

Practicing Medicine in a Technological Age: Using Smartphones in Clinical Practice

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Mobile technology has the potential to revolutionize how physicians practice medicine. From having access to the latest medical research at the point of care to being able to communicate at a moment's notice with physicians and colleagues around the world, we are practicing medicine in a technological age. During recent years, many physicians have been simultaneously using a pager, cellular telephone, and personal digital assistant (PDA) to keep in communication with the hospital and to access medical information or calendar functions. Many physicians have begun replacing multiple devices with a "smartphone," which functions as a cellular telephone, pager, and PDA. The goal of this article is to provide an overview of the currently available platforms that make up the smartphone devices and the available medical software. Each platform has its unique advantages and disadvantages, and available software will vary by device and is in constant flux.

Mobile technology has the potential to revolutionize how physicians practice medicine. From having access to the latest medical research at the point of care to being able to communicate at a moment's notice with physicians and colleagues around the world, we are practicing medicine in a technological age [1].

Until the widespread availability of mobile telephones in the 1990s, pagers were the sole connection between physicians and their staff, colleagues, and patients. However, pagers are rapidly becoming obsolete in favor of mobile telephones. During recent years, many physicians have been simultaneously using a pager, cellular telephone, and personal digital assistant (PDA) to keep in communication with the hospital and to access medical information or calendar functions. Many physicians have begun replacing multiple devices with a single handset, known as a "smartphone," which functions as a cellular telephone, pager, and PDA. Previous studies have demonstrated that PDAs (often used as a repository of medical information or textbooks) are able to provide treatment recommendations on the most commonly encountered infectious disease syndromes seen in practice [2].

The goal of this article is to provide an overview of the 6 currently available platforms that make up the smartphone devices. Certain platforms are unique to specific wireless carriers, although many are available for multiple networks. Direct comparisons among wireless service providers are not made in this review.

ADVANTAGES OF USING A SMARTPHONE

Using a smartphone may simplify the life of an infectious diseases physician, but such use comes with significant costs of upgrading and maintaining the devices. The use of multiple devices also weighs down physicians, filling up their pockets, laboratory coats, and belts with various devices. In addition, the more devices physicians carry, the more items they may misplace.

Smartphones perform multiple functions. Smartphones can be used to maintain multiple calendars or contacts at numerous locations (e.g., office, home, or laptop) by synchronization (by Bluetooth, Wi-Fi, or a USB connection). Many devices now have built-in keyboards, which allow for rapid data entry. Some devices, such as the iPhone (Apple), Palm OS telephones, and Pocket PC telephones, have touch screens that allow data to be entered interactively by touching the screen.

Memory was an issue with earlier devices. However, now most have either adequate internal memory or the ability to expand the data storage by the insertion of flash memory cards (specific memory cards vary by device). One drawback to flash

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memory is speed, because software installed to a flash memory card may perform at a slower speed than programs that reside in native memory. Therefore, users who want to install numerous programs should look for telephones with more available internal memory.

Smartphones are able to function as 2-way pagers, allowing text messaging and e-mailing to colleagues and family members from anywhere in the world. If a physician is not available at the time of a telephone call, most cellular telephones can function as pagers by receiving numerical text messages. Voice mail is a popular service for some physicians, although it requires setup with the cellular carrier and can be prone to time lag and service quality issues.

SMARTPHONE OPERATING SYSTEMS

Six primary operating systems (OSs) are used by the cellular telephone carriers. Each has its own unique features. What one user finds as an advantage to a particular format, another user may find as a disadvantage. Before purchasing a new device, we recommend viewing table 1 and browsing online review sites (e.g., <http://www.phonedog.com> or <http://reviews.cnet.com>) to compare various devices and to review user experiences.

WINDOWS MOBILE 6.0

Windows Mobile 6.0 has the reputation of supporting strong cellular telephone features but at the expense of its PDA functionality. This OS is often confused with Windows Mobile 6.0 for Pocket PC. The 2 OSs are distinct, and individual software applications are not supported on both platforms (even though both OSs are supported by Windows). The availability of medical software is limited but improving (table 2) in part because of a unique OS that was not previously popular in the medical field and that required different program coding to write software but also because of the small screen size and the lack of a touch screen. Windows Mobile 6.0 telephones, in general, are physically smaller than the other listed devices, except for Symbian telephones.

Outlook synchronization is extremely reliable because of Windows OS support. Many third-party personal information management systems exist that will upgrade the native software. However, synchronization of the memo pad with the built-in application is not available and requires third-party software if a user is interested in this feature.

Like the iPhone and Blackberry (Research in Motion), the platform relies heavily on internet connectivity (via a data package from the service provider) for reference suites and other medical applications. Such reliance will significantly increase the costs of maintaining the device because monthly fees apply. Surfing the internet is not as seamless as with other devices. Web pages may not convert well to the Windows Mobile 6.0

platform to allow easy review (figure 1). Windows Mobile 6.0 devices are also prone to frequent “freezes,” when the device will become inactive for several minutes.

SYMBIAN

The Symbian OS is an open OS designed for various companies and requires unique network capabilities. Although the telephones are widely used, stand-alone medical software is much more limited than with any of the other devices. Of the other smartphones listed in this review, the Symbian OS most closely corresponds with the Windows Mobile 6.0 platform.

BLACKBERRY

Although they are distinctly different platforms, Windows Mobile 6.0 and Blackberry devices share similar features. Both require data packages for online information retrieval and e-mail communication. This platform gained a popular reputation because it was one of the earliest devices that was able to “go online” and access the internet and e-mail seamlessly. Built-in keyboards are standard to allow quick data entry and text messaging. Blackberry telephones still lag somewhat in availability of medical software, although this is improving. The handset offers more advanced on-screen scrolling but lacks a touch screen.

PALM OS

The oldest and most stable of all of the platforms, the Palm OS (also known as the Palm Pilot or Treo) has been incorporated into several lines of smartphones to allow expanded access to programs and software. The Palm OS has perhaps the largest number of medical applications of all of the smartphones, although there are still some medical software titles not supported by the Palm OS. There are multiple models, including the Treo line, but all are made by Palm Inc. and have similar designs. Each model has a built-in QWERTY thumb board and a small high-resolution screen display (~2.4 inches in diagonal; 320 × 320 pixels). Navigation can be accomplished through menus controlled by external buttons on the device. Navigation is also possible via a touch screen, generally with the use of a stylus. Unlike non-smartphone Palm PDAs, it is impossible to enter data directly through the touch screen with the use of Graffiti. The newer models are Bluetooth capable and have infrared ports. They are not Wi-Fi capable. Installation of software does not require a data package, providing a significant cost advantage to many of the other devices.

Voice quality for these telephones is generally rated as very good. Palm OS-based telephones are often recommended for first-time users but probably have a learning curve similar to other smartphones. Individuals who have experience exclusively with Palm-based PDAs will generally prefer Palm OS-

Table 1. Comparison of smartphones.

Variable	Blackberry	iPhone	Palm OS	Pocket PC	Windows Mobile ^a
Battery capacity	++	+	++	++	++
Bluetooth	+	++	++	++	++
Wi-Fi	–	++	–	++	+
Infrared port	+	–	+	+	+
Data entry and retrieval	++	+	++	++	+
Device speed	++	++	++	++	+
Device stability	++	++	++	++	+
E-mail access	++	++	++	++	++
Internet browsing	++	++	++	++	++
Infectious disease software	+	–	++	++	+
Medical software	+	–	++	+	+
Screen size	+	++	+	++	+
Sync with Outlook	++	–	+	++	++
Sync with Mac	++	++	++	+	+
Text messaging	++	++	++	++	+
Website viewing	+	++	+	+	+
Voice mail	+	++	+	+	+

NOTE. +, Good/limited availability; ++, excellent/universally availability; –, poor/not available.

^a Platform most similar to the Symbian OS.

based smartphones. Palm-based devices will sync with either Mac or Windows personal computers. Microsoft Outlook support is at times inconsistent and may require the installation of third-party software.

POCKET PC

Many different models of Pocket PC–based smartphones are made by multiple manufacturers. As a result, far more choices are available compared with other platforms. Because of the widespread support of the Pocket PC platform, even Palm Inc. has released a Pocket PC–enabled Treo with a QWERTY thumb board. However, the screen resolution is only 240 × 240 pixels on this telephone (compared with 320 × 320 for the Palm OS–based devices). Other models have a slide-out QWERTY keyboard and larger screen display (~2.8 inches in diagonal; 240 × 320 pixels). Navigation can be accomplished through external button menus and via a touch screen, generally with the use of a stylus. Most medical and personal applications are available for the Pocket PC platform. The block recognizer and letter recognizer use individual characters for text, number, and symbol entries. The keyboard and symbol pad display characters that are selected with the stylus. The transcriber recognizes handwriting, including cursive writing. Because software can be installed directly to the device, a data connection is not essential, providing a significant cost advantage to some of the other devices.

Voice quality for these telephones is generally rated as very good and has significantly improved with the latest models.

Newer Pocket PC–based devices are generally more stable than older devices. Individuals who are most familiar with Windows may prefer Pocket PC–based smartphones. However, despite similarities in appearance, Pocket PC is not identical to Windows Mobile 6.0 and does not run the same versions of program software. The Pocket PC OS requires third-party software to work with Mac personal computers, and there are issues in downloading some applications through a Mac computer to a Pocket PC device. Pocket PC smartphones are designed to sync with Microsoft Outlook and other e-mail software and are generally Bluetooth capable.

IPHONE

The introduction of the iPhone was eagerly anticipated in 2007, with ~1.4 million iPhones sold during the first 3 months after introduction [3]. Early users of the device were subject to activation glitches, premium pricing, and frequent software updates. Even so, customer surveys suggested an extremely high rate of satisfaction with the handset among its owners [4].

For physicians, many of whom who were already using a smartphone, the iPhone platform brought with it several unique features but at the expense of a few notable compromises. Highlights included a more fully integrated collection of native applications, such as the almost seamless transition among telephone, contacts, maps, e-mail, Short Messaging Service (SMS), and browser functions. A handheld version of the OS X browser Safari permitted access to full-sized Web pages and could download and display complete Adobe portable doc-

Table 2. Software and Websites available for use on smartphones.

Smartphone Websites	URL	Compatible platforms supported ^a
Blackberry Software	http://na.blackberry.com/eng/services	Blackberry
Collective Med	http://www.collectivemed.com/pda	Blackberry, Palm OS, Pocket PC, Windows Mobile
Epocrates	http://www.epocrates.com	Blackberry, Palm OS, Pocket PC, Windows Mobile
Handango	http://www.handango.com	Blackberry, Palm OS, Pocket PC, Windows Mobile
Johns Hopkins Antibiotic Guide	http://hopkins-abxguide.org	Blackberry, Palm OS, Pocket PC, Windows Mobile
MedCalc	http://www.med-ia.ch/medcalc/	Palm OS, Pocket PC
Medical Pocket PC	http://www.medicalpocketpc.com	Blackberry, Palm OS, Pocket PC, Windows Mobile
Merck Medicus	http://www.merckmedicus.com/pp/us/hcp/templates/tier2/PDAtools.jsp	Blackberry, Palm OS, Pocket PC
Micromedex	http://www.micromedex.com	Pocket PC, Palm OS
Mobipocket	http://www.mobipocket.com	Blackberry, Palm OS, Pocket PC, Windows Mobile
Lexi-Comp	http://www.lexi.com	Blackberry, Pocket PC, Palm OS
PDA Medisoft	http://www.pdamedisoft.com	Blackberry, Palm OS, Pocket PC, Windows Mobile
PDR	http://www.pdr.net	Palm OS, Pocket PC
Pepid	http://www.pepid.com	Blackberry, Palm OS, Pocket PC, Windows Mobile
PocketConsult	http://www.pocketconsult.com	Palm OS, Pocket PC
Pocketgear	http://www.pocketgear.com	Palm OS, Pocket PC, Windows Mobile
Pocket PC Central	http://pocketpccentral.net/software/med.htm	Blackberry, Palm OS, Pocket PC, Windows Mobile
QxMD	http://qxmd.com	Blackberry
Sanford Guide	http://www.sanfordguide.com	Palm OS, Pocket PC
Shots 2008	http://www.immunizationed.org	Blackberry, Palm OS, Pocket PC, Windows Mobile
Skyscape	http://www.skyscape.com	Blackberry, Palm OS, Pocket PC, Windows Mobile
Tarascon	http://www.tarascon.com	Blackberry, Palm OS, Pocket PC
Unbound Medicine	http://www.unboundmedicine.com	Blackberry, Palm OS, Pocket PC, Windows Mobile
UpToDate	http://www.uptodate.com	Palm OS, Pocket PC, Windows Mobile
USBMIS	http://www.USBMIS.com	Blackberry, Palm OS, Pocket PC

^a The iPhone does not yet support downloaded medical applications, although it can access many online resources via its internet browser. Data packages that provide internet access may allow software or Website access for nonsupported devices.

ument format pages, a helpful feature for those who preferred accessing the medical literature remotely. Possessing far more integrated flash memory (8/16 gigabytes) than any smartphone before it, the iPhone provides ample space to store contacts, schedule items, e-mails, and digital music and video files.

Unlike its Palm and Windows Mobile-based predecessors, the iPhone platform emphasized connectivity—the potential for unlimited, instant access to applications and other resources via its Wi-Fi (802.11) and Enhanced Data Rates for Global System for Mobile Communication (GSM) Evolution (EDGE) connections. To access a medical resource, physicians could point to it with the Safari browser application, and with Web 2.0 support, the program could be accessed via the wireless connection. Unlike the Palm and Windows mobile platforms, applications initially could not be directly downloaded to the device. According to Apple, support for third-party native applications has not been initially available out of concern for device and network security issues [5].

Unfortunately, a device with as much Web integration as the iPhone is often at the mercy of its network connection. As a result, internet-based medical applications often run more slowly than similar native applications on Palm or Windows Mobile smartphones. Although less apparent in environments where Wi-Fi is available, the EDGE network is noticeably

slower. Compatibility with the much faster 3G standard is expected in the next version of the iPhone, due in mid-2008 [6], although first-generation telephones cannot be upgraded to the faster network.

Perhaps in response to growing feedback from its users, in late 2007, Apple announced support for an iPhone software developer's kit [5]. First released in March 2008, this permits the development of third-party, downloadable applications to the iPhone. With this added capability, many more medical software suites from established PDA platforms may add iPhone support, which is welcome news that may at last allow iPhone users to shed their pockets of a second Palm or Windows Mobile-based PDA.

Several other unexpected iPhone features enhance overall functionality as medical information device. The YouTube application allows easy access to a growing number of medical education videos that are available on the popular site (<http://www.youtube.com>). Many educational institutions are now using standard iPods as learning accessories [7] for reviewing downloadable educational materials. With the inclusion of a fully functional iPod, the iPhone can also permit access to downloaded audio and video continuing medical education content without wireless access or the need to carry a separate MP3 player.



Figure 1. A, iPhone, portrait layout. B, iPhone, landscape layout. C, Pocket PC, viewed with Opera Mobile, zoom at 50%, landscape layout. D, Windows Mobile. E, Palm. F, Pocket PC, viewed with Opera Mobile, zoom at 50%, portrait layout.

WEB BROWSERS

As smartphones become more popular, there may be a transition from free-standing medical software (such as Epocrates or Hopkins Antibiotic Guide) to Web-based software. All available devices currently have the ability to view Web sites, with some devices having a much better aesthetic appearance than others (figure 1). To optimize Web viewing, a separate browser may be downloaded. One alternate browser is Opera (<http://www.opera.com>). This software is available in different versions for various telephones and makes Web site viewing much closer to the capability of the iPhone.

INFECTIOUS DISEASES AND MEDICAL SOFTWARE

One advantage to using a smartphone over a regular cellular telephone is the availability of stand-alone medical applications. Below is a brief discussion of a few commonly used infectious diseases programs that may help practicing physicians or fellows in training become more efficient in patient care. Links to the programs and other software or references are available in table 2.

HOPKINS ANTIBIOTIC GUIDE

The Hopkins Antibiotic Guide has been available for many years, mostly for the Palm OS. Originally designed for the Palm OS and Pocket PC 2003 platforms, it has recently been made available through Skyscape (<http://www.skyscape.com>), expanding the available platforms. The guide has 3 main sections: syndromes, pathogens, and antibiotics. It provides clinically oriented, highlighted information regarding the diagnosis and management of infectious disease syndromes and other useful information, all the while not bogging down the user with too much information. One unique aspect of this software is the “author opinion” section. This section allows the user to select various medications for a specific infection and receive the author’s comments on that selection of therapy.

EPOCRATES

Perhaps the most commonly accessed medical software on a smartphone is a drug database. Many such databases are available, but Epocrates is perhaps the most commonly accessed. The free version provides access to the drug database, whereas the subscription service allows access to numerous other med-

ical resources. Currently available for most platforms, Epocrates is a drug database that provides a wealth of clinical information. Physicians are able to access dosing, adverse reactions, drug interactions, and basic pharmacologic information among with other information. One useful feature of this software is the "multi-check." This option allows entry of 2–30 drugs with subsequent scanning of the database for drug interactions. Results provide a list of drug-drug interactions and the nature of the reaction. Additional free programs are available within this software package, and device support varies by platform. Infection Management, a resource edited by Dr. John Bartlett, provides information regarding medical conference highlights, clinical news, and Dr. Bartlett's Digest. Epocrates also provides category 1 mobile continuing medical education that can be obtained on the smartphone with certificates of completion sent via e-mail. See table 2 for other available drug databases.

MEDICAL CALCULATOR

Several medical calculators are available for the smartphone. The 2 most commonly used are MedMath (supported by Epocrates) and MedCalc. Both provide access to routinely used medical equations, such as for determining creatinine clearance or ideal body weight. Both are free, but supported platforms vary.

SANFORD GUIDE

The traditional paperback pocket infectious disease guide is also available in an electronic format. The information provided electronically is identical to the paperback manuals but does allow for more frequent updates and will allow physicians to have access to the infectious disease recommendations even when away from the office. Users who are familiar with the paperback product may find the electronic version more difficult to navigate.

INFECTIOUS DISEASE PODCASTS

Podcasts are becoming an increasingly useful means of reviewing educational video and audio content on the Web. Some infectious disease-oriented educational sites (e.g., <http://www.IDPodcasts.net>) permit broadcasts of medical presentations to smartphones with streaming audio and video playback capability. With the iPhone, content downloaded to a computer may also be transferred to the device and played back using the iPod feature.

PATIENT BILLING

Patient billing using smartphones is feasible. Numerous proprietary programs are available for either a single or multiple platforms. Physicians need to check with their billing provider to

determine availability. Billing via the smartphone is advantageous in that users have access to their patient database at all times, allowing access to previous diagnosis and clinical information. Advanced users may even be able to design their own database using software such as HanDbase (<http://www.ddhsoftware.com>). When tracking patients on a personal device, Health Insurance Portability and Accountability Act policies must be followed and password protection is recommended.

CONCLUSIONS

Smartphones are a new tool that will allow physicians to become more efficient in their daily activities while providing clinically updated care to their patients. Users must consider many facets of a device before deciding which one to purchase. We recommend users consider the following: screen size, availability of medical software and likelihood of using software, monthly financial expenditures for cellular and internet access, devices that colleagues are using, and presence of a keyboard to permit faster data entry.

It is a dynamic time for smartphones, with new devices being released every month. As developers continue to push the envelope and produce better and faster devices, the power of the smartphone will provide the potential ability to improve physician efficiency. For this to happen, physicians must be willing to accept the new technology, embrace it, and customize it to meet their needs.

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