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Health and the Mobile Phone

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Introduction

Within the next 8 years, annual U.S. expenditure on health care is projected to reach $4 trillion/year, or 20% of the gross domestic product.[1] Whether resource consumption of this order of magnitude is sustainable is an open question, but at the very least it suggests the need for population-level solutions for everything from the primary prevention of disease to improving end-of-life care. Ours is a society that often views challenges like this as being solved through the application of technology, and one technology in particular is emerging that may become very important to the delivery of health care: mobile phones. By June 2007 there were 239 million users of mobile phones in the U.S. or 79% of the population,[2] and users are highly diverse.[3] Mobile phones are beginning to replace landline telephones for some, and except for very young children, may ultimately reach an effective penetration of “one phone: one person” as is already the case in some countries such as Finland.[4]

This paper provides an overview of the implications of this trend for the delivery of healthcare services. In addition to addressing how mobile phones are changing the way health professionals communicate with their patients, a summary is provided of current and projected technologic capabilities of mobile phones that have the potential to render them an increasingly indispensable personal health device. Finally, the health risks of mobile phone use are addressed, as are several unresolved technical and policy-related issues unique to mobile phones. Because these issues may influence how well and how quickly mobile phones are integrated into health care, and how well they serve the needs of the entire population, they deserve the attention of both the healthcare and public health community.

Technical Capabilities of Mobile Phones

Mobile phones support a variety of technical functions, most basically voice and short message services (SMS or text messages) enabling two-way communication in real time or near-real time. Many mobile phones have a camera to capture pictures or short-duration video that can be viewed on the phone, downloaded to one’s computer, or transmitted to others. Data-processing and -storage capabilities resident on mobile phones increase each year and, via connections through a client-server architecture to a larger and more powerful network of

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servers, supports the transmission and analysis of data in a variety of forms, including text, numerical, graphic, audio, and video files. While many mobile phones remain primarily communication devices, “smart phones” mimic what a personal computer can do but with adaptations to the mobile phone’s small screen, keypad, or other user interface. All current phones can access wireless data networks whenever the phone has a signal, and new phones often have additional radios (e.g., WiFi [wireless fidelity]) that enable fast data exchange via the Internet in some locations. Some mobile phones can communicate with other electronic devices through the use of Bluetooth, a wireless technology supporting data exchange over short distances (e.g., 5–10 meters). Also included in all mobile phones is location-determination capability, initially mandated by the Federal Communications Commission (FCC) to help public safety personnel locate the caller in the event of a 911 call, but increasingly used to support location-based services such as providing directions while walking or driving.

Experience to Date of Mobile Phones in Health-Related Applications

Several aspects of the impact of mobile phones on personal health are self-evident, for example, the greater ease with which health professionals and patients can reach and leave messages for one another because of fewer barriers related to time of day or location. Because mobile phones are often accessible only by a single individual, outreach for sensitive medical issues can be improved, such as reminders for medical appointments or information on lab results. The convenience of using mobile phones for these purposes is now almost taken for granted as memories fade of how cumbersome “telephone tag” was with earlier phone systems.

Beyond enhanced capabilities for voice, health-related applications for mobile phones are emerging in the commercial sector. Some applications use mobile phones on their own and others combine mobile phone functions with other technologies such as home-based patient monitoring devices or web-based programs. For example, some mobile phone applications (e.g., sensei.com; myfoodphone.com) help users track their behaviors related to weight management. Behaviors such as calorie counting can be supported by software on the phone, reminders for special dietary needs can be preset and then sent to the user during the day, and the phone camera can be used to take a picture of a meal that is sent to a dietician who uses it to interpret meal content and make recommendations about future diet behavior. Other applications (e.g., mymobilesponsor.com) provide support for those recovering from drug or alcohol addiction.

Evidence of the effectiveness of mobile phone–based health applications is beginning to emerge. For example, a combination of daily and weekly SMS messages sent to mobile phones of children and adolescents with type 1 diabetes mellitus produced favorable changes in diabetes self-efficacy and adherence to treatment, and achieved a high level of satisfaction among users.[5] An application for adults with diabetes and hypertension demonstrated promising utility of the mobile phone’s Bluetooth capabilities to facilitate up-linking of home blood pressure monitor readings to the participant’s doctor with subsequent follow-up based on these readings.[6] The feasibility of using mobile phones to assist in the collection and transmission of peak flow monitoring in patients with asthma has been demonstrated.[7] And among a group served by an urban sexual health clinic, SMS messages improved time to diagnosis and treatment of *Chlamydia trachomatis* infection while at the same time reducing costs for staff follow-up.[8]

Mobile phones have shown utility in helping collect data on alcohol use in adults[9] and craving for cocaine among homeless patients.[10] A text message–based intervention using advice and support to promote smoking cessation among adolescents and young adults demonstrated improved quit rates at 6 weeks,[11] and researchers studying low-income individuals with HIV/AIDS provided mobile phones with pre-paid minutes to support an intervention for smoking

cessation. Using only the voice capabilities of the phone to deliver an eight-session cognitive–behavioral intervention over a 2-month period allowed the researchers to overcome barriers commonly experienced by low-income individuals living with HIV/AIDS such as geographic mobility, homelessness, and lack of transportation or phone service.[12]

Risks and Concerns About the Increasing Use of Mobile Phones

The increased use of mobile phones also raises concerns about risks they pose to health and quality of life. Perhaps the most substantial risk is the use of mobile phones while driving. A recent review of experimental studies of mobile phones and simulated driving situations found slower reaction time to be the most common effect, particularly among drivers aged 50–80 years.[13] The review found fewer naturalistic studies, in which normal rather than experimental driving conditions were evaluated, but those reported to date confirm that mobile phone use while driving degrades essential driving skills. For example, studies using mobile phone company billing records to confirm the risk of crash have found a fourfold increase in injury-producing crashes with no differences found by age, gender, or hand-held versus hands-free phones.[13] Although there is no published research to date on the phenomenon of "driving while texting" this issue has gained considerable attention and is the subject of legislative initiatives in several states. Driving is not the only behavior that might be compromised by use of a mobile phone, with pedestrians using mobile phones distracted as well.[14]

Concern about the habitual use of mobile phones and risk of brain tumors, present for many years, has yet to be validated, as demonstrated in a recent large study in Germany.[15] However, a recent report from the National Academy of Sciences recommends that this issue be further studied, especially in light of increasing use of mobile phones by children.[16] Finally, no discussion of the proliferation of mobile phones would be complete without addressing the negative impact of mobile phone use on the quality of life of bystanders. From obnoxious ringtones to unavoidably overheard conversations, the use of mobile phones in public has, from the perspective of many, become highly problematic. Plans to permit mobile phone use on airplanes are shaping up to become a major policy issue for the airlines.

Technologies Shaping the Future of Health-Related Mobile Phone Applications

Advances in the technologies that underlie mobile phones are enabling them to become better, faster, and less expensive. Moore's Law, proposed in 1965 by Gordon Moore, the founder of Intel, postulated that the number of transistors on a computer chip doubles about every 24 months.[17] This has stood the test of time and, coupled with improvements in wireless technologies, batteries, and interface design, has enabled mobile phones to become an increasingly sophisticated computer and communication device that is readily carried by individuals throughout the day. This convergence of *increasing computing power*, *personalization*, and *mobility* is yielding a profound shift in the evolution of information technologies.

Information storage and computing capabilities that in the 1980s moved from central mainframes to the desktop at work or at home is now making the "leap" to the person. Improved computing power supports the inclusion of additional data-intensive functions on the phone. An example of the type of technology that capitalizes on this convergence is a combination mobile phone–blood glucose monitor (HealthPia, Palisades Park NJ) that simplifies the process of measuring, entering, and tracking blood glucose by transmitting glucometer results from the mobile phone/monitor to a server that is monitored by the patient and the clinician through a website. Promising usability and acceptability data of this device have been shown among a group of adolescents with type 1 diabetes.[18]

Another example of capabilities that may contribute to health care is use of the mobile phone as the hub of a body area network (BAN), a set of wearable devices or sensors on the body that monitor health-related parameters such as glucose or oxygenated blood.[19,20] BANs connect these sensors via low-power wireless communication to a hub that in turn connects them to some form of remote monitoring system. A wireless interface to an mobile phone, already habitually carried in a pocket or on the belt, can enable monitoring, up-linking and centralized tracking of data over time. These data could be summarized and provided to a physician or other healthcare provider for interpretation or, perhaps, subjected to expert logic-system analysis that could be preset to search for patterns or thresholds to trigger an alert. It requires only a modest extension of logic to envision combining this sort of monitoring with just-in-time prompting to promote medication adherence or improved diet or exercise behaviors.[21,22]

Location awareness of mobile phones, combined with Bluetooth and other short-range wireless capabilities, supports another set of functions with potential use in health care: context awareness and interaction with other computer-based technologies in the environment. This type of functionality may become increasingly important as ecologic models improve our understanding of how to intervene to improve health.[23,24] For example, auto-generated reminders for medication refills or influenza shots could be sent via SMS or voicemail based on knowledge of where a person is and the location of the nearest pharmacy. Additional levels of detail could be built into the system, such as whether the pharmacy participates in the user's health plan. Use of short-range wireless communication could be used to improve health outcomes via context-aware behavioral prompting. For example, a restaurant might offer wireless access to nutritional and content data of the items on its menu. This could be automatically pulled into the mobile phone and compared with preferences previously established by the user, perhaps to flag potential allergens or to provide prompts for behaviors like portion size reduction or substitution.

Finally, information technologies are increasingly emphasizing social interaction, collaboration, and sharing of information through online support groups and websites such as Facebook and MySpace. Although the effects on health outcomes of peer-to-peer communication are mixed,[25] it is reasonable to hypothesize that capabilities inherent in mobile phones might improve this circumstance, perhaps as simply as supporting more frequent communication with distant friends and family during the course of an illness rather than only when online at a desktop computer.

Policy Issues for Mobile Phones and the Role of Health Professionals

Incorporating mobile phone–based health applications into health care, including reimbursement for their use, should depend on the level of evidence that supports their use. However, as this evidence continues to grow, there are several unresolved technical and policy-related issues that may influence both how quickly and how well mobile phones are adopted for use for health-related purposes.

Usability and Access

Technologies intended to be used for health-related purposes should be useable by all types of individuals, including the elderly, people with low literacy, and those with permanent or temporary disability. The majority of mobile phones on the market today are sophisticated devices with relatively complicated user interfaces, often requiring high levels of manual dexterity and visual acuity. Mastery of their functions can sometimes take a long time. There are exceptions to this, such as the Jitterbug telephone (GreatCall, Inc., Del Mar CA) in which the user interface of the phone has been simplified for use by those with reduced vision, hearing, and dexterity through the use of a brighter screen, larger numbers on the key pad, and simpler

input buttons. But this sort of offering is the exception rather than the rule and represents only one approach to extending the usefulness of mobile phones to the entire population. Additional options and improvements in usability are likely to emerge but it is not clear whether a range of options that ensure affordability and population-wide impact will emerge through market forces alone. As is the case with orphan diseases where low numbers of individuals with a disease do not justify private research and development costs for treatments, assuring that mobile phones are available and usable for some groups of users might fall to the government or nonprofit sector. Similarly, if mobile phone–based health applications with proven value emerge in the marketplace but are expensive to purchase, there should be low-cost options for individuals with limited means.

Using a mobile phone depends on whether it can achieve a good connection to a network. However, the quality of network connections vary by geographic region and commercial carrier, and most mobile phone users are familiar with the occasional poor quality of signal access in even the most populous areas. New forms of wireless communication might improve this, and health applications can be built so that they do not rely on continuous coverage. But as with usability and affordability, whether high-quality coverage is available in all settings such as low-income, rural, and remote areas might require a policy-level solution to ensure optimal outcomes.

Data Security and Interface with Personal and Medical Health Records

Several aspects of the use of mobile phones for health care raise concerns about health data security and confidentiality, including capturing personal health-related data from a mobile phone, up-linking it to a server, transmitting it to a web-based or other form of electronic personal health or medical record, using the data for interpretation and professional judgments in the care of that individual, and responses back to the person via, for example, an SMS message. The chain of custody of the information in this exchange can be highly complex and sometimes outside of traditional secure electronic medical record environments. A complicating factor is that while a mobile phone might be used predominately by a specific person, it may occasionally be shared or left unlocked in a purse, on the coffee table at home, or on the desk at work. To date, the discussions on the move to electronic health records have placed minimal attention on how to address the growing use of mobile phones and their unique capabilities. Experience sorting out similar issues for e-mail–based communication between doctors and patients suggests that this will not be easy, yet our patients may be well ahead of us in terms of expectations. As has been suggested in the UK,[26] now might be the time for organizations representing the interests of healthcare providers and patients to begin dialogue in this area.

Openness (or Lack Thereof)

Mobile phone services are provided by carriers such as Verizon, Sprint, AT&T, and T-Mobile almost always through an “end-to-end” approach in which they purchase handsets from manufacturers and resell them to consumers along with a fixed-term contract for bundles of services for voice, data, SMS, and other services. Because carriers often offer the same or very similar handsets, competition among carriers sometimes comes down to who offers the best of a certain type of service such as location-based navigation assistance, sports video, or financial information. At present, carriers do not compete on health-related services outside of the domain of programs for things like tracking diet and fitness-related behaviors. This may change as health-related applications for mobile phones grow in number and type and might create opportunities for new markets for some carriers. Qualcomm, a major mobile phone chip manufacturer, is attempting to stimulate the mobile phone health application market with their LifeComm initiative, a mobile phone and service specifically developed for health-related

applications.[27] But there could be unanticipated problems if and when this market grows. For example, exclusivity of a type of handset can become a defining feature for a carrier as is the case at present with the Apple iPhone and AT&T. It is possible that a combined handset–health device like the mobile phone–glucometer described above would be offered by a carrier other than the patient's current one when there is an indication for its use. Mobile phone contracts with carriers can have severe financial penalties for breaking them that could create a barrier to access for a specific service in the event of a new medical condition.

Another barrier to the development and adoption of health-related mobile phone applications is the multiple software operating systems for mobile phones. Much like the PC and Macintosh, development environments for handsets vary, including systems such as Microsoft Windows Mobile, Symbian, Blackberry, Palm OS, Mobile Linux, J2ME, and the Android platform recently announced by Google. The software language used to program and operate each of these differs, and applications developed to run in one environment do not operate in another. At present, other than voice, SMS is essentially the only fully functional capability of mobile phones that is operating system–neutral, and there is nothing at present that approaches the open nature of, for example, the Internet. Tools like Flash Lite are starting to emerge that make some types of applications easier to develop cross-platform, but these have yet to become widely adopted. Likewise, the cross-platform capabilities of Google's Android system are still untested. Thus, applications for specific conditions such as hypertension or post-cancer therapy might be developed that operate on only one type of mobile phone and carrier. Given the frequency of comorbidities among patients, it is not difficult to envision a scenario in which more than one mobile phone/carrier would need to be used if access to multiple health-related applications were required. It is well known from reviewing the growth trajectories of past technologies that a lack of standards, including open standards where appropriate, Balkanizes the marketplace and can slow the innovation, adoption, and improvement of information technologies. If healthcare professionals wish to see mobile phones reach their full potential as platforms that support health care they should consider participating in policy discussions intended to promote such standards.

Conclusion

The technologies that underlie mobile phones are becoming more powerful and cheaper, and evidence is beginning to emerge about the value of mobile phones for the delivery of healthcare services and the promotion of personal health. However, important obstacles to the use of mobile phones for health-related purposes also exist. As in other areas of the economy, market-based approaches to overcome these obstacles may not be sufficient to reach all segments of the population and may leave those already experiencing health disparities even more disadvantaged. From lasers to MRIs, health professionals have been remarkably creative in adapting technologies developed in non–health-related domains to serve the needs of their patients, improve health outcomes, and strengthen the health of the public. The growing use of mobile phones by essentially all segments of the population provides an opportunity to do this once again.

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