

Mobile Devices and Apps for Health Care Professionals: Uses and Benefits

C. Lee Ventola, MS

INTRODUCTION

The use of mobile devices by health care professionals (HCPs) has transformed many aspects of clinical practice.^{1,2} Mobile devices have become commonplace in health care settings, leading to rapid growth in the development of medical software applications (apps) for these platforms.^{1,2} Numerous apps are now available to assist HCPs with many important tasks, such as: information and time management; health record maintenance and access; communications and consulting; reference and information gathering; patient management and monitoring; clinical decision-making; and medical education and training.¹⁻⁸

Mobile devices and apps provide many benefits for HCPs, perhaps most significantly increased access to point-of-care tools, which has been shown to support better clinical decision-making and improved patient outcomes.^{2,8-10} However, some HCPs remain reluctant to adopt their use.^{1,4} Despite the benefits they offer, better standards and validation practices regarding mobile medical apps need to be established to ensure the proper use and integration of these increasingly sophisticated tools into medical practice.^{4,8,10,11} These measures will raise the barrier for entry into the medical app market, increasing the quality and safety of the apps currently available for use by HCPs.¹¹

USE OF MOBILE DEVICES BY HEALTH CARE PROFESSIONALS

Types and Prevalence of Devices Used

The introduction of mobile computing devices (personal digital assistants [PDAs], followed by smartphones and tablet computers) has greatly impacted many fields, including medicine. Health care professionals now use smartphone or tablet computers for functions they used to need a pager, cellphone, and PDA to accomplish.⁷ Smartphones and tablets combine both computing and communication features in a single device that can be held in a hand or stored in a pocket, allowing easy access and use at the point of care.⁷ In addition to voice and text, new mobile device models offer more advanced features, such as web searching, global positioning systems (GPS), high-quality cameras, and sound recorders.¹² With these features, as well as powerful processors and operating systems, large memories, and high-resolution screens, mobile devices have essentially become handheld computers.¹²

The first mobile device that incorporated both communication and computing features was the Blackberry, which was introduced in 2002.⁵ After the Blackberry was brought to market, other handheld mobile devices were introduced. Perhaps most notably, in January 2007, Apple launched the first-generation iPhone.⁵ Subsequently, smartphones that run the Google Android operating system were introduced

in October 2008.⁵ Because of the intuitive touch-screen user interfaces and advanced features and capabilities that the iPhone and Android smartphones offer, ownership of mobile devices has increased rapidly.¹² In April 2010, Apple introduced a new innovation, the iPad tablet computer, which because of ease of use, portability, and a comparatively large screen was yet another transformative computing tool.⁵ The iPad ignited the tablet computer market.⁹ Tablets that run the Google Android operating system (Samsung Galaxy and others) were launched later that year, making the use of these mobile devices even more widespread.⁵

Without a doubt, medicine is one of the disciplines that has been profoundly affected by the availability of mobile devices.⁴ This is evident in many surveys of HCPs that reveal a high ownership rate of these tools, which HCPs use in both clinical practice and education.² Smartphones and tablets have even replaced desktop systems as the preferred computing devices for HCPs who need fast access to information at the point of care.⁹

The June 2012 Manhattan Research/Physician Channel Adoption Study found that doctors' ownership and use of mobile devices is pervasive, with 87% using a smartphone or tablet device in their workplace, compared to 99% who use a computer.¹³ Surveys have shown that around 80% of physicians use an iPhone, while most of the remainder opt for Android smartphones.^{1,14} An estimated 66% of doctors own a tablet computer, which 54% use in their practices.¹³ Interestingly, the popularity of mobile devices does not correspond with age, since 80% of physicians ages 55 and older own a smartphone.¹³ Similar results reflecting the pervasive use of mobile devices by HCPs were reported in a survey of medical school faculty, residents, and students.¹ The results of this study found that 85%, 90%, and 85% of respondents, respectively, use mobile devices in a wide variety of clinical settings ranging from classrooms to hospitals.¹

Need for Mobile Devices at the Point of Care

One major motivation driving the widespread adoption of mobile devices by HCPs has been the need for better communication and information resources at the point of care.^{7,14} Ideally, HCPs require access to many types of resources in a clinical setting, including:

- Communication capabilities—voice calling, video conferencing, text, and e-mail⁷
- Hospital information systems (HISs)—electronic health records (EHRs), electronic medical records (EMRs), clinical decision support systems (CDSSs), picture archiving and communication systems (PACSs), and laboratory information systems (LISs)⁷

The author is a consultant medical writer living in New Jersey

Disclosure: The author reports that she has no commercial or financial relationships in regard to this article.

Mobile Devices and Apps for Health Care Professionals: Uses and Benefits

- Informational resources—textbooks, guidelines, medical literature, drug references⁷
- Clinical software applications—disease diagnosis aids, medical calculators⁷

Prior to the development of mobile devices, these resources were mainly provided by stationary computers, which do not support the need for mobility in health care settings.⁷ In an attempt to address this need, some health care environments set up portable, wireless mobile information stations such as Computers on Wheels (COWs) or Workstations on Wheels (WOWs).⁷ With the availability of mobile devices, however, clinicians now have access to a wellspring of information at their fingertips, through their smartphones and tablets.¹⁰

The results of the 2012 Manhattan Research/Physician Channel Adoption Study also identified the purposes for which HCPs rely on mobile devices.¹³ Searching was the most popular activity among HCPs, with 98% using their desktops/laptops to search, 63% using their tablets, and 56% using their smartphones.¹³ Focusing on smartphone use for doctors alone, searching is again the most common activity, occupying 48% of phone time, with professional apps consuming an additional 38%.¹³ Physicians were also found to spend an average of three hours per week watching web videos for professional purposes on desktops/laptops (67%), tablets (29%), and smartphones (13%); the most frequently viewed content (55%) was continuing medical education (CME) activities.¹³ A frequent reliance on mobile devices was also reported in the survey of medical school HCPs and students, with 85% reporting the use of a mobile device at least once daily for clinical purposes, often for information and time management or communication relating to education and patient care.¹

MOBILE APPS FOR HEALTH CARE PROFESSIONALS

What Are “Apps”?

The rapid integration of mobile devices into clinical practice has, in part, been driven by the rising availability and quality of medical software applications, or “apps.”² Apps are software programs that have been developed to run on a computer or mobile device to accomplish a specific purpose.¹ Faster processors, improved memory, smaller batteries, and highly efficient open-source operating systems that perform complex functions have paved the way for the development of a flood of medical mobile device apps for both professional and personal use.⁴

The ability to download medical apps on mobile devices has made a wealth of mobile clinical resources available to HCPs.¹⁵ Medical apps for many purposes are available, including ones for electronic prescribing, diagnosis and treatment, practice management, coding and billing, and CME or e-learning.^{9,10} A broad choice of apps that assist with answering clinical practice and other questions at the point of care exist, such as: drug reference guides, medical calculators, clinical guidelines and other decision support aids, textbooks, and literature search portals.^{7,13,15} There are even mobile apps that simulate surgical procedures or that can conduct simple medical exams, such as hearing or vision tests.^{6,7} Many mobile apps are not intended to replace desktop applications, but are meant to complement them in order to provide a resource that has the potential to improve outcomes at the point of care.⁷ The use of medical apps

has become frequent and widespread; 70% of medical school HCPs and students reported using at least one medical app regularly, with 50% using their favorite app daily.^{1,9}

In July 2008, access to apps was further revolutionized by the launch of the Apple iTunes Appstore, which gave iPad, iPhone, and iPod Touch (iTTouch) users the ability to shop for and download apps from an online marketplace.^{9,15} As of January 2014, Apple reported that a staggering 1 million apps were available through the iTunes Appstore.¹⁶ In 2011, Apple created the “Apps for Healthcare Professionals” section within the medical category of the iTunes Appstore, a unique feature among mobile app marketplaces.¹⁷ In 2013, this section was further divided into subcategories including: reference, medical education, EMR and patient monitoring, nursing, imaging, patient education, and personal care.¹⁸ Google similarly launched a “Google Play” shop that provides a wide variety of apps, including some for HCPs, for mobile devices that use the Android operating system.¹⁵ To reach more users, some mobile apps have been made available for use on either Apple or Android platforms.⁹

The primary criteria for choice of app is often cost; users may prefer to download a free app but will replace or upgrade it later, if necessary, with one that requires payment.⁹ Some free apps are fully functional, while others are nonfunctional or partially functional unless a subscription is purchased.⁹ Many well-known medical journals and medical textbooks can be purchased as mobile apps after payment of a subscription fee.⁹ Although some medical apps may initially be costly, they can ultimately be cost-effective if updates are included.^{9,15} For example, medical textbook apps are often updated annually, eliminating the need to buy newer editions.⁹

How HCPs Use Mobile Devices and Apps

Health care professionals use medical devices and apps for many purposes, most of which can be grouped under five broad categories: administration, health record maintenance and access, communications and consulting, reference and information gathering, and medical education. The many uses for mobile devices and types of medical apps that fall under these categories are discussed in the following section, and are also listed in Tables 1 and 2.

Information and Time Management

One of HCPs’ most frequent uses for mobile devices is information and time management.¹ Popular information management apps, such as Evernote and Notability, enable users to write or dictate notes, record audio, store photographs, and organize material into categories within a searchable electronic database.⁶ E-book reader apps, such as GoodReader and iAnnotate, allow users to view, underline, highlight, enlarge, and annotate text in PDF files.^{2,5}

Cloud-based storage and file-sharing services that can be accessed using a mobile device are also useful for information management, since they allow users to store, update, and share documents or photographs with others without exchanging a flash drive or CD.^{2,5,6} Most cloud-based storage systems provide users with a few gigabytes of memory for free; additional space often requires payment of an annual subscription.² Cloud-based information storage provides the

Mobile Devices and Apps for Health Care Professionals: Uses and Benefits

Table 1 Uses for Mobile Devices and Apps by Health Care Professionals

<p>Information Management</p> <ul style="list-style-type: none"> • Write notes • Dictate notes • Record audio • Take photographs • Organize information and images • Use e-book reader • Access cloud service <p>Time Management</p> <ul style="list-style-type: none"> • Schedule appointments • Schedule meetings • Record call schedule <p>Health Record Maintenance and Access</p> <ul style="list-style-type: none"> • Access EHRs and EMRs • Access images and scans • Electronic prescribing • Coding and billing 	<p>Communications and Consulting</p> <ul style="list-style-type: none"> • Voice calling • Video calling • Texting • E-mail • Multimedia messaging • Video conferencing • Social networking <p>Reference and Information Gathering</p> <ul style="list-style-type: none"> • Medical textbooks • Medical journals • Medical literature • Literature search portals • Drug reference guides • Medical news <p>Clinical Decision-Making</p> <ul style="list-style-type: none"> • Clinical decision support systems • Clinical treatment guidelines • Disease diagnosis aids 	<ul style="list-style-type: none"> • Differential diagnosis aids • Medical calculators • Laboratory test ordering • Laboratory test interpretation • Medical exams <p>Patient Monitoring</p> <ul style="list-style-type: none"> • Monitor patient health • Monitor patient location • Monitor patient rehabilitation • Collect clinical data • Monitor heart function <p>Medical Education and Training</p> <ul style="list-style-type: none"> • Continuing medical education • Knowledge assessment tests • Board exam preparation • Case studies • E-learning and teaching • Surgical simulation • Skill assessment tests
---	--	--

additional advantage of permitting information to be accessed instantaneously from multiple devices, which allows people who are collaborating together to share materials quickly.^{2,5,6}

Dropbox is a popular cloud-based storage service that can be used with multiple devices.^{2,5} Google Drive also allows file uploading, sharing, and management through Google Docs.^{2,5} SkyDrive, a cloud-based storage service that is compatible with mobile devices, uses the Windows 8 operating system.⁵ Box is a cloud-based storage service that is reportedly compliant with both the Health Insurance Portability and Accountability Act (HIPAA) and the Health Information Technology for Economic and Clinical Health (HITECH) Act.¹⁹ However, it should be noted that some cloud-based storage services are not compliant, and therefore may not be suitable for storing or exchanging patient information.² Access to cloud-based storage services requires an Internet connection, but files can be saved to the mobile device's internal memory for offline use.⁵

An additional advantage provided by information management apps is that they can be used in combination. For example, GoodReader can be connected to a cloud service, allowing PDF files to be downloaded from the cloud into the reader app.⁵ Evernote, as well as some other information management apps, can be used in conjunction with a cloud service and reader.⁵ This enables a PDF downloaded from the cloud to be viewed with a reader, then sections of the document can be cut and pasted into the information management app.⁵

HCPs frequently use mobile device apps for time management. This doesn't require a special app; native apps that come installed on mobile devices are often sufficient to organize and track appointments, meetings, call schedules, and other clinical obligations.^{1,3} Mobile apps such as ZocDoc, which allow patients to view information about and make appointments with participating doctors, are also available for the iPhone, Android, and Blackberry devices.⁴

Health Record Maintenance and Access

Apps are also available that aid in data collection and retrieval, such as entering information into a patient's EHR or EMR.^{3,7} Hospital information systems often include features that allow HCP management of EHRs and PACSs, permitting secure access to patient information (medical history, vitals, prescriptions, lab results, x-rays, scans, consultations, and discharge notes) either on site or remotely.^{3,7}

One health care software company, Epic Systems, has partnered with Apple and released versions of the Epic scheduling, billing, and clinical support app for the iPhone and iPad.⁴ PatientKeeper Mobile Clinical Results provides physicians with access to patient clinical data via either Apple or Android mobile devices.⁷ Teamviewer is a general-purpose record maintenance and access app that can be installed on mobile devices, allowing remote access to desktop PCs.⁵ In the absence of such apps, a virtual private network (VPN) log-in can often be obtained from the hospital to allow remote secure access into the in-house network through the Internet to view records for emergency consultations.⁵

Specialized apps are also available for remote viewing of medical imaging scans.¹⁰ Mobile MIM is a free app for the iPad and iPhone, approved by the Food and Drug Administration, that allows remote viewing of x-rays and imaging scans when users cannot access imaging workstations.⁶ This software works with a paid subscription or pay-per-use plan using MIMCloud, a HIPAA-compliant server that allows users to store and share medical images.⁶ Images can be downloaded from the cloud and viewed with the MIMViewer paid app in any setting, whether during discussions with team members or patients.⁶

In some instances remote evaluation of image scans via a medical device has been proven to be just as effective as viewing them at a standard workstation.⁴ In fact, one group demonstrated that its members could use their iPhones to diagnose acute stroke on CT brain scans just as accurately as when a workstation was used.⁴ Mobile devices' cameras are

Mobile Devices and Apps for Health Care Professionals: Uses and Benefits

also useful for documenting images to aid in diagnoses, such as taking pictures of gross or microscopic pathology specimens to get a colleague's opinion or for personal reference.³

Communication and Consulting

Health care systems are often highly dispersed, encompassing multiple locations such as clinics, inpatient wards, outpatient services, emergency departments, operating theaters, intensive care units, and labs.⁷ Consequently, HCPs not only need to be mobile themselves, they also need to be able to communicate and collaborate with people in different locations.⁷ Mobile devices satisfy this need by offering multiple means of communication, including: voice and video calling; text, e-mail, and multimedia messaging; and video conferencing.^{3,7} Clinical communication apps are available for mobile devices that are specifically designed to simplify communication among clinicians.⁷

Mobile devices have been proven to improve contact between HCPs and their colleagues.^{1,4} In one study, mobile devices were shown to improve communication between doctors and nurses on inpatient wards.⁴ In a survey of medical school HCPs and students, more than 80% of respondents described using mobile devices to communicate with colleagues about patient care via e-mail, telephone, and text messages.¹ They described texting as a more efficient means of communication than telephone conversations or in-person meetings.¹ Mobile devices also allow rapid response to e-mail, allowing users to keep up with communication.¹ Texting or calling colleagues directly on their mobile devices, rather than paging them, has also been shown to save critical time in emergency cases.^{3,7} Mobile devices can also be used by HCPs to aid long-distance patients by allowing them to text or send pictures regarding problems or questions.³

Social networking apps are useful tools for enabling discussion, consultations, and collaboration among HCPs.⁵ Doximity is a HIPAA-compliant social networking site that has been described as a "Facebook for doctors."⁴ Registration on Doximity requires validation of a potential user's credentials through verification against a medical license database.⁴ Once registered, physicians can network with colleagues from medical school, residency, or elsewhere, and exchange patient-related information via text messages.⁴ Facebook itself has also reportedly been used to establish a "nondisclosed" forum for consultations, discussions, and mini-lectures among infectious disease specialists who are registered university professors.⁵ Such forums can provide a convenient and efficient means for medical specialists to rapidly and efficiently share opinions.⁵ Chatting apps that allow text messaging and image exchange can be used to trade detailed information during consultations.⁵ It should be noted that Facebook, as well as many other social media and chatting apps, is not HIPAA compliant.⁵

Reference and Information Gathering

Literature Research and Review

Mobile devices are invaluable tools for HCPs to use to search or access medical literature, as well as other information sources.¹ The survey of medical school HCPs and students found that mobile devices were often used to access medical journal websites (60%) or medical news online (74%).¹ Several

medical journals, such as the *New England Journal of Medicine*, *The Lancet*, and *BMJ* (formerly the *British Medical Journal*), provide apps that allow articles to be viewed on mobile devices.⁵ However, journals rarely provide free access to articles without the purchase of a subscription.⁵

Search applications for HCPs, such as PubMed/MEDLINE, also facilitate searches of medical literature databases to identify published medical information.⁷ Mobile medical literature search apps used by HCPs include: PubSearch, PubMed on Tap, Medscape, MEDLINE Database on Tap (MD on Tap or MDOT), Docphin, Docwise, Read by QxMD, askMEDLINE, PICO, and Disease Associations.⁷ PubSearch is available for free, while PubMed on Tap is available for several dollars.^{2,7} Both apps work with the iOS platform to facilitate PubMed/MEDLINE searches using the iPhone, iPod, and iPad.⁷ The free app MD on Tap is provided by the National Library of Medicine to help HCPs using PDAs access medical information at the point of care through three search engines: PubMed, Essie, and Google.⁷

Drug References

Drug reference applications are generally used to access information including: drug names, indications, dosages, pharmacology, interactions, contraindications, cost, formulary status, identification guides, and dose by weight calculators.^{3,7} The most frequently used mobile drug reference apps include: Epocrates, Skyscape RxDrugs/Omnio, Micromedex, FDA Drugs, and DrugDoses.net.^{2,4,7} Epocrates, Skyscape RxDrugs/Omnio, and FDA Drugs allow users to check multiple drug-drug interactions at the same time.⁷ FDA Drugs, which includes official FDA labeling for prescription and over-the-counter drugs, permits searching by active ingredients.⁷ The authors of Epocrates, the most commonly used drug reference app, found that 90% of physicians use mobile device apps to access drug information.^{7,14}

News Acquisition

MedPage Today is one of the most popular apps among HCPs for accessing breaking medical news, organizing news by interest, and earning CME credits.⁴ The MedPage Today app provides information about drugs, diseases, and medical procedures, as well as daily podcasts, videos, and news updates.^{2,3} It encompasses 30 medical specialties and provides annual coverage of more than 60 meetings and symposia.²

Other medical news apps are available.⁵ For example, the "Outbreaks Near Me" app for users of either Apple or Android mobile devices provides real-time information regarding disease outbreaks according to geography.⁴ This information is gathered from multiple resources, including online news, eyewitness accounts, and official reports.⁴ The Outbreaks Near Me app was funded by Google and developed in collaboration with the Centers for Disease Control and Prevention, as well as other organizations.⁴

Patient Management

Clinical Decision-Making

Mobile devices provide HCPs with convenient and rapid access to evidence-based information, supporting clinical decision-making at the point of care.⁸ HCPs' increased reliance

Mobile Devices and Apps for Health Care Professionals: Uses and Benefits

Table 2 Medical Apps for Health Care Professionals^{2,4}

Information Management	
Evernote	Note-taking and organization
Notability	Note-taking and organization
iAnnotate	PDF viewer
GoodReader	PDF viewer
Box	Cloud storage and file sharing
Dropbox	Cloud storage and file sharing
Google Drive	Cloud storage and file sharing
Communication and Consulting	
Doximity	Social networking site for MDs
Reference and Information Gathering	
Epocrates	Drug and medical reference
Dynamed	Drug and medical reference
Skyscape/Omnio	Drug and medical reference
Micromedex	Drug reference
Dynamed	Medical reference
UpToDate	Medical reference
Medscape	Medical reference
Johns Hopkins Antibiotic Guide	Medical reference
Sanford Guide to Antimicrobial Therapy	Medical reference
Medpage Today	Medical news
Patient Management and Monitoring	
Diagnosaurus	Differential diagnosis
Pocket Lab Values	Laboratory reference
Lab Pro Values	Laboratory reference
Archimedes	Medical calculator
MedCalc	Medical calculator
Mediquations	Medical calculator
Calculate	Medical calculator
AHRQ ePSS	Screening and prevention tool
Medical Education and Training	
MedPage Today	Continuing medical education
QuantaMD	Continuing medical education

on electronic resources for this purpose was identified in the Manhattan Research/Physician Channel Adoption Study, which reported that physicians spend the majority (64%) of their online time looking for information to make or support clinical decisions, double the time spent reviewing print resources.¹³

Many evidence-based software apps serve as useful bedside clinical decision-making tools.⁷ Printed medical references often used in disease diagnosis are now available as mobile device apps that provide information on diagnosis, treatment, differential diagnosis, infectious diseases, pathogens, and other

topics.⁷ Such apps include: Johns Hopkins Antibiotic Guide (JHABx), Dynamed, UpToDate, 5-Minute Clinical Consult (5MCC), 5-Minute Infectious Diseases Consult (5MIDC), Sanford Guide to Antimicrobial Therapy (SG), ePocrates ID, Infectious Disease Notes (ID Notes), Pocket Medicine Infectious Diseases (PMID), and IDdx.^{2,7}

Diagnosaurus, a popular, low-cost mobile differential diagnosis app for the iPhone, iPad, and iPod, can help ensure that alternative diagnoses are not overlooked.⁴ Flowcharts to help physicians identify diagnostic possibilities are included in the apps 5MCC and Pocket Guide to Diagnostic Tests.⁷ Other diagnostic mobile apps apply clinical algorithms to aid physicians in determining a disease diagnosis.⁷ Mobile devices can also be used to access CDSSs installed on desktop computers in clinical settings to aid in diagnosis and treatment decisions.⁸

Mobile apps can also help clinicians identify the appropriate scans or tests to order, decreasing unnecessary procedures and reducing cost of care.⁷ Lab test apps provide information such as: reference values and interpretation, causes for abnormal values, and laboratory unit conversions.⁷ They include: Pocket Lab Values, Lab Pro Values, Palm LabDX, Normal Lab Values, Lab Unit Converter, Labs 360, Davis's Laboratory and Diagnostic Tests, and Pocket Guide to Diagnostic Tests.^{2,7}

Mobile apps can also be used directly to conduct simple examinations for visual acuity or color blindness, as well as blood pressure or glucose level.^{3,5,7} The iPhone iSeismometer app, which is used to measure tremor frequency, has been reported to match more sophisticated and expensive devices used for electromyogram analysis.³ The iMurmur app provides recordings of 20 types of heart murmurs, allowing a physician to match and identify what she or he hears.³ Many apps are available to determine pregnancy due dates by using a patient's sonogram and date of last period, such as "Perfect OB Wheel."³ These apps have been said to predict pregnancy due dates more accurately than the paper wheels that had previously been the standard.³

Current treatment guidelines available at the point of care via mobile apps also provide a valuable resource for HCPs.⁶ Several guidelines are accessible on mobile platforms, including the National Comprehensive Cancer Network guidelines for cancer care available through the Epocrates app, and the American College of Chest Physicians antithrombotic therapy guidelines available via the CHEST app.⁶ The Johns Hopkins ABX Guide app provides an impressive compilation of antimicrobial recommendations and guidelines, including some for surgical prophylaxis and surgical site infection treatment.⁶

Other mobile apps, such as medical calculators, use standard formulas to make calculations to determine risk scores and other measures, such as body mass index (BMI), body surface area (BSA), and proper drug doses.^{4,7} Calculation of clinical scores or indices typically involves utilizing complex formulas that require several input parameters.⁷ Even if a HCP knows the formula, performing even simple clinical score calculations manually can be surprisingly time consuming and error prone in a fast-paced clinical environment.⁷ In contrast, HCPs who use medical calculators do not necessarily need to know the formula for calculating a clinical score or index; they only need to enter the parameters to quickly produce a reliable result.⁷

Popular medical calculators include: Epocrates MedMath,

Mobile Devices and Apps for Health Care Professionals: Uses and Benefits

MedCalc, MediQuations, Calculate, Medical Calculator, Archimedes, uBurn Lite, Soffforce's Antibiotic Dosage Calculator, and Paeds ED.^{2,6} Others that are available are: Vancomycin ClinCalc Full, Soffforce's Antibiotic Dosage Calculator, and MedCalc 3000 Pharmacology.⁵ Calculate by QxMD is a free app that calculates heart disease and stroke risk based on various patient variables.³ Since the results are visual, this app can be very effective in communicating risks to patients during discussions about potential behavior change.³ Another free medical calculator called Archimedes is available through Skyscape.⁴

The Agency for Healthcare Research and Quality (AHRQ), part of the U.S. Department of Health and Human Services, provides the free Electronic Preventive Services Selector (AHRQ ePSS) app.^{3,4} This app is designed to assist primary care physicians in screening, counseling, and identifying preventive measures, based on a patient's age, gender, sexual activity, tobacco use, and other risk factors.^{3,4} Surgical risk calculators are also available, such as the euroSCORE calculator, which uses recommendations from the Society of Thoracic Surgeons to calculate operative risk at the point of care.⁶ The American Cancer Society National Surgical Quality Improvement Program is also developing a surgical risk calculator.⁶

Patient Monitoring

The use of mobile devices to remotely monitor the health or location of patients with chronic diseases or conditions has already become a viable option.⁷ Mobile device apps can provide public health surveillance, aid in community data collection, or assist disabled persons with independent living.¹² In one study, a single-lead electrocardiograph (ECG) was connected to a smartphone to diagnose and follow treatment of patients with sleep apnea, providing a possible alternative to costly and labor-intensive polysomnography.⁴ Sensors attached to garments that communicate with mobile devices have also been used to remotely monitor and collect medical data regarding chronically ill elderly patients.⁴

A clinical monitoring system was developed to monitor an entire unit or one bed in intensive care via smartphone; it displays an alarm, color-coded according to severity, based on patient vital signs.⁷ The app iWander for Android was developed to monitor and track patients with early Alzheimer's disease who are prone to wandering by using the mobile device GPS.⁴ HanDBase, a HIPAA-compliant relational database software program, can be used on mobile devices to track hospitalized patients according to their locations, diagnosis, tests, treatments, and billing information.³ Smartphone apps have also been used to monitor patients during rehabilitation.⁴ For example, a smartphone connected via Bluetooth to a single-lead ECG device enabled the monitoring of patients in their own neighborhoods when they were unable to reach traditional hospital-based rehabilitation.⁴ Although potentially useful, patient monitoring apps can be limited by factors such as Internet and GPS reliability, as well as the patient's ability to use the device.⁴

Mobile apps that supplement medical devices are being developed.⁵ One example is iStethoscope, which uses the microphone function of the iPhone to auscultate and record.⁵ While this app isn't officially intended for use as a medical

device, it is significant in that its existence suggests that mobile devices can eventually replace medical devices.⁵ Mobile devices have also been used to accurately track heart rate and heart-rate variability.⁴ In January 2011, MobiSante became the first company to receive FDA approval for a smartphone-based medical diagnostic tool that uses an ultrasound probe for echocardiography.⁴ Work has also already been initiated to develop ECG recording devices that work with smartphones.⁴

Medical Education and Training

Mobile devices play an increasingly important role in medical education as students and schools use more technology during training.⁴ Mobile devices are used by health care students in a variety of ways: to log their experiences, to access information about medical conditions and drug treatment, to perform calculations, and to make basic notes.¹

Mobile devices have become ubiquitous in educational settings, particularly because they are a "learn anywhere" resource for accessing information or double-checking knowledge.^{1,15} Health care students are increasingly relying on mobile devices as a "pocket brain" for quick, easy access to information they need in order to succeed in their programs and careers.⁹ Resources frequently used by health care students include: online textbooks and lectures, medical podcasts, medical calculators, and search engines to look up unfamiliar terms.¹ In addition, many mobile apps for health care students can be used for knowledge assessment, such as case study quizzes or tests to help prepare for board examinations.^{6,7} The ability to access all of these resources has been shown to enhance student learning in the clinical environment and to increase student knowledge scores.¹

Mobile devices are also used by practicing HCPs for educational purposes, especially for CME activities that keep them informed about the most current evidence-based information and medical practices.^{3,4,7} QuantiaMD has a mobile CME app that provides well-scripted interactive case studies that can be shared with colleagues.⁴ In a survey of medical school faculty, residents, and students, 75%, 95%, and 55%, respectively, agreed that using a mobile device for rapid access to educational resources while on the go had a positive educational effect.¹

Mobile devices have been shown to be important tools for teaching medical curricula. In one example, doctors who used a mobile device app during advanced life-support training had significantly improved scores during cardiac arrest simulation testing.⁴ Mobile apps such as Touch Surgery or vCath are available for simulated surgery training.⁶ In addition, Northwestern University's Feinberg School of Medicine faculty uses an iPhone app to assess residents' autonomy and skill level in the operating room based on self-assessment and the attending surgeon's evaluation.⁶

BENEFITS PROVIDED BY MOBILE DEVICES AND APPS FOR HEALTH CARE PROFESSIONALS

Mobile devices and apps have provided many benefits for HCPs, allowing them to make more rapid decisions with a lower error rate, increasing the quality of data management and accessibility, and improving practice efficiency and knowledge.^{1,7,8,10,20} Most importantly, these benefits have been shown to have a positive effect on patient care outcomes, as evidenced

Mobile Devices and Apps for Health Care Professionals: Uses and Benefits

by a reduction in adverse events and hospital length of stay.^{8,10} These and other benefits mobile devices and apps provide to HCPs are discussed in the following section.

Convenience

Many mobile apps have made the practice of evidence-based medicine at the point of care more convenient.^{7,14} Health care professionals associate numerous conveniences with using a mobile device in clinical practice, such as: portability, rapid access to information and multimedia resources, flexible communications, and a choice of powerful apps to accomplish many different purposes.^{1,12} Medical school HCPs and students cite access to information instantaneously at the time of need as a major convenience.¹ Other studies describe keeping current through access to updates about new books, guidelines, reviews, and medical literature as an appreciated convenience.¹⁰ Health care students also no longer have to carry reference books, since many can now be accessed with a mobile device.⁶ Consequently, students can carry all of the information found in standard medical textbooks and other necessary references in one small device that fits in a lab-coat pocket.⁹

Better Clinical Decision-Making

Many medical apps make mobile devices invaluable tools that support clinical decision-making at the point of care.^{7,10} This quality is very important when practicing evidence-based medicine, since clinicians may not always seek answers to clinical questions after the completion of every clinical encounter.^{2,7,10} Practicing clinicians, as well as medical and nursing students, cite the most useful mobile tools for supporting evidence-based medicine and clinical decision-making as being drug reference, medical textbook, disease diagnosis, and medical calculator apps.⁷ The use of mobile devices can also support better decision-making by pharmacists by providing instant access to multiple drug information sources and other medical references.²

Studies have reported an increase in the appropriateness of diagnoses and treatment decisions when mobile devices were used for clinical decision support, particularly when a CDSS app was used.⁸ Data have shown that when electronic references were consulted, there were twice as many adjustments in patient management decisions compared to cases in which only paper resources were available.¹⁰ Another study tested participants' understanding of prescribing accuracy and found that the use of a mobile device improved drug knowledge and understanding to a statistically significant level ($P = 0.005$).⁸ Similarly, a risk assessment study evaluated the occurrence of gastrointestinal side effects with nonsteroidal anti-inflammatory drugs and found that unsafe prescribing was significantly reduced ($P = 0.001$) in the group of HCPs that used a mobile device app compared with a control group.^{8,10}

Improved Accuracy

Mobile devices have repeatedly been found to improve the completeness and accuracy of patient documentation, an effect that has often been attributed to ease of use.^{2,8,10,15} More accurate diagnostic coding, more frequent documentation of side effects, and increased medication safety through reduced medical errors have been reported.¹⁰ Based on a more detailed

description of clinical findings and a correct progress assessment, documentation prepared using a mobile device was judged to be of higher quality than documentation prepared using paper records.¹⁰ Inclusion of specific intervention rules on a mobile device has been found to significantly reduce prescription error rates ($P < 0.05$).¹⁰ Use of a mobile device significantly reduced discharge order list errors (from 22% to 8%, $P < 0.05$) and yielded fewer discrepancies in recording neonatal patient weights in intensive care compared to using paper records.¹⁰ Timely communication within hospitals has also been determined to reduce medical errors, especially in critical care environments.⁷

Increased Efficiency

Evidence has shown that mobile devices allow HCPs to be more efficient in their work practices.^{3,10} The Deloitte Center for Health Solutions 2013 Survey of U.S. Physicians found that most doctors believe that meaningful adoption of health information technology (EHRs, e-prescribing, health information exchange, analytics/decision support, patient support tools [websites, mobile apps, tools to track and manage health and wellness], and mobile health technologies [tablets, smartphones]) can improve the efficiency of clinical practice.²¹

The use of mobile devices has been shown to provide HCPs with numerous enhanced efficiencies, including: increased quality of patient documentation through fewer errors and more complete records, more rapid access to new information, and improved workflow patterns.¹⁰ Physicians have reported that the use of a mobile device for retrieving information from a drug database led to more efficient decision-making and patient care.¹⁰ Physicians working in health care organizations have cited improved care coordination, as well as quicker and more efficient access to clinical support resources (guidelines, lab tests, and reports) as principal benefits associated with mobile device use.¹⁰ Physicians who used mobile devices during patient rounds reported spending less time accessing, retrieving, and recording data and said that the increased efficiency freed up more time for direct patient care.¹⁰ In contrast, another study found that the increased efficiency in median doctor-patient encounter time (227 vs. 301 seconds) provided by the use of mobile devices, rather than paper resources, resulted in less time spent with the patient.¹⁰

Enhanced Productivity

Research has shown that the use of mobile devices at the point of care has helped streamline workflow and increase the productivity of HCPs.² Mobile devices have been found to cause a significant increase in the average rate of electronic prescribing, from 52% to 64% ($P = 0.03$).¹⁰ Mobile apps can also increase pharmacist productivity by allowing important drug information, such as contraindications and interactions, to be checked quickly, resulting in more rapid processing of prescriptions.²² Pharmacists using a mobile device reported recording more information and completing more fields, which resulted in more thorough documentation.¹⁰

Studies that investigated patient record maintenance and revision found that more patient information was documented when a mobile device was used, reportedly because of ease of use in comparison to paper records.⁸ Another study found a

Mobile Devices and Apps for Health Care Professionals: Uses and Benefits

statistically significant difference ($P = 0.0001$) in the number of diagnoses documented with a mobile device compared to paper records.⁸ Mobile apps can also help increase productivity by improving professional and personal time and information management.²

FUTURE TRENDS FOR MOBILE DEVICES AND APPS IN HEALTH CARE

Several interesting trends regarding the use of mobile devices and apps in health care have been predicted for the future. As better health outcomes become the ultimate goal of the health care system, apps will be needed to fulfill that purpose.²³ The prevention and management of chronic health conditions, such as diabetes, obesity, and heart disease, present serious problems for HCPs, patients, and the health care system.²³ Patient care management and compliance are difficult challenges, too, so apps that successfully address these issues are needed and eagerly awaited.²² Apps that support caregivers and promote better communication among patients, physicians, and other resources have also been identified as important unmet needs.²³ As patient ownership of mobile devices increases, new opportunities for direct communication with HCPs and for improved self-monitoring and disease prevention are expected to develop.¹⁰

Mobile device hardware and apps are expected to continue to improve, bringing additional and enhanced benefits to clinical practice.^{1,10} Future mobile apps are expected to include even larger databases, as well as CDSS prompts that will aid in clinical decision-making, similar to features that are already built into the EMR systems on desktop computers in clinical settings.⁵ Various other types of mobile apps will continue to evolve and transform into CDSS apps that incorporate artificial intelligence-oriented algorithms.⁵ There is also a need to develop standards for mobile apps so that they can integrate seamlessly with HIS capabilities, such as EMRs and patient monitoring systems.^{7,8} This may require in-house CDSSs that are carefully custom designed for each patient care setting.⁸ Such measures will enable HCPs to use mobile apps in a more meaningful way that hopefully leads to improved patient care.⁷

The role played by mobile devices and apps in health care education is also expected to grow.^{1,4} Medical school HCPs and students predict that mobile devices and apps will become even more integrated into patient care and will eventually completely replace textbooks.¹ As the use of medical devices and apps expands, more educational health care programs are expected to incorporate them into medical curricula.^{1,4}

Several issues challenge the future integration of mobile devices and apps into health care practice.² While the majority of HCPs have adopted the use of mobile devices, the use of these tools in clinical care has been debated since their introduction, with opinions ranging from overwhelming support to strong opposition.^{1,4} Among the concerns raised regarding mobile devices are: their reliability for making clinical decisions; protection of patient data with respect to privacy; impact on the doctor-patient relationship; and proper integration into the workplace.^{10,14,22} In addition, HCPs have expressed concerns about lack of oversight with respect to standards or content accuracy, especially for apps involved in patient management.¹⁴ Older HCPs, as well as those who are intimidated by or less

inclined to use new technologies, may be at a disadvantage if the use of mobile devices becomes a requirement within the health care fields.⁴

The increased use of these devices by clinicians in their personal and working lives has also raised important medicolegal and ethical implications.⁸ Consequently, establishing standards and policies within health care institutions will be necessary to ensure ethical and transparent conduct.^{7,11} A call has also been made for the examination of the effect of mobile devices and medical apps on clinical education.⁴ Adoption of these recommended measures will be greatly helpful in guiding clinicians, administrators, educators, and researchers in determining how to best incorporate these increasingly sophisticated tools into clinical practice.¹⁰ Best-practice standards for medical app developers should also be established.¹¹ These standards will raise the barrier for entry into the medical app market, limiting the overwhelming quantity and increasing the quality of the apps currently available to HCPs and patients.¹¹

It is also important that mobile medical apps that claim diagnostic or therapeutic efficacy be evaluated with regard to claimed outcome, as well as utility in clinical practice.^{4,8,10,11} While many mobile medical apps have been available for years and are very popular, there is still a lack of data that support or identify the best approach to their use.^{4,10} As more data become available, this will lead to a more useful selection of validated mobile medical apps for HCPs.¹¹ Toward this end, in September 2013, the FDA released long-awaited guidelines concerning regulation of mobile device apps, announcing that the agency will evaluate apps that are “used as an accessory to a regulated medical device; or transform a mobile platform into a regulated medical device.”^{22,24} The FDA has chosen to exercise only enforcement discretion for apps that are deemed to pose less risk, such as those that inform or assist patients in managing their disease without providing treatment suggestions, or simple tools that allow patients to track or organize health information or interact with their EHRs.^{22,24}

CONCLUSION

Medical devices and apps are already invaluable tools for HCPs, and as their features and uses expand, they are expected to become even more widely incorporated into nearly every aspect of clinical practice.^{1,2} However, some HCPs remain reluctant to adopt their use in clinical practice.^{1,4} Although medical devices and apps inarguably provide the HCP with many advantages, they are currently being used without a thorough understanding of their associated risks and benefits.¹¹ Rigorous evaluation, validation, and the development of best-practice standards for medical apps are greatly needed to ensure a fundamental level of quality and safety when these tools are used.¹¹ With the implementation of such measures, the main determinant of an app's value may ultimately be its ability to provide meaningful, accurate, and timely information and guidance to the end user in order to serve the vital purpose of improving patient outcomes.²³

REFERENCES

1. Wallace S, Clark M, White J. 'It's on my iPhone': attitudes to the use of mobile computing devices in medical education, a mixed-methods study. *BMJ Open* 2012 Aug;2:e001099.
2. Aungst TD. Medical applications for pharmacists using mobile

Mobile Devices and Apps for Health Care

- devices. *Ann Pharmacother* 2013;47(7–8):1088–1095.
3. Kiser, K. 25 ways to use your smartphone. Physicians share their favorite uses and apps. *Minn Med* 2011;94(4):22–29.
 4. Ozdalga E, Ozdalga A, Ahuja N. The smartphone in medicine: a review of current and potential use among physicians and students. *J Med Internet Res* 2012;14(5):e128.
 5. Yoo JH. The meaning of information technology (IT) mobile devices to me, the infectious disease physician. *Infect Chemother* 2013;45(2):244–251.
 6. O'Neill KM, Holmer H, Greenberg SL, Meara JG. Applying surgical apps: Smartphone and tablet apps prove useful in clinical practice. *Bull Am Coll Surg* 2013;98(11):10–18.
 7. Mosa AS, Yoo I, Sheets L. A systematic review of health care apps for smartphones. *BMC Med Inform Dec Mak* 2012 Jul;12:67.
 8. Divali P, Camosso-Stefinovic J, Baker R. Use of personal digital assistants in clinical decision making by health care professionals: a systematic review. *Health Informatics J* 2013;19(1):16–28.
 9. Murfin M. Know your apps: an evidence-based approach to the evaluation of mobile clinical applications. *J Physician Assist Educ* 2013;24(3):38–40.
 10. Mickan S, Tilson JK, Atherton H, et al. Evidence of effectiveness of health care professionals using handheld computers; a scoping review of systematic reviews. *J Med Internet Res* 2013;15(10):e212.
 11. Misra S, Lewis TL, Aungst TD. Medical application use and the need for further research and assessment for clinical practice: creation and integration of standards for best practice to alleviate poor application design. *JAMA Dermatol* 2013;149(6):661–662.
 12. Boulos, MN, Wheeler S, Tavares C, Jones R. How smartphones are changing the face of mobile and participatory health care; an overview, with example from eCAALYX. *Biomed Eng Online* 2011 Apr;10:24.
 13. Chase J. iPads and other drugs. *Medical Marketing & Media: The Interactive Guide*. 2013:10–11.
 14. Moodley A, Mangino J, Goff D. Review of infectious diseases applications for iPhone/iPad and Android: from pocket to patient. *Clin Infect Dis* 2013 Oct;57:1145–1154.
 15. Payne KB, Wharrad H, Watts K. Smartphone and medical related app use among medical students and junior doctors in the United Kingdom (UK): a regional survey. *BMC Med Inform Dec Mak* 2012 Oct;12:121.
 16. Apple store sales top \$10 billion in 2013. Apple Inc. Available at: <https://www.apple.com/pr/library/2014/01/07App-Store-Sales-Top-10-Billion-in-2013.html>. Accessed February 14, 2014.
 17. Lewis T. Apple launches dedicated 'Apps for Healthcare Professionals' collection. IMedicalApps.com. Available at: <http://www.imedicalapps.com/2013/02/apple-apps-healthcare-professionals-collection>. Accessed February 17, 2014.
 18. Dolan B. Apple helps MDs cut through medical app clutter. *Mobihealth News*. Available at: <http://mobihealthnews.com/13254/apple-helps-mds-cut-thru-medical-apps-clutter>. Accessed February 17, 2014.
 19. Box HIPAA and HITECH Overview and FAQs. Box Help. Available at: <https://support.box.com/hc/en-us/articles/200526618-Box-HIPAA-and-HITECH-Overview-and-FAQs>. Accessed March 12, 2014.
 20. Van Velsen L, Beaujean DJ, van Gemert-Pijnen JE. Why mobile health app overload drives us crazy, and how to restore the sanity. *BMC Med Inform Decis Mak* 2013 Feb;13:23.
 21. Deloitte Center for Health Solutions 2013 Survey of US Physicians. Physician adoption of health information technology: implications for medical practice leaders. Deloitte Development. 2013:1–12.
 22. Tam C, Sharma A. Mobile medical apps: to regulate or not to regulate? American Pharmacists Association. Available at: <http://www.pharmacist.com/mobile-medical-apps-regulate-or-not-regulate>. Accessed February 14, 2014.
 23. Robinson R. App revolution: Avoiding the app trap, *PharmaVOICE*. 2014;14(2):24–28.
 24. Mobile Medical Applications. FDA. Available at <http://www.fda.gov/medicaldevices/productsandmedicalprocedures/connectedhealth/mobilemedicalapplications/default.htm>. Accessed February 17, 2014. ■