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ABSTRACT

PDAs and Smartphones allow medical professionals to access medical information more easily than ever before. This literature review examines use of these devices and associated "apps" in medical education, finding widespread use by medical students, residents, and faculty. Surprisingly, little generational bias was noted.

INTRODUCTION

Background

The usage of smartphone devices by Americans continues to rise. A 2013 report from the Pew Research Center's Internet & American Life Project found that, for the first time, more than 90% of Americans own a mobile phone and 56% owned a smartphone (Rainie, 2013), a cell phone that contains additional software functions such as e-mail and Internet browsing capabilities (Merriam Webster Dictionary, 2012). Based upon another recent survey (Anonymous, 2013), it is predicted that 80% of Americans will be using a smartphone regularly by 2014.

The predecessor to the smartphone, the personal digital assistant (PDA), once dominated the market for hand-held mobile devices and had sales growing "exponentially" (Wiggins, 2004), but its sales actually started dropping about 2003 (Krazit, 2004), with the decline quickly becoming precipitous (Anderson, 2007). The transition from PDA to smartphone should not be terribly surprising: a 2011 smartphone had over 16,000 times the data storage of the Palm III, one of the earliest PDAs (Friedman, 2011). Despite their relative departure from the current scene, PDAs are included in this review for two reasons: (1) due to several studies demonstrating their contribution to the study of mobile medical devices on medical education and (2) as recently as 5 years ago, PDAs were considered to be a "valuable tool" in medical education (Lindquist et al., 2008) and "an essential part" of medical practice (Chatterley and Chojecki, 2010). Mobile technology has changed the landscape of the medical profession, as the majority of providers and providers-to-be desire decision support and current clinical information at the point of care (Baumgart, 2011; Mosa, Yoo and Sheets, 2012).

PDAs allowed healthcare professionals and the general public to communicate more efficiently, collect data and research topics in healthcare (Lindquist et al., 2008). A 2008 study of Canadian medical students found that 65% owned a PDA, and 77.4% of those used it for accessing drug references and 49.1% for looking at medical textbooks. The vast majority (over 75%) had received no formal training in how to use a PDA; i.e., they were self-taught (Chatterley and Chojecki, 2010). Another study was conducted in 2012 among medical students at Brighton and Sussex Medical School to determine how the use of mobile devices affected learning (Davies et al., 2012). After students were given preloaded PDAs containing software known as DrCompanion to use over a ten month period, the authors conducted a survey as well as a focus group. Of 387 total participants, 134 surveys were able to be used finding that 102 students (76%) actually used the device during the allotted time. The authors determined four ways in which the PDAs enabled learning. First, they found that PDAs allowed for timely access to key facts. They also found that there was consolidation of knowledge through repetition since students were able to look up information with ease leading to a higher degree of confidence. Third, the students saw that PDAs allowed them to make use of wasted time as they could use the device during times when they had a few minutes to spare. Finally, authors determined that students felt the PDAs were more a supplement, rather than a complete replacement of textbooks (Davies et al., 2012).

Recent surveys have determined that more than 80% of physicians (O'Reilly, 2012) and Certified Registered Nurse Anesthetists (Johns, 2012) used smart phones. About 70% of nurses report using smartphones while working (Spyglass Consulting Group, 2012), a 40% increase in two years (RNsearch, 2010). Smartphones have offered physicians a less cumbersome format for Health Information Technology (HIT) without the imposition of a large financial burden (Sarasohn-Kahn, 2010), by combining the features of a cellular telephone, pager, and a PDA (Burdette, Herchline and Oehler, 2008), although some have posited that this new technology may be more of an interruption than a help (Ross and Forgie, 2012). Nonetheless, doctors have moved away from the traditional pagers to smartphone devices (Putzer and Park, 2012; Sheth and Kane, 2009), enhancing the efficiency within healthcare organizations by allowing for improved time management and communication between other medical colleagues (Ozdalga, Ozdalga and Ahuja, 2012; Voalté, 2010). In 2012, there were an estimated 121.40 million smartphones in the US, with this number predicted to grow to 207.4 by 2017 (Staitista, 2012).

It has been estimated that $14 to $27 billion in financial incentives will be distributed over ten years under the Health Information Technology for Economic and Clinical Health (HITECH) act of the American Recovery and Reinvestment Act of 2009 as encouragement for those in the medical field to adopt and meaningfully use HIT (Blumenthal, 2010; Farley, 2013). Many have argued that the implementation of HIT into medical education has not kept pace with the growth of HIT and physician training and accreditation must be reevaluated as to become parallel with the increased use of HIT throughout the country (Graham-Jones et. al., 2012).

Research purpose

The purpose of this paper was to analyze how medical students and medical educators can benefit from the use of smart phone technology. The study was performed to determine if there is benefit from the use of smartphones for medical education.

METHODOLOGY

The methodology for this literature followed the principles of a systematic search and was conducted in distinct stages. The aforementioned stages included: establishing the search strategy, determining the inclusion criteria, evaluating the studies retrieved for relevancy and validity, and data extraction and synthesis.

The electronic databases of EBSCOhost, PubMed and ProQuest were used to search the terms 'Smartphone' AND OR 'Medical Training' OR 'Healthcare' OR 'Edcation'. The reputable websites of the New England Journal of Medicine, the American Medical Association, Google Scholar and other valid healthcare and technology websites were utilized. Citations and abstracts identified by the search were also reviewed in order to recognize additional relevant texts.

The search strategy was limited to relevant texts published within the last ten years as smartphone and tablet technology has only recently become dominant. Sources were also limited to those written in the English language. A total of xx articles were reviewed and xx selected for this research, x of which were used in the results. This literature research was conducted by NM, SA, and BP and validated by AC for this research project. Subsequently, all citations/references were re-checked by DP, who updated the literature search using Google, ABI-Inform, and JSTORE.

RESULTS

The use of Smartphones in the medical field

A digital study was conducted in California among all Accreditation Council for Graduate Medical Education (ACGME) training programs, via email, to examine the usage of smartphones and related applications in the medical field (Franko and Tirrell, 2012). Results showed that 85% of respondents used smartphones and more than 50% reporting the use of smartphone applications in clinical practice. While medical calculators and drug guides were among the most frequented, applications, textbook/ reference material, classification and treatment algorithms were highly requested upon respondents. It was also determined that physicians and trainees had a strong desire to use relevant and higher quality applications upon their discovery (Franko and Tirrell, 2012). Franko (2011) also surveyed ACGME accredited orthopaedic surgery departments and found that 84% of respondents owned a smartphone, 53% of which currently used relevant applications in clinical practice. Finally, 96% of the respondents using applications noted that they wish more orthopedic applications for smartphones were available, particularly those for medical reference, techniques and guides, and Orthopaedics In-Training Exam review.

Applications ("apps")

More and more convenient and customized applications ("apps") are being developed for smartphone users (Mosa, Yoo and Sheets, 2012); some (van Velsen et al., 2013) even believe that medical professionals are "being overwhelmed" with apps. These applications can be downloaded onto smartphones for a predetermined cost (some are available for free) via the app store and are available in almost every category imaginable (Burdette, Herchline and Oehler, 2008), especially medical education and health (Vinay and Vishal, 2013). As of February 2010, there were 5,805 health apps available within Apple's App Store, with 27% of those apps targeted towards healthcare professionals (Sarasohn-Kahn, 2010). Although many apps designated as "healthcare apps" are not strictly that, being related not at all or only loosely to healthcare, the IMS Institute for Healthcare Informatics in 2013 found 7,400 apps designed for healthcare professionals, and 16,275 designed for consumers (Baum, 2013). Clearly, the market for healthcare apps designed for healthcare professionals is large and growing.

The availability of medical apps for use on smartphones has made it easier for patients and healthcare professionals to control their health and access medical reference material. With the added convenience of these medical tools, 89% of residents and 98% of faculty in medicine and pediatrics used smartphones (Katz-Sidlow et al., 2012).

Patients have been given the opportunity to better understand their personal health with apps related to fitness and weight loss. Condition specific apps have been created as well, such as Diabo, an app that allows individuals with Type 1 Diabetes to collect and store information related to plasma glucose levels, carbohydrate counts and planned physical activity (Ozdalga, Ozdalga and Ahuja, 2012). With the rapid improvement of smartphones and the available features, these devices have the potential to aid in the improvement of healthcare systems across the country. In the United States (U.S.), many areas lack proper medical care and it has been estimated that more than 65 million Americans live in communities with a shortage of primary care doctors (Freundlich et al., 2013).

Many facilities have been especially enthusiastic regarding utilization of the easily accessible and innovative applications that smart phones have been able to offer. Not only have the phones been used for finding information regarding medical conditions, but the efficiency of the communication tools have allowed timelier results and diagnoses for patients. In one such case, the iPhone was used to mount a campaign against a retinal disease that afflicted premature babies. The effort took place mostly at remote outposts, where lab assistants used the phones to take pictures of the preemies' eyes. The lab assistants were then able to send the pictures in real-time to pediatric eye surgeons, who were able to review them immediately (Engelhart, 2010).

More than 40 percent of medical students state that they turn to mobile medical apps first when seeking information regarding a clinical question (Anonymous, 2012). Unfortunately, only 28% of physicians reported being very satisfied with medical "apps" (Glenn, 2013). In a UK study, 79% of medical students and 75% of medical residents owned a smartphone, and the majority owned 1-5 medically related apps, which they used several times a day. Both medical students and residents in this study desired development of additional medical apps (Payne, Wharrad and Watts, 2012).

The use of smartphones in medical education

A mixed-method article published in 2012 used semi-structured interviews and a 17 question survey to determine the use of mobile devices among medical students, residents and faculty at a Canadian medical school (Wallace, Clark and White, 2012). Of the 213 participants, 85% were found to use a mobile computing device at least once daily for medical purposes. Participants suggested benefits of using mobile devices for medical purposes including increased portability, faster access to information on the internet, greater time efficiency, flexibility of communication, powerful applications, and access to multimedia resources. Results from the survey also found that the majority of participants, 55% of students, 95% of residents, and 75% of faculty, agreed that smartphones had a positive educational effect. There were three different categories of usage described by the participants, including information management, communication, and time management.

Generally speaking, students' and residents' use of smartphones for information was greater than that of faculty (Robinson, 2013), which was not unexpected, as the current generation has been described as "thriving" on new and innovative technology (Fay and Greenwood, 2011; Gardner (2013). However, this was not the case across the board (see Table 1). In terms of learning new information, medical students have more to learn than residents, who have more to learn than faculty, so it is not surprising that the percentage of each group using smartphones was observed in this order for use of online textbooks, medical podcasts and online lectures. All three groups were found to use smartphones extensively for medical calculation purposes, residents more than the others, which is perhaps due to their duties of writing orders for direct patient care. This was also the case for note taking, albeit at substantially lower levels across all groups. The large use of smartphones to assist in defining unfamiliar terms demonstrates that the widespread adoption of this technology across all groups.

Table 1: Information Management Categories*

	students	residents	faculty
information management			
online textbooks	70%	67%	35%
medical podcasts	60%	38%	23%

medical calculators	75%	98%	75%
online lectures	50%	17%	17%
note taking	45%	67%	50%
defining unfamiliar terms	93%	95%	82%

* Wallace, Clark and White (2012)

At least one medical app, such as Epocrates, Pepid, Medscape, Skyskape, and Dynamed, was found to have been used regularly by 77% of individuals in the study (Wallace, Clark and White, 2012).

Regarding communication, more than 80% of respondents stated that they use their smartphones to connect with peers, teachers and other individuals involved in their healthcare team. The majority of respondents stated that texting was more efficient than meeting in person or speaking via telephone. In terms of time management, participants were found to use their mobile devices to manage their time by accessing schedules and calendars (students, 81%; residents, 84%; faculty, 56%). The authors found that some participants expressed concern that the use of mobile devices could lead to superficial learning, with the rapid access of information potentially leading to inhibition of internalization of knowledge. Privacy of information was a concern for 34% of participants and 66% of students were concerned that mobile devices were causing distraction in the classroom. Finally, the researchers determined that 96% of survey respondents agree that the use of smartphones in medical education with increase in the future (Wallace, Clark and White, 2012).

Smartphone usage by both medical students and professionals is increasing almost daily (Vinay and Vishal, 2013; Wu et al., 2013). A study in 2011 showed that healthcare professionals desire current and up to date clinical information and decision support which can be provided by smartphones. Through the National Library of Medicines, PubMed for Handhelds apps, individuals in medicine have gained access to traditional texts/reference materials, professional society guidelines, drug references, and institution specific therapy standards at a moment's notice. Smartphones were also found to serve those seeking re-validation of medical licenses as they provide a means to earning continuing education credits through the use of apps such as Epocrates, Skyscape, and Medline (Baumgart, 2011).

The effectiveness of smartphones in medical education

In 2011, researchers in Miami, Florida administered a study to determine the efficacy of three minute chest tube insertion tutorial prior to an actual chest tube insertion. Of the 128 healthcare trainees, including medical residents, medical students and U.S. Army Forward surgical team members, 50% were shown the video via an Apple iPod touch while the other group was shown nothing. It was found that those participants who viewed the simulation on the iPod prior to insertion performed better and scored higher on a skills checklist assessed by a trained clinician (Davis et al., 2012). A similar study was conducted in the United Kingdom in 2011, to determine whether the use of a smartphone application improved the results of advanced life support in a simulated emergency. Of 31 junior doctors, half were randomly selected for the test group, which allowed the use of an iPhone equipped with the iResus© application. Results showed that the test group had a significantly higher score on the overall cardiac arrest simulation as the mean score was 84.5 while the control group, who did not have access to smartphones, had a mean of only 72 (Low et al., 2011).

After interviewing a number of professors and college officials across the country in 2011, it was found that smartphones improved teaching, studying, and research. Professors admitted that they were using smartphones to take attendance, through apps such as Attendance, to collect data for research, and uploading lectures and reference material (Young, 2011). Professors and students have access to scholarly articles and are sharing documents through smartphones and tablets through apps such as DropBox, Good Reader, and Evernote. Students have found these apps useful as they are able to create virtual libraries, highlight and take notes (Young, 2011).

Another study administered in 2011 compared physicians and medical students usage of a drug calculator on a smartphone with the use of the British National Formulary for Children (BNFC) to test the accuracy, speed, and confidence of prescribing in a simulated pediatric emergency (Flannigan and McAloon, 2011). The authors found that participants who used the drug calculators on the smartphone were more accurate, as 100% of them correctly prescribed, while only 28% of participants using BNFC were correct. The participants using smartphones were also found to be timelier; on average each smartphone participant saved over five minutes compared to users of BNFC. Finally, the smartphone participants stated they felt much more confident with the calculated prescription (Flannigan and McAloon, 2011). All of these differences were statistically significant.

The use of smartphones in medical research

Researchers conducted an online survey in 2012 to research assistants, post-doctoral and postgraduate medical staff at Monash University in Clayton, Australia, to determine the use of smartphones in medical research. From the 10 question survey, it was found that smartphone use increased productivity levels, enabling the respondents to access email and calendars, connect with colleagues and to transfer data. Only two of the five respondents used applications on their smartphones. The authors discovered some limitations of smartphone use in medical research, particularly in the lab, including occupational health and safety risks, security, distractions, absence of wireless network, and lack of awareness (Abeynaike, 2012).

New medical applications for smartphones

A study published in 2012 found new advantages to smartphones. A health monitoring system based on the smartphone has even been developed. A small and low-power-consuming Biosignal Monitoring Unit (BMU) measured electrocardiogram (ECG), photoplethysmogram (PPG), temperature, oxygen saturation, energy expenditure, and location information. The 2.4 GHz Bluetooth network in the BMU communicated with a smartphone. From there health information was able to be transmitted to a remote healthcare server through a built-in 3G or Wi-Fi network in the smartphone. The remote server was able to be monitor multiple users in real-time. Normally, vital sign data were being transmitted to a remote server, but in an emergency or for a special care case, additional information such as the waveform of the ECG and PPG were displayed at the server. For increased transmission efficiency, data compression and a simple error correction algorithm were implemented. Using a smartphone, an efficient personal health monitoring system was developed and tested successfully for multiple users (Lee, Jeong and Yoon, 2012).

Another study described a new opportunity for mobile devices users, the eCAALYX mobile application. The eCAALYX Mobile Application has been developed under the scope of the eCAALYXEU-funded project (Enhanced Complete Ambient Assisted Living Experiment, 2009-2012), which focused on building a remote monitoring system targeting older people with multiple chronic diseases. Patients', care givers' and clinicians' involvement was extensive throughout the prototype design, deployment and testing, and clinical trial phases of the project. The main purpose of the eCAALYX Mobile Platform was to act as an easy information based link between the wearable health sensors used by the older person and the health professionals' Internet site, by informing the patients and health professionals about alerts and measurements obtained from sensors and the geographic location through the use of the smartphone GPS of the user. Also, the mobile platform was able to reason with the raw sensor data which identified higher level information, which included easy-to-detect problems including tachycardia and signs of respiratory infections, based on established medical knowledge. Additionally, a user interface was also offered, which allowed the user to be able to evaluate the most recent medical details obtained from sensors, perform new measurements, and communicate with the caretakers (Boulos et al., 2011). As of October of 2013, there appear to be no published results for eCAALYX or the BMU system, but both appear promising.

DISCUSSION

There is a significant and undeniable growing interest in the use of smartphones and their capabilities in the field of medical education, mirroring the growing interest in this technology worldwide. The use of these devices appears to be growing rapidly because of the real-time advantages they offer in making critical decisions. The findings suggested that the future generation of medical students, medical residents and medical educators will rely on these devices and their medical applications more than previous generations. Presumably, as these individuals who have been exposed to the advantages offered by use of smartphones enter the practice of medicine, they will continue using this mobile technology. After all, the half-life of medical knowledge has for some time been estimated at 5 years (Emanuel, 1975; Singh, 2014), so continuing education for physicians is mandatory, and physicians in training who have been exposed to smartphones as a learning mechanism acknowledge the utility of this approach (Hardyman et al., 2013).

CONCLUSION

A review of the literature leads to the inescapable conclusion that smartphones are playing an increasingly important role in medical education, before, during and after medical professionals enter practice. A somewhat surprising finding is the relative lack of a generational bias in the use of this mobile technology.

It is expected that medical professionals will become more dependent upon these kinds of devices as time goes on. However, technology will continue to evolve, with smartphones eventually being replaced by other technology, as were pagers and PDAs. But, for now, smartphones and medical education appear to be increasingly and inevitable intertwined for the next few years. After that, who knows what the future will hold?

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