Handheld Mobile Devices in Medicine

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Abstract

Healthcare refers to diagnosis and treatment of diseases. The healthcare field is one of the most advanced fields today, but it still needs some significant convergence between the practice of medical arts and the lessons learned of medical craft. Health apps are increasingly helping consumers and healthcare professionals track, monitor, and share personal-health information for a variety of increasingly complex conditions, including heart failure, respiratory illness, and mental illness. Our modern technologies produce an immense amount of information—

information that needs to be transferred and infused—and this information needs to be shared far beyond mere oral transcription and the text-based medical charts of yesterday.

With the push to reform medical care in the U.S., providers are expected to improve quality while reducing costs. Clinicians are under pressure to focus not only on the care of the individual patients sitting in front of them, but also the larger population with the same disease or condition. As a result, health management will require much more sophisticated tools for data-analytics in order to manage care for an exponentially growing population. The varying specialties and influences among the practice of medicine are broad; similarly, the use and capabilities of mobile technology are also broad and consistently evolving.

The gap between doctors, patients, medical staff, and between hospitals greatly needs to be bridged. In this sense, our research focused on whether medical practitioners were accepting mobile device assistance in their practice, whether patients viewed this added dimension of healthcare as expeditious to their needs, or more of a threat to the privacy of personal information, medical history, and whether mobile devices can reliably perform in an interconnected environment to enhance patient outcomes and overall care.

Introduction

A group of doctors were at a convention in Switzerland.
The topic of discussion was the new medical technology from their countries.

"In my country," a German doctor said, "medicine is so advanced; we can perform heart surgery on a person on Monday, and have him back to work in 2 weeks."

"That's nothing," a Japanese doctor said. "We can perform an appendectomy on a person on Tuesday, and have him back in work by Saturday."

"That's nothing!" said an American doctor. "We can complete a brain transplant from Texas; put him in the White House, and half the country is out of work the next day!"

The explosion of mobile handheld technology has impacted nearly every aspect of our lives, from how we travel to how we connect with friends. Mobile phones have become ubiquitous in American society to the point that more than half of Americans between 25 and 29 years of age live in a home that has no traditional land-line and rely solely upon mobile phones. Mobile technology has expanded dramatically around the world. According to the Cisco Visual Networking Index, global mobile data traffic has doubled for the fourth year in a row. And looking toward the future, the report estimates that "global mobile data traffic will increase 18-fold by 2016"; it is projected that **there will be 10 billion mobile devices in use around the world** (Cisco Public Information, 2012).

For healthcare professionals, mobile or tablet apps also have enormous potential for training and professional development. Health apps are increasingly helping consumers and healthcare professionals track, monitor, and share personal-health information for a variety of increasingly complex conditions, including heart failure, respiratory illness, and mental illness. Connectivity is built in, facilitating a blended learning platform with easily updatable information, in an accessible format. Further, tablets and smartphones are readily available and are relatively less-expensive when compared to other health technologies and professional training tools.

Accordingly, it's only natural that mobile technology would have an impact on how we receive medical care. The possibilities for improving the care physicians and other health care professionals provide appear to be endless. Increasing emphasis has been placed on interconnectivity between and among health care providers prompting the medical community to move to digital records, in-room computers, laptops and tablets. Health care providers can

immediately access records with the most up-to-date information available before treating a patient. Going smaller and more mobile, the use of smartphones in clinical practice is increasing.

The smartphone has quickly evolved from industry newbie to omnipresent in little more than a half a decade. The smartphone brought with it the ability to access information any place and any time. In addition to instant access to patients' ever-evolving records, health care professionals can hold entire reference texts, drug formularies and applications tailored to their specialty in the palm of their hand. However, has mobile technology begun to eclipse true knowledge and interfere with doctors' interaction with their patients? Can this technological boon actually detract from the provision of health care?

These developments create opportunities for physicians to explore the advantage and discover shortcomings of mobile computing in a clinical setting. As a result of these developments, there is a need to study how and when physicians are using their handheld devices, and specifically smartphones, in the provision of health care. The aim of our research is to identify the extent to which doctors and residents are using smartphones during clinical activities and how they feel the use of smartphones impacts their interaction with their patients.

Literature Review

For this review, we sought to include articles published within the past five years in peer-reviewed journals whose area of research focused on the use of mobile handheld devices in the provision of medical care. The subject of the study (medical students, junior doctors, physicians, residents, and patients themselves) was not used as a criterion for selection. The authors searched for articles that had been published in peer-reviewed journals since January 2009 using the following key search terms: medicine, mobile, smartphone, digital records, computer, physician

and wireless. The search methods employed seemed to be effective in producing relevant, timely research articles on myriad topics within the subject area.

Rather than focusing on one particular aspect of mobile medicine, this review includes articles that span several areas of concern in the use of handheld devices in the provision of medical care. The selected articles in aggregate cover a significant portion of the spectrum of mobile medicine. The articles cover the use of handheld devices to access medical-related apps among junior doctors, how the use of handheld devices impacts physicians' work practices, how the mobile internet is being used by physicians, whether physicians are likely to adopt the use of mobile technology and even an example of how patients can use mobile technology to enable remote monitoring.

Payne et al. (2012) researched the extent to which junior doctors and medical students own and use smartphones to improve their performance in providing care to patients and whether or not the students and junior doctors used applications in medical education and professional development. The authors identify the research as a pilot study and express their hope that the information will be used to form a basis for future research. Payne et al. (2012) emailed links to two online questionnaires to junior doctors and medical students asking recipients about their smartphone profiles. Did the respondents own a smartphone, did they use medical applications, how often the respondents referred to their device during the course of work or study, and what environments the respondents used their devices? The authors found that nearly three quarters of junior doctors owned smartphones and three quarters of them used medical applications in the provision of care. Nearly 8 in 10 medical students owned a smartphone and of those, 80% had medical applications on their smartphones. The research shows that there is a high rate of

adoption of smartphones with medical applications among younger physicians and medical students, which suggest the use of handheld devices, will increase in clinical settings as this group advances in their careers.

Understanding that physicians are using mobile technology in the provision of care, Prgomet et al. (2009) reviewed existing literature investigating whether handheld devices provided benefits to workflow as the result of increased mobility. The authors included 13 studies in their article that were published from 2000-2007 in English. The article cited several results. First, the use of handheld and mobile technology to transmit test results significantly decreased the mean time to treat a patient and discharge them, but none of the included studies discussed the impact on long-term patient outcomes. Second, physicians who used handheld devices for decision support (e.g. medication error prevention) showed no improvement in avoiding inappropriate non-steroidal anti-inflammatory prescription, but did indicate a significant decrease in the use of antibiotics. Third, the article evaluated the use of mobile devices in medication safety, finding that transcription errors decreased significantly, from 22% to 8%. Finally, the authors reviewed the impact of mobile devices' impact on documentation and information access and found that while all of the reviewed studies demonstrated positive findings, only one conclusively connected the use of handheld with the study outcomes. Knowing that physicians are using mobile devices in the provision of care is irrelevant without knowing how that use impacts care. Prgomet et al.'s (2009) study shows that adopting mobile devices in the clinical setting can decrease patient treatment times, decrease prescription errors and increase efficient coding for billing.

With evidence that physicians are using mobile technology in the clinical setting, the question becomes whether those devices aiding or hampering the provision of health care. Alsos et al.

(2011) investigated how the use of paper charts, handheld devices and computers-on-wheels impacted doctor-patient communication. To gather data for evaluation, they observed simulated interactions involving 22 physicians in 80 patient interactions. The study's results suggested physicians were most comfortable with paper charts, which allowed the physician to position the chart so that it was easy to glance from the chart to the patient with minimal interruption to communication flow. The handheld device was reported to be a distraction to communication when compared with the paper chart because it took the physician's attention away from the patient. However, the handheld device also allowed the physician to re-establish eye contact and resume the conversation relatively smoothly. The computer-on-wheels fared the worst in the study due to its size in relation to patient exam rooms. Many times, the physician was forced to position the computer so that it required the physician to turn away from the patient to enter information. Even when the room was large enough to accommodate the computer-on-wheels, it became a physical barrier between the patient and the doctor. The study concluded that paper charts could not offer the same benefits of handheld devices and computers-on-wheels (e.g. real-time access to medical records and test results), but that despite the improved access to records, patient care could still suffer if health care providers failed to compensate for the impact these devices could have on doctor-patient communication. As medicine becomes more mobile and more physicians are using handheld devices in the provision of care, this article serves as a warning of some of the pitfalls of using handheld devices in the clinical setting.

Medical personnel are using mobile devices during patient interactions, but are they using them for learning as well? Are they using these mobile resources as much as they are using workstation-based systems such as full computer terminals? Desai et al. (2011) tracked and analyzed the use of the Nephrology On-Demand website in both the full version and a mobile

version. Users did not have to choose between the two as code inserted into the full site's root files automatically re-directed users accessing the site on a mobile device to the mobile site. Both versions of the site provided the same information, content, functionalities and capabilities. Researchers used Google Analytics to track use patterns from 1 February to 31 December 2010. Desai et al. (2011) found that the number of times the mobile site was accessed never exceeded the number of times the full site was accessed despite a precipitous increase in mobile use among physicians. The authors concluded that either visitors were unaware of the mobile site or preferred to engage in online learning from the full version site, a question which could be explored in follow-on research. Despite the absence of a conclusive reason for the significantly lower use of the mobile site, Desai et al. (2011) suggest that developers will have a difficult time producing teaching tools that are mobile friendly. In relation to the research topic, understanding the impact of users' preferences and a lack of awareness on mobile applications and resource sites is critical to the ability to develop a successful plan to implement mobile medicine.

In a survey, Putzer et al. (2012) evaluated the role of seven factors regarding physician attitudes toward smartphones. Those factors were compatibility, observability, job relevance, personal demographics, personal experience, internal environment, and external environment. Each of these factors was hypothesized to affect a physician's disposition toward using a smartphone in a clinical setting. The questionnaire was sent to 400 physicians in three hospitals (two community hospitals and one academic center in the southeastern U.S.). The authors received 103 responses, but only evaluated 87 after eliminating incomplete questionnaires and found evidence that all of the factors they hypothesized to impact physician attitudes did except for one. The only factor for which the study did not find a positive relationship was personal demographics. Putzer et al. (2012) expressed concern that because the questionnaire was self-selected, the results would be

skewed. The authors reviewed the responses and determined there was no significant demographic skewing between early and late responses. Physician attitudes toward using smartphones in the provision of care will have a direct impact on any institutional or governmental directive to incorporate their use in medicine.

Boulos et al. (2011) provided an overview of applications available for smartphones for both physicians and patients in many different scenarios and uses eCAALYX (Enhanced Complete Ambient Assisted Living Experiment), a program that is attempting to create a remote-monitoring system for older patients with chronic disease. The authors comment on the sheer volume of smartphones in the U.S. and suggest that these devices and mobile communication in general has the potential to completely transform healthcare. As a patient-targeted system, eCAALYX faces numerous challenges, especially getting older patients to use new, usually complex technology when in many cases, these patients are dealing with poor vision, fixed budgets (impacting their ability to acquire smartphones) failing health and an inability to comprehend complex instructions (in cases of cognitive decline). Boulos et al. (2012) point out that while health care professionals' adoption of this technology will likely outpace the general population's adoption of it, the bigger impact will be among the latter.

Chen et al. (2012) highlight the benefits of mobile devices providing 24-hour care given their constant presence, data connectivity, and multiple intrinsic sensors that can support around-the-clock chronic disease prevention and management. What's more, when providing 24-hour patient overwatch care, mobile devices also are collecting tremendous amounts of location-rich, real-time data that is sharable across multiple applications and connected to electronic health records. However, the implications of this data can negatively result the difficulties associated with tools

and techniques for making sense of the health data and the difficulties of avoiding critical response-lags that may bottleneck/limit the impact of improvement on health outcomes.

In a summary of the role of the smartphone in medicine, Ozdalga et al. (2012) highlight the ways in which smartphones can enhance continuing medical education, patient care, and communication. The article covers many published smartphone uses that could be applicable to the field of medicine and medical education; however, it also details the need for more high-quality studies to better understand the role it will have in this field.

Resch et al. (2013) describe the increasing importance of mobile technologies and mobile devices in private practice by use of mobile marketing. Some of the key questions and challenges associated with the integration of mobile technologies by physicians in private practice are investigated and suggestions are made for future research. For example, as mobile technologies and applications continue to evolve, the resulting opportunities for their increased use in the health care sector at large, and within specific sectors in the industry, are poised to increase significantly in coming years.

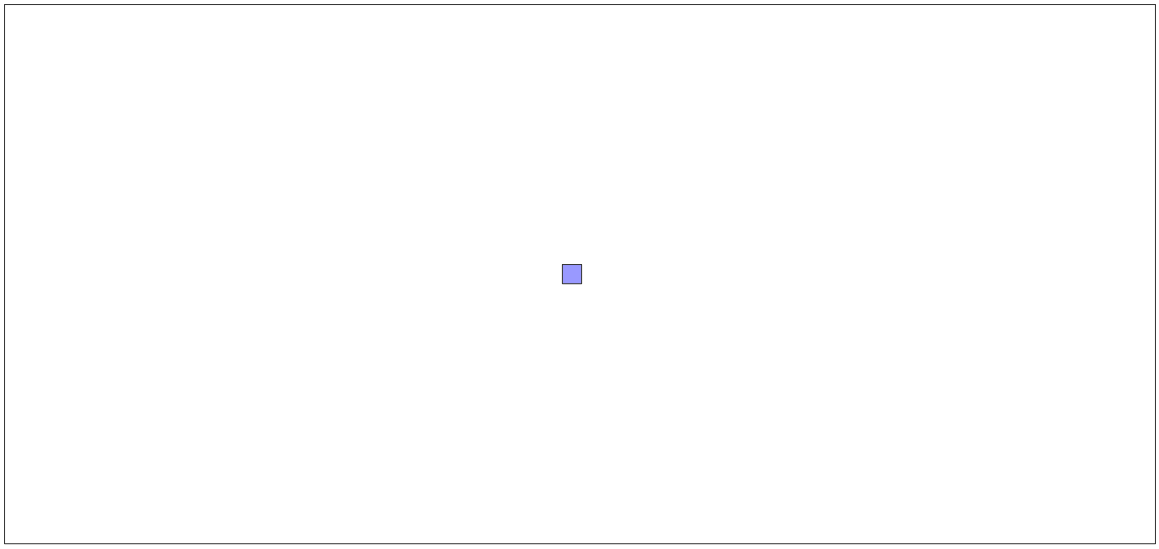
Van Velsen, et al. (2013) identify a critical concern—when we add something to improve the state of our system, it may also adversely overwhelm our system. This can be observed as smartphones and tablet computers have become an integral part of our lives. One of their key features is the possibility of installing third-party apps. These apps can be very helpful for improving health and healthcare. However, medical professionals may experience difficulty with finding the right app, as information and features are fragmented over too many apps, thereby limiting their usefulness. This article further identifies the need to standardize content, so that the

information provided via apps is readable. And, in order to prevent information overload from occurring within an app, content should be personalized towards an individual's characteristics and context.

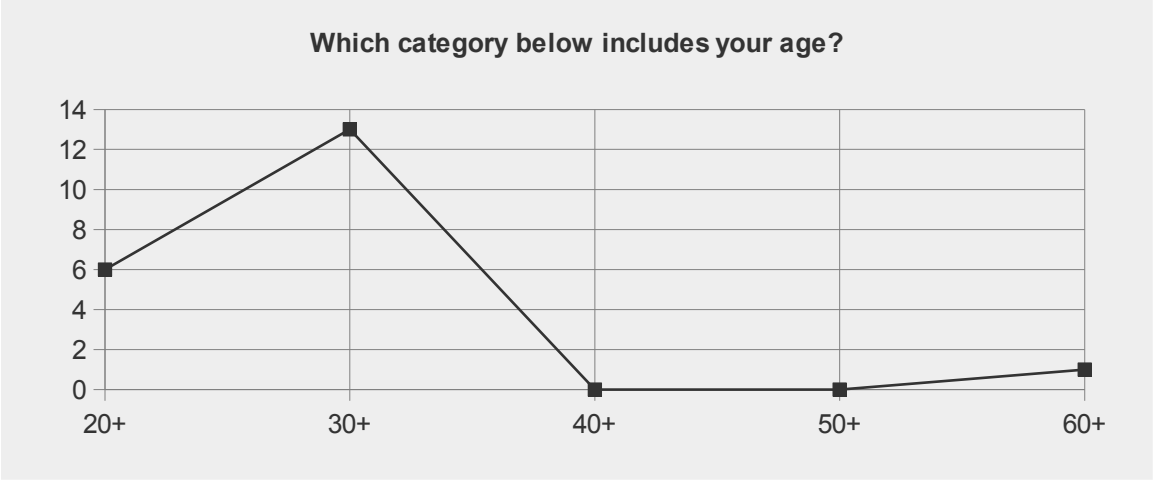
While much research has been accomplished on the topic of mobile devices in health care, all studies reviewed agree that more research is needed. The focus of this study, doctors' use of mobile technology in the provision of care, is understudied and warrants more research. Understanding doctors' usage habits, preferred apps, and the impact the presence of mobile devices has on decision making is critical to understanding how mobile devices impact patient outcomes. Patients and doctors alike can only benefit from this additional research.

Methodology

We distributed the same survey to physicians and residents through social media connections and paper copies during USF Emergency medicine grand rounds at Tampa General Hospital. The majority of our respondents specialized in emergency medicine, but we had one pediatrician, one obstetrician and one dermatologist. All respondents except one had worked in their field for fewer than five years. In total, 21 people completed our survey, but one response was eliminated because the respondent reported he did not own a smartphone or tablet computer or have one issued to him by his employer, but also reported he used his smartphone for work purposes for 1-30 minutes per shift. Respondents were 80% residents and 20% attending physicians and 60% were male.



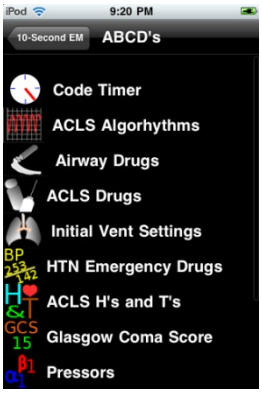
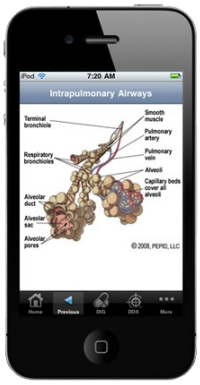
The survey was constructed by this study's authors and built upon the questionnaires developed by Payne, K.F.B., Wharrad H., & K. Watts (2012). While our scope was much narrower, we developed our survey questions using Payne et al. as a springboard. Participants were asked whether they owned or were issued a smart phone or tablet computer and if they used that mobile device to access data during the provision of care. The survey questions explored frequency of use and apps used as well as attitudes toward physicians' use of mobile devices in the care setting. Due to our convenience sampling method, our data might be skewed because 80% of the respondents were residents and 95% of them were under the age of 40.



Use of mobile devices in the provision of healthcare

Our survey showed the use of mobile devices among those surveyed to be universal. All of our respondents had a smartphone and indicated they used it to access medical information. However, only 70% owned a tablet computer, but of those, more than 85% reported they use their tablet computer to access medical information. Also, all respondents used apps to access medical information as opposed to simply accessing information via the internet which 70% of respondents reported accessing several times a day. None of our respondents reported using their smartphone for more than 60 minutes per shift for work purposes while most reported between one and thirty minutes of use each shift.

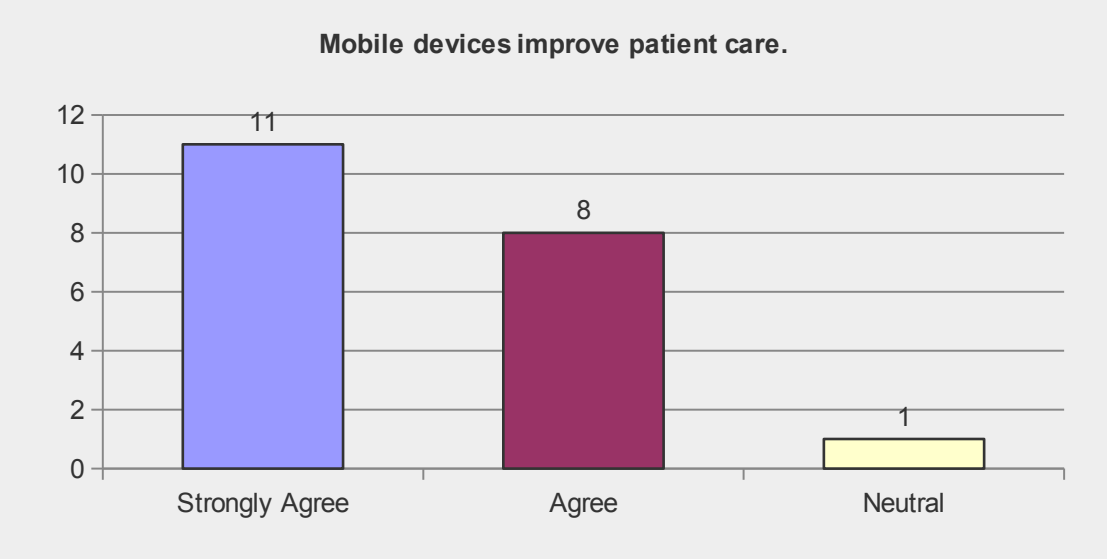
The three most popular apps:

Epocrates Essentials	**14 of 21 respondents = 67%**	
10-second Emergency Medicine	**8 of 21 respondents = 39 %**	
PEPID Emergency Medicine Suite	**7 of 21 respondents = 33%**	

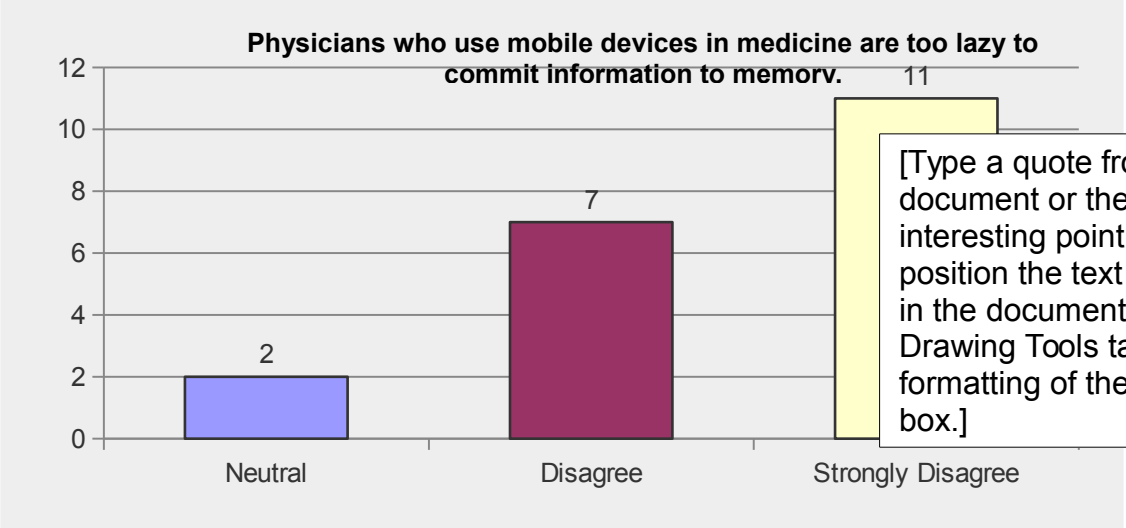
How respondents felt about access to mobile devices

"How does mobile technology impact your practice?"

Every respondent providing an answer (80%) responded positively or neutrally. There were no negative responses to mobile technology's impact on respondents' practice. Slightly less than half felt that mobile devices were underused in medicine while a third of respondents were neutral. However, nearly all felt that mobile devices in the care setting improved patient care.



Nearly all of the participants either disagreed or strongly disagreed that physicians who use mobile technology in the provision of care were too lazy to commit information to memory. Respondents indicated a lack of concern that the use of mobile devices in the provision of care might compromise the security of patient information.



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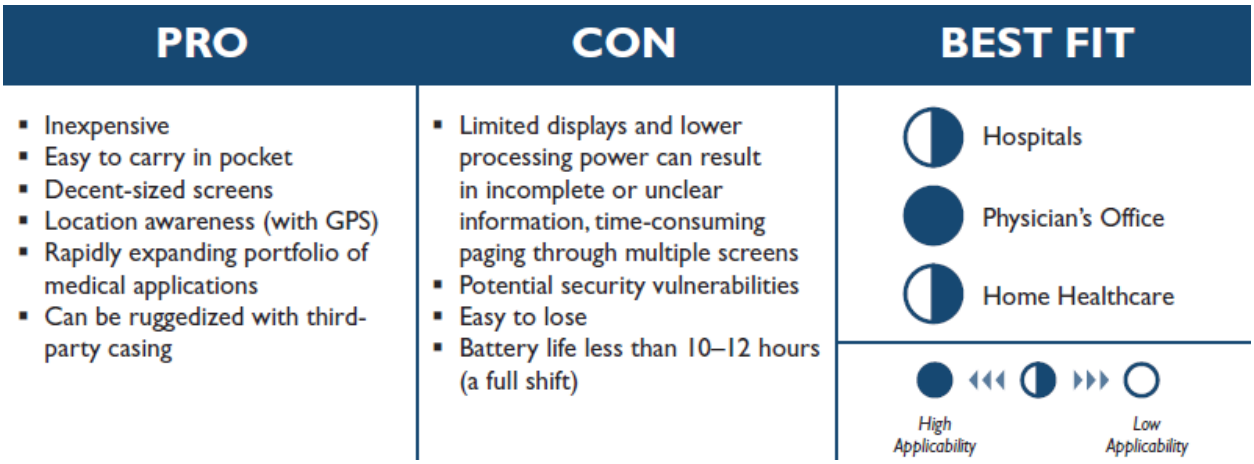
When asked if increased access to mobile technology would decrease malpractice lawsuits, respondents were nearly evenly split among agree, neutral and disagree, suggesting the physicians' use of mobile technology is not intended to be an insurance policy against errors. The majority felt that the same increased access would certainly not increase malpractice lawsuits. Half of respondents strongly agreed having access to mobile devices in the provision of care had the potential to improve their efficiency and another 45% agreed with the statement.

The form-factor, or how easy the device size meets the needs of the working environment, is highlighted for smartphones within the following chart:



Discussion and Conclusion

The primary research conducted for this study reveals that mobile-device technology has the potential to play a key role in fundamentally changing the healthcare market. Mobile devices have exploded into healthcare and are affecting all providers. As physicians work to improve outcomes and be more efficient, effective, and flexible in their delivery of healthcare, they are increasingly looking for ways to integrate mobile devices such as smartphones and tablets into their workflow. One way mobile technologies can make life better is to reduce the amount of time we waste waiting: waiting to see our doctor, waiting for a prescription to be filled, waiting for test results.

Attending and resident physicians alike responding to this survey indicated overwhelmingly they used handheld mobile devices in the provision of care. These physicians also indicated they relied on their device on a near-daily basis. These findings are not surprising based upon previous studies, especially that of Payne, K.F.B., Wharrad H., & K. Watts (2012). Physicians in this study use their devices to research questions to which they do not have answers, double check information they believe to be true, and acquire information such as dosing amounts based on formulas too complex to calculate in one's head.

Longer-term studies should be conducted among physician populations who do not use handheld devices in the provision of care compared with their counterparts to determine whether the presence of handheld devices has any impact on patient outcomes. Many of the respondents identified the same apps as their go-to reference software. More research is needed to identify what these apps provide, what physicians are looking for in an app, what, if any, needs are not being met, and whether apps can be developed to meet those needs.

Finally, physicians' use of mobile technology in health care is only one piece of the puzzle. This is a multi-faceted issue that impacts users and patients alike. More research is needed in areas that are peripheral to physicians' use of mobile technology, such as patient perceptions of the use and presence of mobile devices in the care setting, what the cost benefit is to employing mobile devices versus a stationary computer-based medical record system, potential barriers from hospital administrators concerned with higher potential for the compromise of patient data from a lost device, and more. Until each of these has been answered, the question of whether mobile devices in the care setting are beneficial cannot fully be answered.

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Appendix A—Interview Protocol

Participant is a physician who is currently practicing in any specialty at any facility. Age, gender, experience are varied. We are interviewing these participants because they have indicated they use mobile handheld devices in their work and we hope to gain additional insight into the role these devices play in the provision of care and the participant's attitude toward mobile technology in healthcare. The interview should take approximately 20-30 minutes and will take place at the person's place of work before or after a shift as the participant prefers.

Intro

Thank you for agreeing to speak with me today. I'm speaking with you today because you indicated you use mobile device, a smartphone or a tablet computer, at work. We hope to gain more insight into the role mobile devices play in healthcare. This interview should take no more than 30 minutes of your time. Is it ok if I record your answers digitally so I can spend less time taking notes and more time understanding your answers?

1. How many years have you worked in your field?
2. What is your specialty?
3. What kind of device? Make/model/brand/version/hard drive size
4. Is this your personal device or does your employer provide it?
5. Would you mind telling me how much you paid for your device and how much you pay for service per month?
6. When you use your device at work, what is the primary reason?
7. How often do you use your device for work purposes?
8. How do you feel about the presence of mobile devices in health care?
9. How would you respond to the following statement? "*Doctors who use mobile devices for reference in the course of their practice are too lazy to learn the material outright.*"
10. Do you have any favorite apps?
11. Would you be willing to download an app to your personal device specific to your employer for patient tracking if one were available?

Closing Script

Thank you for your time and your candidness. Your answers will help us gain more insight into the role of mobile devices in the provision of care.

Appendix B

MOBILE MEDICINE

***1. Are you male or female?**

- Male
- Female

***2. Please indicate your position.**

- Resident
- Physician

Other (please specify)

***3. Which category below includes your age?**

- 17 or younger
- 18-20
- 21-29
- 30-39
- 40-49
- 50-59
- 60 or older

***4. Please indicate the number of years you have worked in your field.**

- 0-5
- 6-10
- 11-15
- 16-20
- 20+

***5. What is your medical specialty?**

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Appendix C

Payne et al. BMC Medical Informatics and Decision Making 2012, 12:121
http://www.biomedcentral.com/1472-6947/12/121

BMC Medical Informatics & Decision Making

RESEARCH ARTICLE Open Access

Smartphone and medical related App use among medical students and junior doctors in the United Kingdom (UK): a regional survey

Karl Frederick Braekkan Payne[1], Heather Wharrad[2*] and Kim Watts[2]

Abstract

Background: Smartphone usage has spread to many settings including that of healthcare with numerous potential and realised benefits. The ability to download custom-built software applications (apps) has created a new wealth of clinical resources available to healthcare staff, providing evidence-based decisional tools to reduce medical errors. Previous literature has examined how smartphones can be utilised by both medical student and doctor populations, to enhance educational and workplace activities, with the potential to improve overall patient care. However, this literature has not examined smartphone acceptance and patterns of medical app usage within the student and junior doctor populations.

Methods: An online survey of medical student and foundation level junior doctor cohorts was undertaken within one United Kingdom healthcare region. Participants were asked whether they owned a Smartphone and if they used apps on their Smartphones to support their education and practice activities. Frequency of use and type of app used was also investigated. Open response questions explored participants' views on apps that were desired or recommended and the characteristics of apps that were useful.

Results: 257 medical students and 131 junior doctors responded, equating to a response rate of 15.0% and 21.8% respectively. 79.0% (n=203/257) of medical students and 74.8% (n=98/131) of junior doctors owned a smartphone, with 56.6% (n=115/203) of students and 68.4% (n=67/98) of doctors owning an iPhone.
The majority of students and doctors owned 1–5 medical related applications, with very few owning more than 10, and iPhone owners significantly more likely to own apps (Chi sq, $p<0.001$). Both populations showed similar trends of app usage of several times a day. Over 24hours apps were used for between 1–30 minutes for students and 1–20 minutes for doctors, students used disease diagnosis/management and drug reference apps, with doctors favouring clinical score/calculator apps.

Conclusions: This study found a high level of smartphone ownership and usage among medical students and junior doctors. Both groups endorse the development of more apps to support their education and clinical practice.

Keywords: Smartphones, App use, Medical students, Doctors, Mobile technologies, Survey

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