User Satisfaction and Frustration with a Handheld, Pen-Based Guideline Implementation System for Asthma
Richard N. Shiffman, MD, MCIS, Yischo Liaw, MD, Deborah D. Navedo, MSN, Kimberly A. Freudigman, PhD
Yale Center for Medical Informatics, New Haven, Connecticut

Abstract
Objective: To evaluate clinicians’ satisfaction and frustrations with the use of a handheld computer system that implements a guideline for management of childhood asthma exacerbations.
Setting: Nine primary-care pediatrics practices
Design: Survey component of a randomized, prospective before-after trial
Intervention: Newton MessagePad outfitted with custom software (called "AsthMonitor") that assists in documentation of clinical findings and provides guideline-based recommendations
Results: Overall, 3 users gave strongly positive global ratings while 6 users were neutral. The majority used the documentation functions concurrently with care. Except for recommendations to administer oxygen (which were unsupported by evidence), users found the recommendations appropriate and appreciated the reminders. Seven of 9 participants believed it took more time to document with AsthMonitor.
Conclusions: Handheld computers are acceptable to some office-based practitioners to provide guideline-based advice within the context of the clinical encounter.

Numerous studies have demonstrated widespread variation in clinical practice among physicians, some of which is inappropriate [1]. Clinical practice guidelines, which are developed using evidence-based methods, encapsulate the current understanding of best clinical practice. Finding effective strategies to implement these guideline recommendations is an area of active investigation in medical informatics [2]. To be effective, guideline implementations should integrate guideline recommendations into clinical workflow [3].

Handheld computers can be used at the point-of-care for documentation, decision support, and communication. Moreover, pen-based data entry is a familiar metaphor for most primary care pediatricians and has the potential to overcome barriers related to direct entry of clinical information by physicians [4].

We conducted a time-series trial in a random sample of 9 general pediatric practices in the vicinity of New Haven, CT between October 1996 and September 1998. The study was designed to investigate (1) whether a handheld computer program could be effective in improving physician adherence to a clinical practice guideline (reported in [6]) and (2) physicians’ satisfaction and frustrations with the computer-based intervention. This paper reports our findings from the latter investigation.

METHODS
AsthMonitor Design
The AsthMonitor system consisted of an Apple Newton MessagePad 130 (Apple Computer, Inc., Cupertino, CA) outfitted with customized software developed at the Yale Center for Medical Informatics and a Stylewriter 1200 inkjet printer (Apple Computer, Inc.) with a serial cable connection. The Newton MessagePad is a handheld computer that accepts pen-based data entry on a touch sensitive screen. The screen is a 3" x 4", backlit, transflective LCD, with 320 x 240 pixels resolution. The unit’s dimensions are 8.0" x 4.0" x 1.25" (about the size of a videotape cassette) and it weighs 1.0 lb. It uses the Newton Operating System version 2 and performs both word and letter recognition on text entered with a stylus.

The AsthMonitor software was designed to facilitate documentation of office encounters with patients experiencing asthma exacerbations and to provide patient-specific advice regarding appropriate management of the exacerbations based on a Practice Parameter from the American Academy of Pediatrics [5]. A guiding principle in the design of AsthMonitor was that the guideline advice was to be tightly integrated into an application that facilitates the workflow of clinicians. By displaying checkboxes and radio buttons wherever possible, the software required minimal textual data entry and consequently had minimal requirements for handwriting recognition.

In practice, the user entered the patient’s name, age, weight, and height on a registration screen and proceeded to document clinical findings using pen taps on radio buttons and checkboxes. At any time, a blank screen could be called up to record unstructured text that was not submitted for handwriting recognition.

The patient’s symptoms, triggers, risk factors, and current medications were entered on a series of history screens. Next, the physical examination screen appeared for documentation of clinical findings. The child's predicted peak expiratory flow rate (PEFR) and normal respiratory rate for age were
participants were asked to collect data on an additional 10 children using the handheld computer system for documentation. The authors provided a 30-45 minute orientation to the MessagePad and AsthMonitor software in the pediatricians' offices and an illustrated 14-page manual.

At the conclusion of the study, each participant completed an exit questionnaire, which included an assessment of the participants' experience in using AsthMonitor, specific satisfaction and frustrations, self-assessed changes in practice, and opinions about the desirability of a variety of functionalities for data entry and decision support tools. We specifically sought to evaluate users' assessments of the information management services that the Newton provided [7]. Questions were both closed-ended and open-ended.

To provide a global indication of satisfaction, we extracted 18 closed-ended questions from the questionnaire whose answers addressed issues of satisfaction and frustration with AsthMonitor. Individual item contributions to the score varied from -1 or 0 at minimum to 1 at maximum. The participants' scores on these questions were summed with each response weighted equally.

RESULTS

Characteristics of Physician-Participants

Of the 375 listings of pediatricians within a 20 mile radius of New Haven, 138 were eliminated because of categorization as residents or fellows in-training (n = 80) or an address at a medical center or medical school (n = 58). The remaining 237 were subjected to a random, rolling recruitment process. Of those nominated, 28 were not in active primary care pediatric practice—22 were retired, working in administration, or practicing part-time—and 6 had moved away; 4 did not anticipate seeing 20 asthma patients in the coming year; 7 did not have required equipment; and 5 were partners of participants who had been enrolled previously. Eighteen potentially eligible physicians declined to participate in the study, 7 of whom belonged to a single multi-site group practice whose administration proscribed participation (despite the willingness of individual group members to take part). Of the 11 physicians who enrolled in the study, 2 dropped out during the control data collection phase—one because of a move out-of-state, and the other because of excessive workload.

Of the nine participants who completed exit questionnaires, 6 were male and 3 were female (both physicians who left the study during the control phase were women). The average age was 41.9 (range: 30–52). The interval since completion of residency training averaged 10.6 years (range: 1–18). Seventeen percent practiced in an urban, inner-city setting, 22% described their practice as urban, not inner city, and 61% practiced in a suburban setting.
Two participants described themselves as "non-users" of computers, 4 were novices, and 3 described their level of computer expertise as intermediate. All 9 participants had computer systems installed in their offices; all had systems for patient accounts and billing, 5 had computerized appointment systems, 1 each recorded immunization and screening data, and 2 had on-line information access through the Web, MEDLINE, etc. No participant had a computerized system for recording problem lists, encounter notes, telephone triage, or laboratory results reporting.

General Assessment of AsthMonitor

Individual participants' composite scores on the global satisfaction index ranged from -1 to +12 (within a possible range of -13 to +18). Three participants had relatively high positive scores (8, 9, and 12), while the remainder clustered within a neutral zone of -1 to +4. The mean ratings for individual items are summarized in Table 1.

Although we asked each of the 9 physician-participants to collect data on 10 patients using AsthMonitor, only 6 did so. Of the remainder, 1 enrolled 8 patients, 1 enrolled 5 patients and the last only used AsthMonitor with 1 patient.

Five participants (including all 3 who failed to enroll 10 patients) "never became comfortable" with using AsthMonitor. Among the other 4 participants, one reported comfort after using the system with 2 patients, another after 3, another required 4, and the last reported achieving comfort after 5 patients. The majority of participants (5) described the Newton's physical size as "about right"; 2 responded that the MessagePad was too small and 2 found it too large.

With regard to weight, 7 pediatricians found it "just right" and 2 evaluated it as being too heavy.

The MessagePad's built-in handwriting recognition capability was judged to be adequate for clinical activities by 4 users and inadequate by 5 users. Participants were invited to explore the use of the Newton's built-in functions (calendar, name file, note-writing) on their own, since no orientation was offered. Only 1 user reported "regular" use of the note-writing program.

Navigation through the AsthMonitor program was perceived as "straightforward" by 5 participants and "confusing" by 4. Typical comments of the physicians who criticized the user interface were: "Software inconsistent, eg checkmark would cancel out in some screens and not in others"; "I had problems going from initial FE to subsequent FE. Sometimes 'Record' was a necessary step to get to next screen, sometimes it put me in the notepad"; "At times I couldn't figure out how to get where I needed to go and if I forgot something I couldn't get back".

Participants were asked to describe the features of the AsthMonitor system they liked best. Comments included: "Size and ease of recording written word, quick response; portable"; "Once I became comfortable with the different functions and steps I loved it! Much faster than writing (even though I continued writing)"); "In general it was user-friendly. I thought the handwriting recognition was very good"; "Asthma recommendations were helpful"; "Thorough documentation-summary of care";

<table>
<thead>
<tr>
<th>Feature</th>
<th>Min</th>
<th>Max</th>
<th>Mean Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concerns re safety of advice (often, sometimes, never)</td>
<td>-1</td>
<td>1</td>
<td>1.00</td>
</tr>
<tr>
<td>Dosage calculations accurate (no, didn't verify, yes)</td>
<td>-1</td>
<td>1</td>
<td>1.00</td>
</tr>
<tr>
<td>Weight of MessagePad (too heavy or light, just right)</td>
<td>0</td>
<td>1</td>
<td>0.78</td>
</tr>
<tr>
<td>Write notes concurrently with patient care (never, sometimes, always)</td>
<td>-1</td>
<td>1</td>
<td>0.67</td>
</tr>
<tr>
<td>Size of MessagePad (too small or large, just right)</td>
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<td>1</td>
<td>0.56</td>
</tr>
<tr>
<td>Legibility (less, same, more)</td>
<td>-1</td>
<td>1</td>
<td>0.44</td>
</tr>
<tr>
<td>Thoroughness of documentation (less, same, more)</td>
<td>-1</td>
<td>1</td>
<td>0.33</td>
</tr>
<tr>
<td>Concerns re appropriateness of advice (never, sometimes, often)</td>
<td>-1</td>
<td>1</td>
<td>0.33</td>
</tr>
<tr>
<td>Willing to purchase MessagePad (no, yes)</td>
<td>0</td>
<td>1</td>
<td>0.22</td>
</tr>
<tr>
<td>Used information button (no, yes)</td>
<td>0</td>
<td>1</td>
<td>0.22</td>
</tr>
<tr>
<td>Used Newton for notes, calendar, addresses (no, yes)</td>
<td>0</td>
<td>1</td>
<td>0.11</td>
</tr>
<tr>
<td>Navigation (confusing, straightforward)</td>
<td>-1</td>
<td>1</td>
<td>0.11</td>
</tr>
<tr>
<td>Speed of printing (too slow, adequate)</td>
<td>-1</td>
<td>1</td>
<td>0.11</td>
</tr>
<tr>
<td>Handwriting recognition adequacy (inadequate, adequate)</td>
<td>-1</td>
<td>1</td>
<td>-0.11</td>
</tr>
<tr>
<td>Interference with patient interactions (excessive, somewhat, none)</td>
<td>-1</td>
<td>1</td>
<td>-0.11</td>
</tr>
<tr>
<td>Number of patients till comfortable (never, any number)</td>
<td>-1</td>
<td>1</td>
<td>-0.11</td>
</tr>
<tr>
<td>Reminder chime (annoying, neutral, useful)</td>
<td>-1</td>
<td>1</td>
<td>-0.33</td>
</tr>
<tr>
<td>Time spent documenting (more, same, less)</td>
<td>-1</td>
<td>1</td>
<td>-0.67</td>
</tr>
</tbody>
</table>

Table 1. Respondents' mean assessments of individual features provided by AsthMonitor
"Reminders to check on things I might have overlooked".

Physicians were likewise asked to describe the features of the system they liked least. These comments included: "Somewhat confusing software"; "Because of my inexperience with computers if I forgot a certain step I got confused and had trouble getting back to the regular sequence"; "Very slow printing. Required more work at each visit. Because AsthMonitor is not a complete record of each visit required lots of double documenting"; "Very slow. It didn’t like my handwriting... It would be helpful to be able to customize prescriptions"; "Too much time consuming for a busy practice. Newton was cumbersome"; "Could not read my writing"; "Going from screen to screen took a while".

Documentation

Six participants responded that they "almost always" wrote notes with AsthMonitor while the patient was in the office; three "sometimes" wrote notes concurrently with providing care. Two users reported that using AsthMonitor did not interfere at all with patient interactions, 4 noted that using the system "somewhat" interfered with patient interactions, and 3 felt that the interference was "excessive".

Compared with their traditional methods for documentation of asthma notes, 6 participants believed that the thoroughness of documentation produced by AsthMonitor was "about the same" and 3 felt that AsthMonitor documentation was "more thorough". Five physicians believed the legibility of notes produced by AsthMonitor was about the same as their traditional system and 4 rated AsthMonitor documentation as more legible. None of the 9 participants used the paper-based documentation produced by AsthMonitor as the sole record of the visit.

Only 1 participant felt that clinical documentation took less time using AsthMonitor; one felt it took about the same amount of time, and 7 felt that using AsthMonitor took more time than traditional documentation methods, even after they had used the system for several patients.

Typical comments on AsthMonitor’s documentation services follow: "History not as complete as I need, eg non-asthma medications pt is on, drug allergies, PMH, etc. Also other problems that come up at visit not related to asthma"; "(Notes) took up too much room (and) paper. Not integrated with rest of chart notes"; "Was able to write more thorough note more quickly without AsthMonitor"

Recommendation

All 9 participants reported that they never had concerns regarding the safety of the interventions recommended by AsthMonitor. Although 3 physicians reported never having concerns regarding the appropriateness of the recommendations, 6 users stated that they "sometimes" did. Most often, these concerns related to recommendations to administer oxygen. The guideline recommended administration of oxygen to all children experiencing a moderate or severe exacerbation. This was not common practice and was not supported by evidence. "Oxygen not readily available by wall outlets as in EDs. Too cumbersome to bring out ox tank when I know pt will improve readily with nebulization therapy"; "Recommendations with regard to giving oxygen and oral steroid more conservative than what I felt necessary"; "Did not use O2 as recommended"; "I felt O2 prescribed too often by AsthMonitor".

Participants were specifically queried regarding their overriding the system’s recommendation to use oxygen for moderately ill children with asthma exacerbations. Five felt that using oxygen in those circumstances would not help their patient, 2 stated that equipment was unavailable to provide oxygen (although all participants had previously stated that oxygen was available as a condition of study entry), 1 felt that staff were unskilled in administering oxygen and 1 stated that using oxygen might create a fire hazard.

Eight pediatricians reported that the interventions recommended by AsthMonitor differed "sometimes" and 1 user "often" from what they actually performed. "I do not use oxygen as often as advised"; "I rarely check pulsim paradoxus, don’t frequently continue to monitor normal oxygen sats, feel oxygen recommendation overly given"; "I didn’t refer to ER as quickly".

Six participants did not believe that their management of patients with asthma exacerbations changed as a result of using AsthMonitor, although 5 perceived a difference. Two physicians reported that performed more PEFR measurements and 2 believed they performed more saturation measurements when using the AsthMonitor program. "Learned to use peak flow meter and ox sat monitor more often and in a scientific fashion. Learned to document treatment and results better".

Explanation

Only 2 of the 9 participants responded that they had used the I(nformation)-button to access information that explained the reasoning behind AsthMonitor’s recommendations. One person stated that the additional information was helpful. "Wished I used but forgot that I could".

Calculation

Five participants responded that they verified AsthMonitor’s dosage calculations and found them to be accurate; 3 did not verify calculations (one did not
respond). AsthMonitor provided a chime at 20-minute intervals to remind the user that it was time to reassess the patient. Three participants found this alarm function to be annoying, while the other 6 were neutral.

**Communication**

The speed of printing was judged to be adequate by 5 participants and too slow by 4. It generally required at least 2 minutes to prepare the written report of the encounter on the StyleWriter printer that was provided.

None of the 9 participants used the prescriptions that were automatically produced by AsthMonitor for their patients. Reasons included “Our prescription pads already pre-printed with DEA number on it”; “I carry a prescription pad with me, out of habit I guess”; “Usually gave out office samples and had to instruct pt on proper use”; “Not easy access to printer—hard time printing”; “I could be more specific by brand (without AsthMonitor)”.

**DISCUSSION**

In general, the private-practice pediatricians in this study appreciated the mobility and form factor of the Newton MessagePad. Most physicians were able to use the system during the clinical encounter. Grimshaw and Russell have shown that guideline implementations have the highest probability of influencing clinicians’ behavior when patient-specific advice is provided within the context of the clinical consultation. AsthMonitor’s advice was generally well accepted, except for guideline suggestions to administer oxygen—which were not supported by any evidence and were contrary to common practice.

The users were divided in their assessment of the built-in handwriting recognition functions. Likewise, with regard to the guideline implementation software, the physicians segregated into 2 groups: those who were generally positively disposed toward the application and those who were more ambivalent toward it. Much of the dissatisfaction of the latter group related to deficiencies in the user interface—e.g., navigation inconsistencies, speed of printing, the reminder chime—that would be amenable to corrective and perfective maintenance. The most serious complaint related to the excessive time required to use the system in a clinical setting. We believe this could be ameliorated by additional training and regular reinforcement.

This study’s generalizability was certainly limited by the small numbers of physicians who participated and the fact that all belonged to a single specialty. However, the success of our random selection process suggests that their responses may be representative of a larger population of physicians. In addition, the fact that AsthMonitor was applicable only to a single disease made its use intermittent, thus limiting opportunities for some physicians to become accustomed to computer-based documentation.

This was the first study of which we are aware that attempted to implement a complex, disease-oriented guideline on a handheld computer. We report elsewhere that the implementation was successful in increasing physician adherence to a variety of guideline recommendations [6]. In addition, this study examined the barriers to computer-based decision support in non-academic, office settings—an area that has received only limited evaluation. Future work will build on lessons learned from this investigation to create additional computer-mediated guideline implementations that are more acceptable to clinician-users.

**References**