

# Information at hand: Using handheld computers in medicine

## ABSTRACT

Call them handhelds, palm-tops, or personal digital assistants (PDAs), pocket-sized computers are becoming a common feature on the medical landscape. As the technology improves, more programs become available, and the demands of medical practice heighten, physicians are recognizing the benefits of having information available at the point of care. This article reviews the use of handheld computers in medicine, emphasizing how they might help the practicing physician.

## KEY POINTS

Physicians can use handheld computers to access reference information, make medical calculations, improve coding and billing, and track patient data, all at the point of care.

Handheld computers currently have various limitations, including small screen size, slow data entry, limited memory, and few security features for protecting sensitive data.

Handhelds will likely become vital tools in the practice of medicine.

**I**F YOU ARE NOT USING a handheld computer in your practice yet, chances are you soon will.

*See related editorial, page 854*

Handheld computers are helping clinicians practice more efficiently and perhaps even provide better patient care. If current trends continue, they will become increasingly incorporated into medical practice as wireless access portals to computerized patient record systems, as resources for practicing evidence-based medicine, and as tools for gathering and managing data for patient care, billing, and clinical research.<sup>1-4</sup>

## IN THE BEGINNING

Handheld computers have been used in medicine for more than a decade. Early models like the Apple Newton MessagePad could do many things and showed promise, but their relatively large size, short battery life, and poor handwriting recognition led to a decline in popularity beyond medicine, and they were discontinued.

The mid-1990s saw the introduction of other handhelds that have since become the major players. Devices such as the Palm Pilot (launched in 1996) solved many of the problems that plagued earlier models. Being smaller, less expensive, and easier to use and having a significantly longer battery life, these devices were quickly embraced by mobile professionals, including some physicians. Today, medical schools, residency programs, physician groups, and healthcare systems are seeing the potential benefit of these devices for improving health care education and practice and are investing in them.<sup>5-7</sup>



### ■ THREE MAJOR OPERATING SYSTEMS

Just as personal computers (PCs) have different operating systems (eg, Microsoft's Windows and Apple's Macintosh), so do handhelds. Since the demise of the Apple Newton, the major players in handhelds are Palm, Microsoft, and Psion.

Although devices that run the Psion/EPOC and Microsoft Pocket PC (formerly Windows CE) operating systems are certainly in wide use, most handhelds today run the Palm Operating System (Palm OS).<sup>8</sup> There is significantly more medical software available today for the Palm OS than for any other operating system, making it the current favorite.

Of course, the marketplace can change rapidly, and it is difficult to predict which operating system will remain most popular in the long run. As with any computer purchase, when deciding which device to buy, consider your needs and evaluate the features and software available for the various models (TABLE 1).

### ■ BASIC FEATURES

Handheld computers share several features that make them well suited for the mobile professional. Being small and lightweight, they are easy to handle and more likely to be carried around than a laptop computer. They turn on and off instantly, making it convenient to access the information they contain whenever it is needed. All popular handhelds have built-in software for managing personal information: a calendar, phone book, to-do list, notepad, and even the ability to exchange e-mail with PCs.

Most systems are controlled with a pen-like stylus and have handwriting recognition software for entering text. With a little practice, most people can enter text relatively easily and accurately, albeit slowly. Popular handheld models do not have built-in keyboards, but external keyboards are available for some. Many also offer the ability to record voice, though no voice-recognition software is available for any device at present. The ability to "beam" information via infrared light to other devices allows for easy exchange of information between handhelds.

In addition, information can be transferred back and forth between handhelds and PCs, a process called synchronization or "hotsyncing." Although handhelds can certainly be used independently, their real power is unleashed when they are used with PCs. Through synchronization, handheld data can be backed up and managed on the PC, and third-party applications can be installed from the PC to the handheld. Modems—standard and wireless—are also available for all of the popular devices, further increasing the ways information can be gathered and distributed.

### ■ CURRENT MEDICAL APPLICATIONS

In addition to helping professionals manage their personal information, handhelds are increasingly being incorporated into the active practice of medicine. Physicians are using their handhelds to:

- Access medical reference information
- Make medical calculations
- Code and bill for patient encounters
- Track patient data
- Write prescriptions.

#### Why use handhelds in medicine?

Medical errors can result from having inadequate access to appropriate information.<sup>9</sup> In addition, physicians often find themselves asking clinical questions and making decisions that require ready access to both clinical and nonclinical resources.<sup>10</sup> Will adding a certain medication produce a drug-drug interaction? What is the appropriate diagnostic code for this condition? How do I adjust this medication dosage based on the patient's renal function? At what billing level may I code this patient encounter, given my documentation?

Having information readily available at the point of care can be extremely useful in view of the growing amount of medical information available, the increased expectations to follow guidelines and formulary restrictions, and the time limitations placed on physicians. Handheld computers can improve efficiency, and early data suggest that they might also help avoid medical errors and achieve better patient outcomes.<sup>11</sup>

**Medical errors can result from poor access to information**

TABLE 1

## Comparison of selected popular handheld computers

MODELS	MEMORY (MB)*		BATTERIES†	WEIGHT (OZ)	COMPUTER CONNECTION‡	FEATURES§	COST¶
	BASE	EXPANDABLE					
<b>DEVICES RUNNING PALM OS</b>							
<b>Palm (www.palm.com)</b>							
m100	2	No	Alkaline	6–7	Serial	K	\$129
m105	8	No	Alkaline	6–7	Serial	K	\$199
IIIc	8	No	Li+ ion	6–7	Serial	C,K	\$299
Vx	8	No	Li+ ion	4	Serial	K	\$299
VIIx	8	No	Alkaline	6–7	Serial	K,W	\$399
m500	8	Yes	Li-polymer	4	USB	K	\$399
m505	8	Yes	Li-polymer	4	USB	C,K	\$449
<b>Visor (www.handspring.com)</b>							
Visor	2	Yes	Alkaline	5.4	USB	K,M	\$169
Deluxe	8	Yes	Alkaline	5.4	USB	K,M	\$199
Platinum¶	8	Yes	Alkaline	5.4	USB	K,M	\$299
Edge	8	Yes	Li+ ion	4.8	USB	K,M	\$399
Prism	8	Yes	Li+ ion	6.9	USB	C,K,M	\$449
<b>Handera (www.handera.com)</b>							
TRGpro	8	Yes	Alkaline	6	Serial	K	\$250
Handera 330	8	Yes	Alkaline#	6	Serial	K,M	\$350
<b>Sony (www.sony.com)</b>							
Clié	8	Yes	Li+ ion	4.3	USB	K	\$300
Color Clié	8	Yes	Li+ ion	5.6	USB	C,K	\$500
<b>DEVICES RUNNING WINDOWS POCKET PC</b>							
<b>Compaq (www.compaq.com)</b>							
iPAQ 3150	32	Yes	Li-polymer	6.3	Serial	K,M	\$349
iPAQ 3600	32	Yes	Li-polymer	6.3	Serial	C,K,M	\$499
<b>Casio (Cassiopeia)</b>							
E-115	32	Yes	Li+ ion	9	Serial	C	\$400
E-125	32	Yes	Li+ ion	9	USB	C,M	\$550
<b>Hewlett Packard (www.hp.com/jornada)</b>							
Jornada 525	16	Yes	Li-polymer	9.1	USB	C,K,M	\$359
Jornada 548	32	Yes	Li-polymer	9.1	USB	C,K,M	\$449

\*Palm OS devices and Windows devices handle memory differently: 8 megabytes (MB) on Palm OS can hold about the same amount of data as 16 MB on Windows Pocket PC device. Memory expansion details vary; check websites for details

†Alkaline batteries last 20–30 hours; Li+ ion batteries are rechargeable and last 6–7 hours per charge; Li-polymer batteries are rechargeable and last 8–12 hours per charge

‡Palm OS devices are compatible with either IBM-type or Macintosh personal computers (with optional adapters), but Windows Pocket PC devices are not Macintosh-compatible; optional universal serial bus (USB) adapters are available for serial devices, and vice-versa

§C, color screen; K, optional external keyboard available; M, built-in microphone; W, wireless capability built-in; all models listed are capable of infrared beaming, synchronization, and handwriting recognition, and have personal information management (PIM) software for handling calendar, contacts, tasks, notes, and e-mail

¶Price information according to companies' web site/phone sales information as of May 7, 2001

¶Platinum has faster processor speed than Deluxe

#Lithium ion battery kit available

**TABLE 2****Sampling of popular medical reference software for handhelds**

TITLES	PLATFORM	SIZE (MB)*	COST†	BRIEF DESCRIPTIONS
<b>GENERAL DRUG REFERENCES</b>				
<b>qRx</b> (www.epocrates.com)	Palm OS	1.1	Free	Extensive database Menu driven, intuitive interface Regularly updated
<b>Lexidrugs</b> (www.skyscape.com)	Palm OS or Pocket PC	2 3.7	\$65	Extensive database Icon-driven; icons take up screen space No pediatric dosing info
<b>PDR 2001</b> (www.franklin.com)	Palm OS or Franklin eBookman	6.3	\$130	Contains full text of the PDR or subsets thereof (requiring less space)
<b>Physicians Drug Handbook</b> (www.handheldmed.com)	Palm OS or Pocket PC	2.1	\$75	More than 5,000 drugs, no pediatric info Quick access to data via hyperlinks Can run from memory expansion card
<b>Tarascon ePharmacopoeia</b> (www.medscape.com)	Palm OS	0.8	Free	Similar database to paper version, though not all tables available Has over-the-counter information, unlike qRx and PDR
<b>ANTIMICROBIAL DRUG REFERENCES</b>				
<b>ABX Guide</b> (http://hopkins-abxguide.org/)	Palm OS or Pocket PC	0.9 5	Free	From Johns Hopkins Division of Infectious Diseases Search by organ, pathogen, or drug for diagnostic and therapeutic information Regularly updated by experts
<b>qID</b> (www.epocrates.com)	Palm OS	0.5	Free	Organ/bug-based algorithmic searches for antimicrobial therapy recommendations Linked to qRx and regularly updated
<b>GENERAL MEDICAL REFERENCES</b>				
<b>The 5 Minute Clinical Consult 2000</b> (www.skyscape.com)	Palm OS or Pocket PC	2.1	\$65	Full text of paper version Has helpful hyperlinking to subcategories
<b>Harrison's Principles of Internal Medicine 14e Companion Handbook</b> (www.handheldmed.com)	Palm OS or Pocket PC	1	\$80	Pocket version of book text Searchable, but significant scrolling
<b>Merck Manual</b> (www.handheldmed.com)	Palm OS or Pocket PC	4	\$80	Full text of book Takes up much memory Searchable, but significant scrolling

\*Palm OS and Windows CE/Pocket PC devices handle memory differently. If more than one value provided for size, top represents approximate memory size or requirement for Palm OS and bottom for Windows CE/Pocket PC devices

†Price information according to companies' web sites as of May 7, 2001

### General drug references

Among the more popular medical references currently available for handhelds are electronic pharmacopoeias.

- **ePocrates qRx** ([www.epocrates.com](http://www.epocrates.com)), in particular, has been very successful. According to ePocrates, as of February 2001, more than 220,000 users (110,000 physicians, approximately 18.5% of US physicians) had downloaded qRx since its introduction in November 1999. It has an extensive database, an intuitive interface, regular updates, and it is free, all of which quickly made it a staple.

Other general drug references in wide use (TABLE 2) include the electronic versions of popular paper-based references such as:

- **Tarascon Pocket Pharmacopeia** ([www.medscape.com](http://www.medscape.com))
- **Lexidrugs** (based on the *Lexicomp Drug Handbook*; [www.skyscape.com](http://www.skyscape.com))
- **PDR** ([www.franklin.com](http://www.franklin.com)).

### Antimicrobial drug references

- **qID** was released by ePocrates in January 2001. The user searches for recommended antimicrobial therapy algorithmically by either an organ-based or "bug"-based approach, and links to more detailed drug information found in qRx with a tap of the stylus (the two programs are interconnected). Like qRx, qID is free.
- **ABX Guide**, released in April 2001 by the Johns Hopkins University Division of Infectious Diseases, is available for both Pocket PC and Palm OS devices, as well as via the Web. Price: free.
- **The Sanford Guide to Antimicrobial Therapy** ([www.sanfordguide.com](http://www.sanfordguide.com)), one of the more popular print antimicrobial guides, is due to be released in a PDA version this year.

### General medical references

As with the pharmacopoeias, general medical references range from those designed specifically for handhelds to electronic versions of well-known books. Popular examples include:

- **Merck Manual**
- **Griffith's 5-Minute Clinical Consult**
- **Harrison's Principles of Internal Medicine 14e Companion Handbook.**

The number of more specialized medical references for use on handhelds is ever-increasing. One of the best ways to discover which applications are available is to browse some of the web sites dedicated to indexing and delivering medical and general handheld content and applications. Demonstration versions of many applications can be downloaded (TABLE 3).

On the downside, although carrying a virtual library of such references in one's pocket is appealing, it can be cumbersome to read through large volumes of text on the handheld's small screen.

### Medical calculators

Some of the earliest medical applications for handhelds were designed to help physicians perform medical calculations. Programs like **MedCalc** ([netxperience.org/medcalc/](http://netxperience.org/medcalc/)) and **MedMath** ([mail.med.upenn.edu/~pcheng/medmath/](mailto:med.math@upenn.edu)) give quick solutions to many common calculations, including the alveolar-arterial (A-a) oxygen gradient and creatinine clearance. Others, such as **ABG-Pro** ([www.stacworks.com](http://www.stacworks.com)) and **PregCalc** ([www.thenar.com](http://www.thenar.com)), are more specialized. Still others such as **MedRules** ([pbrain.hypermart.net](http://pbrain.hypermart.net)) calculate useful clinical predictions (eg, what is the probability that this patient has pneumonia, pulmonary embolism, or pancreatitis, and what is his or her risk of death?), based on evidence in the medical literature.

Most of these programs cite the sources of the formulas used, and nearly all are shareware (created by independent programmers and available for free or at a modest price).

In May 2001, the National Cholesterol Education Program released a new set of guidelines for lipid testing and treatment. Calculating the risk for an individual patient requires physicians to go through a number of calculations, so to make the process easier, the National Heart, Lung, and Blood Institute published a free program downloadable on devices using Palm OS ([www.nhlbi.nih.gov/guidelines/cholesterol/profmats.htm](http://www.nhlbi.nih.gov/guidelines/cholesterol/profmats.htm)).

### Patient data tracking

Since their introduction, handhelds have been used to manage patient data through built-in notepad software. In addition, several

You can carry a library in your pocket, but it may be hard to read



applications have been designed specifically to capture and organize patient data.

Although these are useful in certain settings, some critics argue that entering data on handheld devices is too slow to be practical in busy practice. Recent improvements in software interface design, the availability of external keyboards, and the beginnings of integration with existing electronic medical record systems may be changing this perception.

Two of the more popular programs for tracking patients on handhelds are **Patient Keeper** ([www.patientkeeper.com](http://www.patientkeeper.com)) and **Patient Tracker** ([www.handheldmed.com](http://www.handheldmed.com)). By using pull-down menus and a point-and-tap interface to limit the amount of text one must enter by hand and by organizing information in ways familiar to clinicians (eg, representing chemistries and blood counts in diagrams), these applications make tracking data such as demographics, vital signs, test results, medications, diagnoses, and procedures more efficient. Several applications also allow you to generate SOAP (subjective, objective, assessment, plan) notes and history and physical reports, beam patient data to colleagues, and back up patient data by hotsyncing with PCs.

#### Coding and billing

Coding and billing for patient encounters is becoming increasingly complex, but handhelds might help.<sup>12</sup> Software for coding and billing is improving and becoming more plentiful.

- **Stat E&M Coder** ([www.statcoder.com](http://www.statcoder.com)) guides the user through the Health Care Financing Administration (HCFA) 1995 or 1997 evaluation and management coding algorithms to determine the correct level of service at which to code a patient encounter based on documentation.

Other programs that help with various coding and billing processes include:

- **PocketBilling** ([www.pocketmed.org](http://www.pocketmed.org))
- **MD Coder** ([www.curontech.com](http://www.curontech.com))
- **MDEverywhere** ([www.mdeverywhere.com](http://www.mdeverywhere.com))
- **ZapMed** ([www.zapmed.com](http://www.zapmed.com)).

#### Prescription writing

Given the recent reports that many adverse outcomes may be caused by medication prescribing errors, the idea of using handheld devices to automate prescription writing is

drawing significant attention. Several commercially available systems are designed to reduce errors and office inefficiencies associated with prescription writing. Some systems can send prescriptions electronically to pharmacies, while others require printing of prescriptions but promise a fully electronic system in the near future. Current systems include:

- **iScribe** ([www.iscribe.com](http://www.iscribe.com))
- **ePhysician** ([www.ephysician.com](http://www.ephysician.com))
- **PocketScript** ([www.pocketscript.com](http://www.pocketscript.com))
- **Allscripts** ([www.allscripts.com](http://www.allscripts.com)).

#### Other useful applications

**Documents-To-Go** ([www.dataviz.com](http://www.dataviz.com)) converts PC documents to handheld documents, thereby overcoming some limitations of the built-in notepad software. With it, you can transfer documents and spreadsheets created by popular program such as Microsoft Word and Excel to your handheld relatively easily.

**iSilo** ([www.isilo.com](http://www.isilo.com)) translates text or HTML-encoded files to iSilo documents that can be read on handhelds. Applications like these make it possible to download and carry custom resources such as articles, guidelines, and notes that would not otherwise be available for handhelds.

**HanDBase** ([www.ddhsoftware.com](http://www.ddhsoftware.com)) is one of several database applications available for handhelds. It allows users to create quite robust databases via a flexible interface and to view and edit those databases on PCs using popular spreadsheet and database programs. There are also many ready-to-use medical files available in HanDBase and other formats that can be downloaded from online archives (TABLE 3).

**AvantGo** ([www.avantgo.com](http://www.avantgo.com)) lets users select special handheld-formatted web sites called "channels" for downloading and later viewing. With each hotsync to an Internet-connected PC, the sites are updated on the device. Content ranging from national news to local movie listings can be selected, and medical content is becoming increasingly available.

#### ■ LIMITATIONS

As useful as handheld computers are in their present form, they were not designed specifi-

Losing a handheld is the biggest threat to security today



cally for use in medicine and, while improving, they are far from perfect. The following are a few of the limitations to consider.

**Small screens**, while essential, can compromise the optimal display of data.

**Limited memory and slow processors**, though becoming less consequential with the release of handhelds equipped with expansion slots and faster processors, can still be significantly improved and will become more important as the complexity of tasks performed increases.

**Slow data entry.** While the handwriting recognition capabilities of current models allow for reasonably accurate data entry, entering large quantities of data by hand can be quite slow compared with writing, typing, or dictating. New lightweight, collapsible, full-size keyboards that allow for significantly faster data entry have recently become available for several popular handheld models and may make it more practical to enter large amounts of data (TABLE 1).

**Security issues** are becoming increasingly important as handhelds are used to manage patient information. The biggest threat to the security of handhelds today is loss of the device. Although devices running Palm OS or Pocket PC do have built-in password protection, it must be activated by the user and can be cumbersome. To avoid having to enter a password each time the device is turned on, many users choose not to activate this feature. In fact, on Palm OS versions prior to version 4.0, anyone can gain access to password-protected data using readily available software, essentially keeping information away from only casual prying eyes.

As handhelds begin to interface with hospital and clinic systems both directly and wirelessly, measures will have to be instituted to assure adequate security and compliance with new, more stringent regulations about medical record privacy and access.<sup>13</sup>

**TABLE 3**

### Useful general and medical handheld web sites

**Handango (www.handango.com)**

General handheld hardware, software, accessories, and information (formerly Palm Central)

**Handheld Med (www.handheldmed.com)**

Physician and medical student-founded site provides sales of patient tracking and a multitude of electronic medical reference applications, columns, and reviews

**Handspring (www.handspring.com)**

Home of the Visor Palm OS-compatible handheld. Learn about and purchase Visor-related products and find links to Palm and Visor software

**Healthy PalmPilot (www.healthypalmpilot.com)**

Large database of Palm-related healthcare resources organized by categories such as diagnostic, references, research

**Palm (www.palm.com)**

Home of the Palm OS and Palm devices. Includes extensive information and resources on Palm OS computers and links to related sites and resources

**PalmGear HQ (www.palmgear.com)**

General site for downloading Palm shareware, freeware, and commercial demos and ordering a variety of hardware and accessories

**PDA-MD (www.pdamd.com)**

Informative product reviews, discussion boards, sale of handheld products

**Peripheral Brain (pbrain.hypermart.net)**

Home to several useful programs including *MedRules* and *Shots*, designed by Kent Williard, MD. Contains links to many other useful resources

### REFERENCES

1. Duncan RG, Shabot MM. An enterprise web viewing system for clinical and administrative data [abstract]. Proceedings of the AMIA Symposium, Los Angeles, Nov 4-8 2000:1169.
2. Duncan RG, Shabot MM. Secure remote access to a clinical data repository using a wireless personal digital assistant (PDA). Proceedings of the AMIA Symposium, Los Angeles, Nov 4-8 2000:210-214.
3. Lapinsky S, Mehta S, Varkul M, Stewart T. Qualitative analysis of handheld computers in critical care. [abstract].

- Proceedings of the AMIA Symposium, Los Angeles, Nov 4-8 2000:1060.
4. Shabot MM, LoBue M, Chen J. Wireless clinical alerts for physiologic, laboratory and medication data. Proceedings of the AMIA Symposium, Los Angeles, Nov 4-8 2000:789-793.
5. Ho WL, Forman J, Kannry J. Portable digital assistant use in a medicine teaching program [abstract]. Proceedings of the AMIA Symposium, Los Angeles, Nov 4-8 2000:1031.
6. Bass SG. Wireless computing: medical students and



- mobile medicine. *MD Computing* 2000; 17:27.
7. **Wofford MM, Secan R, Herman C, Moran WP, Wofford JL.** Clinical documentation: the handheld computer as a survival tool. *MD Computing* 1998; 15:352-354.
  8. **Chessanow N.** Know your needs, pick a device to fit. *Med Econ* 2000; 77:81-88.
  9. **Kohn LT, Corrigan JM, Donalson MS.** To err is human: building a safer health care system. Washington DC: National Academy Press, 1999.
  10. **Ebell MH, Barry HC.** InfoRetriever: rapid access to evidence-based information on a handheld computer. *MD Computing* 1998; 15:289-297.
  11. **Rothschild JM, Lee TH, Bae T, Yamamoto R, Horsky J, Bates DW.** Survey of physicians' experience using a handheld drug reference guide. [abstract]. Proceedings of the AMIA Symposium, Los Angeles, Nov 4-8 2000:1125.
  12. **McAlduff J, Berkowicz D, Barnett O, Chueh H.** An integrated, mobile web-based billing and diagnosis program. Proceedings of the AMIA Symposium, Los Angeles, Nov 4-8 2000:1085.
  13. **Department of Health and Human Services: Office of the Secretary.** Standards for privacy of individually identifiable health information; final rule. *Federal Register* December 28, 2000; 65:82461-82829.

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