Techniques for Identifying the Applicability of New Information Management Technologies in the Clinical Setting:
An Example Focusing on Handheld Computers

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Abstract
This article describes techniques and strategies used to judge the potential applicability of new information management technologies in the clinical setting and to develop specific design recommendations for new features and services. We focus on a project carried out to identify the potential uses of handheld computers (i.e., the Palm Pilot or a small WinCE-based device) in the ambulatory practice setting. We found that the potential for a robust handheld computing device to positively affect the outpatient ambulatory clinical setting is enormous, and that the information derived from the exploratory research project is useful in creating specific design recommendations for further development.

Introduction
The development of new information management technologies is proceeding at an astounding rate. In just the last 10 years, the Internet and all its accompanying technologies (e.g., browsers, Java, XML, search engines), cellular telephony, handheld computers, and high-speed data networks, to name just a few, have become everyday concepts 1. Unfortunately, as anyone even remotely associated with the field of clinical medicine can attest, we continue to lag most information-rich industries in the adoption of these new technologies 2.

Much has been written about the causes of this seemingly slow adoption rate in medicine 3, but regardless of the possible causes, the job of the informatician remains the same; attempt to identify the potential applicability of (and then realize the benefits of) new information management technologies in the field of medicine. While seemingly a simple and straightforward task, clinicians are often reluctant to accept our "glorious" predictions of the future without any sound evidence for its validity. Therefore, the goal of this article is to describe various techniques and strategies that have been developed in an attempt to solve this type of problem. We will do this by describing a project we carried out to identify the potential uses of handheld computers (i.e., the Palm Pilot or a small WinCE-based device) in the ambulatory practice setting.

Background
Within this section we provide an overview of many of the techniques that researchers have developed in an attempt to provide answers to this type of question. Following a brief description of each technique we present several of the positive aspects of the method, followed by several of the drawbacks that must be overcome.

Overview of Techniques
Review of the literature
Reviewing the available literature pertaining to a particular technology is often the first place an investigator should start. While a literature review is relatively easy to conduct, requiring only rudimentary information retrieval skills, there are several key limitations to this technique. First, the literature is heavily biased toward reports of successes. Second, there is always a lag between the introduction of new technologies and the first reports of their use. Therefore, while a thorough review of the literature should form the basis of any scientific investigation, its use in identifying the potential applicability of new information management technologies is rather limited.

One-on-one Interviews
One-on-one interviews with practicing clinicians that either have used the new technology or can imagine its use are another source of valuable information. Such interviews have the benefit of being much more up-to-date than literature reviews, as well as, often providing information on failed projects. Unfortunately, such interviews also have certain limitations. Specifically, the number of
interviewees that can be identified, contacted, and actually talked to, is limited. Therefore, the conclusions that one can draw from this line of inquiry are difficult to generalize. Ideally, the interview will consist of a mix of structured and unstructured, or open-ended, discussion. There is a definite skill set required to conduct high-quality interviews that is somewhat difficult to acquire.

**Focus groups**
Researchers use group interviews to obtain early exploratory information in areas that are unfamiliar and new. They can be used to identify nuances of how the clinical setting constrains the optimal design for technology and to identify unanticipated issues for further testing. Focus groups usually consist of 8-12 individuals with an interest in, or experience with, the desired subject area. The group is often led through a series of discussion topics by an individual experienced in group facilitation skills. It is important to encourage all members to participate equally and to emphasize that there are no "wrong" answers; it is their opinions and reactions that are desired. Focus groups are also useful as a method to test reactions to prototypes of new technologies, thus providing design feedback in early stages of product development.

**Observations of practicing clinicians**
Going out "into the field" as an anthropologist would term it, is yet another technique available to help an investigator understand the setting, context, and appropriate design for new information management technologies. One of the most important issues for new information technologies has to do with understanding how the new system will fit within the complex clinical workflow. The "new system" is productively viewed as information technology embedded within local practice. Therefore, implementers must consider the social and cognitive constraints in their design decisions. Although observing physicians in their "natural" habitat (i.e., the clinic) can lead to valuable insights, such work is difficult to accomplish. First, it is difficult to find physicians (and patients) willing to be observed. Second, the simple fact that an observer is present often changes the behavior of the person being observed (referred to as the Hawthorne Effect). Third, as with interviews, the sample size is often very small therefore generalization of results is difficult. Finally, the observer must have sufficient background and skill to focus on relevant observations of information flow and clinical constraints, thus anticipating how a new technology might fit into the clinical workflow.

**Design scenarios**
Creating a fictitious scenario that describes a "day in the life" of a busy clinician using the new technology can be a powerful and effective method of conveying the potential benefits of a new device or technique. In addition to text-based scenarios many investigators have created videos that "show" a subject using the new device. The use of video allows the investigator to use "special effects" to create the impression that a new technology actually exists. These scenarios are often used to develop a common specific vision for subjects to then provide feedback, either in the form of a follow-on focus group or survey.

**User surveys**
Surveys of users, whether conducted on paper or via e-mail, provide a fast, easy, and potentially very generalizable method of capturing user experiences and opinions. Such surveys usually consist mainly of multi-choice questions, with a few "open-ended" questions appended at the end to allow users to express additional comments. While seemingly a straightforward method of collecting data, the most difficult part of creating a survey is constructing a set of questions that unambiguously, yet without hinting at the answer desired by the investigator, capture the desired information. In addition there are many statistical procedures available to help assure that the results of the survey are valid and generalizable. Surveys have the advantage of offering a method for obtaining the same information on a large sample of subjects, thus improving the generalizability of the results. However, care must be taken to understand the domain and anticipate the most important questions in advance.

**An Example Project**
The following sections describe an example project that we undertook, focusing on the potential applicability of handheld computers in the ambulatory practice clinical setting.

**The Challenge**
There were several goals and constraints for this exploratory work on handheld computers:
1. Develop a defensible strategy concerning the potential applicability of the use of handheld computers in the ambulatory practice setting.
2. Have it done (i.e., all data collected, analyzed, and the report delivered) within 2 months.
3. Spend no more than $5,000.
4. Perform all other work-related assignments, which take over 60% of our time.
The Plan
Our general plan for accomplishing these goals included using each of the methods described earlier to obtain the necessary information to inform product design and an overall strategy for integrating the new technology into clinical practice.

1. Review the literature (in the broadest sense) regarding the current state of the art in the use of handheld computers in clinical medicine.
2. Conduct 30-45 minute telephone-based, one-on-one interviews with 15 clinicians who are current handheld computer users.
3. Observe 3-4 clinicians in their ambulatory practice setting for an entire session as they perform their "normal" routine.
4. Develop several "scenarios" that illustrate the use of handheld computers in similar settings.
5. "Validate" various aspects of these scenarios through multi-question surveys of approximately 100 practicing clinicians.
6. Monitor 10 physicians' use of a standard set of clinical applications for handheld computers and follow up with a focus group interview to obtain information on their experiences.

The Methods and Results

Literature Review
We scoured the traditional "medical" literature (i.e., MEDLINE), for articles describing the use of handheld computers in clinical settings. In addition, we reviewed trade journals and numerous websites devoted to physician use of handheld computers.

While literature searches for MEDLINE articles produced very few reports, there were many anecdotal reports available on the various websites that provided us with many ideas and the confidence to continue the investigation since many of the reports were extremely positive.

Telephone Interviews
We identified 14 "early adopter" physicians already using handheld devices and arranged to contact them by phone. We used a semi-structured ethnographic design to obtain information on perceived barriers and successes in the current handheld devices and applications available to physicians. We also solicited recommendations for further development in this area. Although early adopters are not necessarily representative of physicians in general, we were able to obtain the most current and informed feedback on both the current state of development and the potential for the use of handhelds in a highly motivated group of physicians.

Site Visit Observation Methodology
We identified potential site visit participants in the Portland area. Our goal was to find out-patient physicians in several types of practices: small 1-3 person clinics, larger 5-10 person clinics, clinicians already using computers in their practice, as well as those who weren't. As it turned out, we identified 3 different practice settings in which we were able to arrange to observe the clinicians in a representative clinical workday.

The first observation was of a single physician in solo practice that did not use a clinical computing system. The second observation was of a physician in a large group practice that shared a practice with another physician. Again, this physician did not have access to a clinical computing system. The third observation took place in a large 12 person orthopedic practice that had an electronic medical record product.

The following digest of data illustrates the type of information we collected during the observations. Whereas each physician we observed had a slightly different office set-up and clinical routine, we believe that the description is representative of the type of information an informatician could collect in ambulatory practice settings in the United States.

On January 18, 2000, we observed a busy orthopedic clinic in metropolitan Portland. The information flows for the following patients were all quite similar (the physician usually sees about 20-35 patients per day). Patient 2 was a follow-up visit (very short) 3.5 weeks after an arm break. The following patient (Patient 3) was a new patient with a recent knee injury. Dr. B took a brief history (including medications, allergies, and family history) and then asked for a description of the injury. After this, Patient 3 was asked to change into a gown for an exam; Dr. B took the opportunity to go to the next patient. For the 4th patient, that Dr. B was trying to fit in the middle of Patient 3's visit, Dr. B explained the results of a recent X-ray, wrote an order for physical therapy, wrote a prescription (paper note that would be entered into the electronic medical record system by the front desk personnel and sent by email to the pharmacy), and then immediately dictated his note (on Patient 4) in the hallway, before returning to Patient 3. While dictating, he was interrupted, and had to be able to back up the tape to listen to what he had recorded.

The Scenarios
Following the collection and analysis of data from the telephone interviews and the on-site
observations, we developed several scenarios that illustrated the potential uses of handheld computers by a physician in an ambulatory practice setting. The next paragraph is a short example from one of the scenarios.

Dr. Green is sitting at home at the breakfast table. He reaches for his handheld computer, turns it on, and presses his thumb on the screen to identify himself and is immediately presented with a screen showing his first 3 appointments of the day and the subject line of several messages that have come in during the night. He taps lightly on the first message to open it and finds that Mrs. Smith, the 83-year-old patient that he saw in his office 2 days ago was admitted to the hospital last night. He clicks on the hospital synch icon and Mrs. Smith's room number and admission note are downloaded via the wireless modem attached to his device. He reads the note and decides he should stop by to see her on his way into the clinic.

User Survey
Once the scenarios were developed we extracted several of the key features and created a survey to attempt to gauge user perceptions of them. In addition to these questions, we also collected some "background" or demographic data designed to help us interpret the findings. The survey asked the physicians about
- If they owned a handheld computer and if so, What type? Did they use it in clinical practice? Which applications?
- Their ratings of the importance of various features of a handheld device
- Their ratings on the importance of various types of applications
In addition to the questions on handheld computers, survey respondents were asked about their previous computer experience, years in practice, specialty, and gender.

As part of a class project in Medical Informatics at Oregon Health Sciences University, a group of 5 students, under the direction of the Knowledge Technologies Group at WebMD, conducted a survey of two groups of physicians:
1. 550 house staff physicians at Oregon Health Sciences University (email survey with 108 returned surveys, response rate = 20%)
2. 30 IPA physicians attending a weekly meeting of affiliated general practice clinics in Salem, Oregon (paper survey during the meeting, 22 completes, response rate = 73%)

The OHSU physicians, as residents in an academic medical institution, were somewhat different from the IPA physicians from the Salem Clinic. The OHSU physicians were generally younger, had a greater percentage of female physicians, had greater access to electronic medical records, had more computer experience, and were more likely to own a handheld device. However, both groups of physicians responded similarly when asked about the importance of features of handheld devices (see Table 1). The respondents were asked to rate the features on a scale from 0 to 10.

<table>
<thead>
<tr>
<th>Handheld Device Features:</th>
<th>OHSU</th>
<th>Salem</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ease of use</td>
<td>8.90</td>
<td>9.83</td>
</tr>
<tr>
<td>Small size</td>
<td>7.91</td>
<td>7.94</td>
</tr>
<tr>
<td>Long battery life</td>
<td>7.06</td>
<td>7.44</td>
</tr>
<tr>
<td>Always-on, wireless</td>
<td>6.03</td>
<td>7.41</td>
</tr>
<tr>
<td>connection to e-mail &amp; Web</td>
<td>5.45</td>
<td>6.50</td>
</tr>
<tr>
<td>24/7 technical support</td>
<td>5.05</td>
<td>3.94</td>
</tr>
<tr>
<td>Built-in phone pager</td>
<td>2.65</td>
<td>3.47</td>
</tr>
<tr>
<td>Color display terminal</td>
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When asked to rate the importance of various types of clinical applications for the handheld on a scale of 0 to 10, both groups of physicians rated almost all of the applications as important (score of 5 or greater).

<table>
<thead>
<tr>
<th>You use your handheld computer to:</th>
<th>OHSU</th>
<th>Salem</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check a drug-drug interaction</td>
<td>8.22</td>
<td>7.79</td>
</tr>
<tr>
<td>Check treatment regimens</td>
<td>7.90</td>
<td>7.00</td>
</tr>
<tr>
<td>View patient data from EMR</td>
<td>7.87</td>
<td>7.83</td>
</tr>
<tr>
<td>Check drug dosage in a patient with renal failure</td>
<td>7.85</td>
<td>6.94</td>
</tr>
<tr>
<td>Dictate into your handheld</td>
<td>7.72</td>
<td>7.39</td>
</tr>
<tr>
<td>Help you find the ICD-9 code for a recent diagnosis</td>
<td>7.38</td>
<td>4.56</td>
</tr>
<tr>
<td>Receive a lab alert Re: patient with a critical K+ value</td>
<td>7.32</td>
<td>6.79</td>
</tr>
<tr>
<td>1-hour course for CME credit</td>
<td>3.68</td>
<td>3.63</td>
</tr>
</tbody>
</table>

The information from these surveys allowed us to obtain more specific information from a larger sample, giving us more confidence in the findings on these particular issues.
Focus Groups
With input on the preferred application types from the survey, the students then carried out a study of 10 physicians using a standard set of clinical applications on their handheld computers. The methodology for debriefing was to hold 2 focus groups with the participants after a short observational period. The physicians were asked to provide feedback on the usefulness of the various applications, as well as perceived barriers to use. From this feedback we were able to determine what suite of application types would be required for physicians, as well as information on how to introduce the devices (e.g., training and setup issues) to new physicians.

Discussion
The plan to use a multi-faceted approach to determine the potential applicability of handheld computers in the clinical setting proved to be quite successful. Whereas each of the individual methods had their limitations, the combination of approaches allowed us to be much more confident in our summary statements.

For example, even though there were very few reports on the use of handheld computers in the traditional medical literature, our use of exploratory and qualitative methods to gather early information on the clinical use of handhelds provided us with recommendations for future product design. The telephone interviews proved to be very informative. Although subjects experienced some difficulties in using their devices for clinical purposes, they all had many ideas for future enhancements, and felt that the future for the handheld computers in the clinical setting was very promising. The on-site observations provided us with invaluable information on the clinical environment and workflow requirements. The surveys then gave us more quantitative evidence from a larger sample on features of handheld use that were important to physicians. Finally, the focus groups with 10 physicians allowed us to understand the success and barriers of the software in actual clinical use.

The Key Lessons Learned
1. Physicians are extremely busy.
2. The workflow in offices has been highly refined.
3. There are insurance coverage questions in nearly every patient encounter (in the environments studied).
4. Most physicians who have tried handhelds are highly satisfied with them.
5. A primary goal for physicians is to "empty the lab coat pocket."
6. Physicians without access to a good practice management system or an electronic medical record were more likely to use handhelds for patient care.
7. Data input is a bottleneck. Most physicians asked for speech recognition or standard templates with intelligent menu selections.
8. The most important device characteristics were that it be easy to use, small, have long battery life, and have wireless capabilities.
9. The most important handheld clinical applications were drug interaction and dosing information, quick reference materials, access to patient data, and dictation.
10. It is important to pilot test early designs of handheld applications. Usability and workflow issues are paramount for the clinical environment.

Many of the best handheld computing ideas rely on a high-speed connection to either the main clinical information system of a hospital, or the patient management information system (PMIS) of the clinic. Without the PMIS connection, the physician cannot access a current list of his scheduled patients. Without a connection to the clinical information system, the physician cannot view the current clinical data.

The Conclusions
The potential for a robust handheld computing device to positively affect the outpatient, ambulatory clinical setting is enormous. Many research and development efforts are required to increase adoption of these products. A set of complementary research techniques provides useful information for specifying design criteria for future development.

References
5. PDAs for Health Care Providers -- http://educ.ahsl.arizona.edu/pda/index.htm