forms that suit their specific needs and that therefore can be adapted to any clinical practice. Furthermore, using a database development program such as Pendragon Forms allows for automatic and efficient data analysis through direct synchronization with desktop applications, a formidable task that is not possible with paper forms. Previous

projects have provided examples of the types of data analysis that can be performed with an electronic monitoring form, including cost savings reports,[3] tracking of pharmacist interventions,[2,4] and drug use evaluations.[7] In this project, the infectious diseases pharmacy database was set up to include approximate antimicrobial acquisition costs, to allow generation of cost analyses as well as workload statistics.

The ability to automatically transfer information from the PDA to a database enabled efficient tracking of patient data, such as antimicrobial use, types of diseases seen on the consult service, and costs of therapy over a specified time period. These data are available for retrieval from the database within minutes of a request. In contrast, it would take weeks to enter data via the existing manual tracking system and transcribe it into a database for future retrieval.

The data collected through the PDA monitoring tool may be used to facilitate future projects, such as tracking drug expenditures on specific services, performing drug use evaluations, and analyzing clinicians' workload statistics. The decreased need to use paper forms for data collection saves resources (both paper and time), and because information is directly downloaded from the PDA to the desktop database, the possibility of error during manual transcription from paper to database is eliminated; furthermore, no time is required for transcription of written information into the database. Although data entry error when using the PDA cannot be completely eliminated, the potential for this problem is reduced by standardized pick lists in the electronic monitoring form.

Future expansion of this project lies in 2 possible directions. The first possibility could be developed within the infectious diseases consult service. Currently, infectious diseases physicians share information about patients through text documents transmitted by e-mail. With the PDA as a monitoring tool, physicians could share information through direct access to and downloading from the infectious diseases database. Patient information could be updated and shared daily, and periodic summaries could be printed from the database for regular review. Members of the infectious diseases consult team would also be able to track antimicrobial usage and costs, common diagnoses encountered, and, in the future, patient outcomes. The other expansion possibility is application of the PDA to other pharmacy services (e.g., cardiology, medicine), which would allow pharmacists in other areas of the hospital to track interventions and to generate reports such as clinical workload statistics.

Limitations

Although the present research project allowed evaluation and pilot-testing of an electronic monitoring form, feedback and input from other pharmacists were not systematically recorded. Informal feedback was incorporated as the forms were developed and refined, but a properly validated survey would have provided a more objective measure of pharmacists' attitudes toward the PDA as a patient monitoring tool. Time and motion studies would have provided an objective assessment of whether a PDA-driven monitoring tool reduces the amount of time needed for documentation of activities and retrieval of relevant patient information. However, time constraints did not allow this type of evaluation.

Using a PDA as a documentation tool did involve an initial learning curve to become comfortable with the new medium, including learning the Graffiti language for data entry and gaining comfort with the compact screen. Because manual data entry was still required at the point of real-time patient monitoring, the time saving was achieved through increased efficiency of information retrieval and data analysis on both the PDA and the desktop database. These limitations should not prevent pharmacists from accepting PDAs in clinical practice, in that they were offset by several features to ease data entry, including using the program Word Complete (version 1.0; Communication Intelligence Corporation, Redwood Shores, California) (a program that suggests complete words on the basis of just the first few letters) and comprehensive pick lists.

The lack of compatibility with existing hospital systems poses a barrier to achieving full integration of such technology.[3] Manual data entry of laboratory results and medications is still required, which leads to some redundancy in data entry of patient information; however, the paper documentation tool also had this limitation. Another hospital pharmacy has used a similar program to directly download laboratory data to a PDA.[8] Future projects will involve working with the hospital information systems department to integrate the laboratory and infectious diseases monitoring systems.

The final limitation of this monitoring tool is the inability of the program to automatically transfer data from task lists to a Microsoft calendar with reminder alarms. It is hoped that future versions of Pendragon Forms will incorporate this feature.

CONCLUSIONS

PDAs have many untapped resources and applications to offer to pharmacists and other health care professionals. Exploring the potential contributions of this new technology will facilitate the progression of clinical pharmacy services. In this study, the features of Pendragon Forms allowed pharmacists to design and successfully incorporate a suitable patient monitoring form into the daily clinical activities of the infectious diseases pharmacist. Because Pendragon Forms also allows for direct synchronization between the PDA and a desktop database, patient information collected with the PDA can be used to track data for future clinical and research projects, including pharmacoeconomic analyses.

In the past year alone, numerous presentations and research initiatives have demonstrated the many applications of PDAs as documentation tools in pharmacy practice.[7,8] With the wide range of possible applications of PDAs, from drug use evaluations to tracking pharmacist interventions, pharmacists are witnessing the birth of a new medium that will enhance clinical practice.

References

1. Felkey BG, Fox BI. Palm OS or Pocket PC? *Hosp Pharm* 2002;37:545-50.
2. Reilly JC, Wallace M, Campbell MM. Tracking pharmacist interventions with a hand held computer. *Am J Health Syst Pharm* 2001;58:158-61.
3. Lau A, Balen R, Malyuk DL. Using a personal digital assistant to document clinical pharmacy service in an intensive care unit. *Am J Health Syst Pharm* 2001;58:1229-32.
4. Brody J, Camamo JM, Maloney ME. Implementing a personal digital assistant to document clinical interventions by pharmacy residents. *Am J Health Syst Pharm* 2001;58:1520-2.
5. Solutions [ePatient2000 product information]. In: ePatient mobile healthcare productivity platform [Internet homepage]. Houston (TX): IatroSoft Corporation; 2002. Available at: http://www.iatrosoft.com. Accessed 2002 Jun 19.
6. Pendragon Forms 3.2 [product information]. In: Web site for Pendragon. Libertyville (IL): Pendragon Software Corporation; 2002. Available at: http://www.pendragon-software.com. Accessed 2002 Jun 19.
7. Scholtz JM. How to perform drug use reviews without killing trees: use of PDAs in pharmacy practice [abstract]. American Society of Health-System Pharmacists 36th Midyear Clinical Meeting; New Orleans; 2001 Dec.
8. Lau A, Lam RW, Balen RM, Malyuk DL. Using a personal digital assistant to document pharmaceutical care services: update [abstract]. American Society of Health-System Pharmacists 36th Midyear Clinical Meeting; New Orleans; 2001 Dec.

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Some aspects of this study were described previously in a letter to the editor published in the September 2002 issue of *CJHP* (volume 55, issue 4, pages 281-2).

Appendix 1. Project Budget

Item	Cost ($)
Palm m505	787.75
Pendragon Forms 3.19	248.07
ePatient2000	106.32
Microsoft Access course (2 at $295.00 each plus taxes)	678.50
Other resources	No cost
Total	$1,820.64