mHealth and the Future of Medicine

Mobile electronic health tools such as cell phones and telemedicine technologies are rapidly transforming the face and context of health service delivery around the world. Currently, there are more than 3.5 billion mobile phones in use across the globe—a figure that is set to double in the next decade. At the same time, telemedicine's role in clinical care, education, research and training in the health sector continues to grow from continent to continent.

Mobile phone use, in particular, is exploding across the developing world, offering the opportunity to leapfrog other applications and services on both the health and technology fronts. As United Nations Foundation President Timothy E. Wirth emphasizes, the power of these technologies to improve health and the human condition cannot be underestimated: "Modern telecommunications, and the creative use of it, has the power to change lives and help...solve some of the world's biggest challenges."

Mobile health information technology (mHealth) typically refers to portable devices with the capability to create, store, retrieve and transmit data in real time to improve patient safety and the quality of care. The flow of mobile health information is characterized by portable hardware coupled with software applications and patient data that travels across wireless networks. Data transmission is realized by technologies common in everyday life, including Bluetooth, cell phone, infra-red, WiFi, and wired technologies, all of which operate as part of a network. mHealth deployment is diverse. A clinician can use a mobile device to access a patient's electronic health record (EHR), write and transmit prescriptions to a pharmacy, interact with patient treatment plans, communicate public health data, order diagnostic tests, review labs, or access medical references, for example.

The United Nations Foundation, the Vodafone Group Foundation, and the Telemedicine Society of India jointly convened mHealth and Mobile Telemedicine, part of the Rockefeller Foundation *Making the eHealth Connection: Global Partnerships, Local Solutions* Bellagio Center conference series. Participants focused on methods for harnessing the spread of mobile technology and its power to transform health and information exchange.

mHealth and Mobile Telemedicine: Key Issues

Experts predict that the impact of mHealth is likely to be more far-reaching than other developments, such as nanomedicine and genetic therapy, as it will create an urgent need to review the way health care is financed and as it will blur the boundaries between professional medical

help and so-called "do-it-yourself" medicine. Key issues as mHealth moves forward, particularly in developing world settings, include the following:

- mHealth markets and scaling
- Imperatives for national-level health data collection processes through mobile devices
- Exploring critical success factors and incentives for local implementations
- Given mHealth's rapid progression, the immediate seeding of a multi-sector partnership dedicated to designing, funding and advancing mobile service projects

Also at play are these issues:

1. INFORMATION ACCESS AND USE⇨ The management of information emerges as an important challenge. Key to the successful implementation of mHealth is the availability of the right information at the right place, at the right time and in the correct form. Medical practitioners and patients must be free to roam and to utilize different access devices (in terms of both communication characteristics and display and processing capabilities). New challenges will arise, however, regarding the secure and reliable delivery of information from a variety of sources and in a multitude of formats (from plain messages to multimedia content). Critical to the successful handling of supporting information are monitoring devices, health care databases, communication networks and access devices.

2. COMMUNICATION NETWORK SOPHISTICATION⇨ The variety and complexity of mHealth application scenarios calls for the combined use of wireless technologies (both short- and wide- range), wired communication backbones and the Internet in a seamless, secure and reliable way. The employed wireless technologies include Bluetooth, wLAN, WiFi, GSM/GPRS, UMTS and satellite communications (VSAT, DVB-RCS). The difficulty of achieving operational compatibility between the telecommunication services, terminals and devices continues to be a challenge for mHealth applications.

Although high-speed digital communication infrastructures are gradually gaining ground, it is often the case that the regions that would benefit the most from electronically delivered health care are underserved in terms telecommunication capabilities. High-speed communication networks are still far from being a reality in many remote rural areas in developing countries. This limits the options for telemedicine, as many services can only function well under specific conditions related to communication capabilities. Many telehealth applications rely on high-speed broadband IP networks to deliver high-quality, timely and converged voice, video and data.

3. ACCESS LIMITATIONS⇨ mHealth employs a multitude of both wired and wireless-access devices, e.g. portable PCs, cellular phones and personal digital assistants (PDAs). Each one of these appliances has its own limitations, in screen size, processor power, memory, bandwidth and battery life. The service capabilities of each device vary depending on these characteristics.

Clinicians should be particularly aware of the access limitations of the devices employed, what amount of information they can provide and how well they can display it. Screen size and digital imaging technologies are particularly important in some highly visual telemedicine applications, such as tele-radiology, tele-dermatology and tele-pathology. Fortunately, technologies currently available provide excellent pixel density and resolution with a high rate of diagnostic agreement between digital and real images, as demonstrated in the scientific literature.

4. UNIFYING INFORMATION SOURCES⇨ Ideally, the entire medical profile of a patient (medical history, results of laboratory tests, etc.) should be retrievable at the point of care at the touch of a button. Yet, the decentralized multi-actor nature of health care and the wide distribution of relevant data sources have produced a patchwork, in terms of content and database implementation, that makes access to and retrieval of data from repositories a real challenge. Consequently, new mobile health applications must focus on the integration and exploitation of heterogeneous scientific information databases in a seamless way. This will enable the storage, updating, search and retrieval of useful information.

mHealth and the Transformation of Health Service Delivery

Telecommunications growth in developing countries over the past five years has been tremendous. In 1998, India and China had less than 1 million and 25 million mobile subscribers, respectively. By early 2008, both countries were adding 8 to 10 million subscribers per month. This outpaces the United States, where growth is around 1.6 million subscribers per month, and Japan, where the corresponding figure is less than 1 million. In fact, the majority of mobile-subscriber growth over the next 10 years will come from the developing world. In 1998, developed nations accounted for more than 76 percent of mobile subscribers worldwide By 2018, only 19 percent of mobile subscribers are expected to come from developed nations.

One of the most important areas that mobile technologies are primed to affect in both developing and developed countries is health care. Mobile technologies do two things well: compress time and distance. Thus, they connect, enable, and empower participants in the health care ecosystem to reduce costs and errors while increasing productivity, access, and efficiency. *mHealth and Mobile Telemedicine* conference participants concluded that mobility and mHealth will affect health care delivery in the following critical areas:

1. GLOBALIZATION OF HEALTH SERVICE DELIVERY⇨ In an interconnected world, health service delivery will be much more decentralized and much more widely distributed. The local clinic might be responsible for monitoring vital signs, but the analysis and prognosis might come from a physician thousands of miles away. You might be lying on a bed in Kuala Lumpur, but your surgeon could be in Stockholm on video conference with experts from Cambridge and Chennai. Real-time translation capability would mean language will not be an issue in the future.

2. REMOTE CARE AND MONITORING⇨ Given the cost of access and administration, there will be significant investment in sensor technology near or on the patient. There will also be significant funding of the communication infrastructure that connects both medical data from sensors and the patient to physicians and their staff. For example, the German firm Biotronic has developed a phone that communicates with a pacemaker using close-range radio frequency and then transmits data over a cellular network to the physician in real time.[1,2,3] Remote care will revolutionize how expertise and drugs are delivered in rural parts of the world. They will also decrease the cost of equipment and care.

3. ALERTING⇨ The mHealth solutions that will be most replicable will be those that are both straightforward and ubiquitous. A simple alerting capability can help reduce costs and increase efficiency in every country. From reducing the number of missed appointments and missed medications through proactive patient monitoring[4] to alerting end-users in the case of an epidemic or an emergency, messaging and alerting technologies will remain an integrated part of the health care system for years to come.

4. EARLY DISEASE DETECTION⇨ There is plenty of research to show that if a disease is detected and treated early, costs and morbidity rates are greatly reduced. If the impact of the therapy can be monitored in real time and adjusted as needed, markers in the human bloodstream can allow physicians to follow the disease and transform medical prognoses into more evidence- and performance-based treatments.

5. DATA COLLECTION AND RECORD MAINTENANCE⇨ Current health care interactions often require that patients fill out countless forms and other paperwork. By automating data collection for patient trials or monitoring and digitizing the medical records for further processing, significant cost savings can be realized. Enormous computing power and Gbps (Gigabits/second) network connections would mean data can be collected, analyzed, and understood in real time from almost anywhere on the planet.

6. WELLNESS AND INFORMATION AWARENESS⇨ We now have the potential for instantaneous access to information and the capacity to use devices to monitor and record vital signs at the touch of a button. This ease of use can increase the desire of individuals to stay fit and healthy as well as improve preventative regimens. In addition, the ability to network with friends, family and patients with similar experiences will help create a better environment for sharing information.

7. GUIDANCE IN EMERGENCY RESPONSE⇨ The effectiveness of medical responses to emergencies is determined by speed and by the level of clear communication. By coordinating with application platforms and operators, command centers can issue very specific guidance, informing end users about what to do, which route to take, how to contact authorities, and, based on real-time modeling, what to expect in the next few minutes or hours.

8. PREVENTING PHARMACEUTICAL COUNTERFEITING AND THEFT⇨ A major challenge, especially in developing countries, is that medications are essentially a form of currency for criminals. Sensors (monitored remotely) placed on drug shipments can help ensure that a medication reaches its intended destination without tampering. Sensors can also help maintain or monitor the environmental conditions necessary for certain drugs to be effective.

Karl Brown, MIA, Associate Director, Applied Technology, Rockefeller Foundation, United States

"The potential for developing countries to become centers of innovation for eHealth is exciting. They don't have to contend with all the legacy issues, can start with best practices and there is such energy and talent devoted to this problem. I think the sky is the limit as far as what the potential outcomes will be."

9. MODELING AND PREDICTING DISASTERS⇨
Significant effort must be put into modeling and predicting emergencies, from disease epidemics to terrorist attacks to wildfires to earthquakes. How will an evacuation plan be directed? How will affected citizens be informed? What if the sensor networks fail? And how will modeled data be fed into a real-time emergency response system?

mHealth in Practice: Indonesia's Mobile Telemedicine System

The United Nations Development Programme has endowed a new mobile-health initiative in Sukabumi, Western Java, in Indonesia. It is run by the Institute Teknologi Bandung, the Health and Medical Bureau, district authorities, three hospitals and 71 community health centers. The system utilized in this project employs existing Internet communication equipment and has been operating with the primary objectives of telediagnosis, remote consultation and the collection and recording of patient information. Medical instruments are installed and used depending on the differing needs of various locations and situations. In addition, the patient information system records the name of the disease and the findings of the physician, the diagnostic tests used to measure the grade of illness, the results of these tests and the type and method of treatment.

The system can also record information such as the patient's address, occupation, marital status and age. In the hospital or doctor's office, data sent in various formats can now be processed collectively. Data exchange can be performed via both pocket radio GSM/CDMA cellular phones and fixed-line telephones. The exchange of information can occur with dedicated software based on the Transmission Control Protocol/Internet Protocol (the basic communication language of the Internet), and the means of communication can be adapted to the local infrastructure.

This ongoing pilot project has allowed people in rural areas and other locales far from hospi-

tals to receive periodic medical examinations using cellular phones. Furthermore, the staff of small hospitals can now receive critical information formerly available only in larger medical settings, such as specialists' diagnoses of rare diseases or advice about the treatment of advanced illnesses.

Conclusion

mHealth holds great promise for better public health and medicine in both the developed and developing worlds. There is a rapidly growing mhealth eco-system, but moving from proof of concept demonstrations to effective deployment of these technologies requires overcoming a series of challenges. The conclusion of the mHealth week at Bellagio was to establish an "mHealth Alliance," which was announced in February, 2009, at the Mobile World Congress. The purpose of the Alliance is to foster mHealth, build partnerships, undertake advanced trials, and advocate for appropriate public policies. Its mission is to help drive mHealth to sustainable scale at the farthest reaches of wireless networks. The Rockefeller Foundation, the United Nations Foundation, Vodafone Foundation, and the U.S. President's Emergency Plan for AIDS Relief (PEPFAR) are the founding donors. The Alliance is rapidly attracting support from a wide variety of quarters as it begins to implement its strategic focus on both information and implementation.

Notes

1 The Emerging Personal Health Information Network, Inside Edge, September 2007, Volume 13, Number 8.

2 We will also see health care-specialized devices with wireless connectivity like the ones from CardioNet, a United States-based company.

3 Many phones already have biometric sensors for authentication. We will be using these same sensors and additional ones to monitor vital signs and transmit them. Some of the innovative concepts being worked on are measuring heart rate with a cell phone and using the measurement for authentication for other purposes like banking and payments. Pharma companies are likely to use bar codes and NFC (near-field communications) to provide more information on labels and drugs so users can just scan the labels from their cell phones and get relevant information or instructions.

4 Research shows that poor adherence leads to increased drug resistance. For example, if a patient with tuberculosis takes treatment once a week rather than the prescribed regimen of twice a week for the duration of the treatment, the risk of a positive culture at 12 months is five times greater. Source: The Role of Mobile Phones in increasing Accessibility and Efficiency in Healthcare, The Vodafone Policy Paper Series, Number 4, March 2006.

Anand Narasimham, PhD, Co-Founder and Chief Technology Officer, Voxiva, Inc., United States

"All over Africa and Asia, countries started putting in networks with high-density coverage for voice and data. The tables have turned. The developing world has very advanced infrastructure for communications whereas many parts of the developed world are playing catch-up."