Opportunities and Obstacles in the Adoption of mHealth

By Mehran Mehregany, MS, PhD, and Enrique Saldivar, MD, MS, PhD

Technological advances have catalyzed tremendous progress in healthcare—patient, workflow and information management, medical devices, drug discovery and delivery, genetic sequencing, imaging, diagnosis and therapy, medical decision making, public health, emergency response and many more.

Video conferencing, known as telehealth, has begun to facilitate “distance medicine” (i.e., bringing healthcare providers face-to-face with remote patients). However, for the most part, healthcare delivery today requires the patient and the provider to come together episodically at a given time and place.

In contrast, continuous care enabled by mobile technology has tremendous appeal; it promises significant improvements in quality, convenience, reach and cost of care. For the sake of clarity, we will refer to this technology approach as mHealth, though it also is called wireless health and uHealth (ubiquitous health).

mHealth also is thought of as using wirelessly connected, mobile computing platforms—such as cell phones—for health services and information. An important but subtle point is that not all mHealth solutions are wireless, and not all wireless solutions are mobile. Having noted this point, we nevertheless use the term mHealth to implicitly include the wireless feature.

mHealth solutions are enabled by the convergence of four pervasive technologies—unobtrusive sensing, wireless communication, ubiquitous computing and social networking. Miniature, low-cost, high-performance sensors can measure a variety of physical, chemical and biological parameters. Wireless connectivity is increasingly available with higher performance at lower cost and in smaller form and lower power. From embedded microprocessors to cell phones to servers in data centers (i.e., the cloud), computing is readily available and is a commodity. Finally, a variety of web-based platforms provide the opportunity to build and leverage a wide range of social networks for many different purposes.

The field is in its infancy and not yet a formal discipline. At this time, mHealth is mostly a concept, but a remarkably powerful and rich one that enables effective and efficient ways to collect, forward and process medical data and information within the healthcare ecosystem.
mHealth: From Smartphones to Smart Systems

Enhancing quality, improving convenience, extending reach and reducing the cost of healthcare are the potential benefits that are anticipated from adoption of mHealth. Enhancing quality shall result from targeted care, at the right time, based on collection and/or communication of relevant health data and information, as well as new care possibilities that are enabled through continuous monitoring, wireless communication and/or rich new databases of disease conditions. Improving convenience shall result from the resulting mobility afforded to patients and care providers. Extending reach shall result from possibilities in diagnosis, therapy and monitoring at a distance and/or in places otherwise difficult to reach. Reducing cost results from keeping patients out of facilities through preventative care and timely diagnosis, as well as by reducing errors and amplifying the productivity of healthcare providers. Regarding the latter, technology integration into medicine has often been responsible for increasing the cost of care, something to keep in mind in developing mHealth solutions.

Given the potential benefits and increasing patient demand, the emergence of mHealth as a staple of care delivery is almost a certainty. What is difficult to forecast is its rate of adoption, which will depend on technology availability, acquisition and ownership costs, regulatory efficiency, reimbursement policy, clinical and health education, demonstrated outcomes and patient awareness.

One can anticipate the mHealth application opportunities in the developed world from historical and current uses of mHealth in the developing countries, where mHealth is used for:

- Education and awareness.
- Remote data collection.
- Remote monitoring.
- Communication and training for healthcare workers.
- Disease and epidemic outbreak tracking.
- Diagnostic and treatment support.

It is reasonable to assume that in the United States and in other industrialized countries, the main interest will center on remote monitoring, remote access, diagnostics and treatment support. (See Table 2-1 and Table 2-2)

OPPORTUNITIES IN ADOPTION OF mHEALTH

The key opportunities for mHealth are enhancing quality, improving convenience, extending reach and reducing the cost of healthcare.

Enhancing Quality

mHealth is expected to enhance quality of care by enabling targeted care at the right time, based on (real-time or recent) collection and/or communication of relevant health data, as well as new care possibilities that are enabled through continuous monitoring, wireless communication and/or rich new databases of disease conditions. Approximately 75 percent of healthcare spending is on patients suffering from one or more chronic diseases, namely diabetes, obesity, heart disease, lung disease, high blood pressure and cancer. Using mHealth solutions to monitor relevant biomarkers of these chronic-disease patients enables better management of those diseases. Better management of a chronic disease improves the quality of life of the patient, while
Table 2-1. Opportunities and Obstacles of mHealth in Developed Nations.

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<tr>
<th>Opportunities</th>
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<td><strong>Enhancing Quality</strong></td>
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<td>• Chronic disease management</td>
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<td>• Medical compliance</td>
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<td>• Wellness and prevention</td>
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<td>• Health information exchange</td>
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<td>• Research and registry data</td>
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<td><strong>Convenience</strong></td>
<td><strong>Regulation</strong></td>
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<td>• Streamlining care processes</td>
<td>• Approval and time to market</td>
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<td>• Persistence and pervasiveness</td>
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<td>• Patient-friendly care modalities</td>
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<td>• Staff productivity</td>
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<td>• Telemedicine</td>
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<td>• Remote patient management</td>
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<td>• Integration with social networks</td>
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<td><strong>Cost Reduction</strong></td>
<td><strong>Reimbursement</strong></td>
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<td>• Clinical resource efficiency</td>
<td>• Lagging incentives</td>
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<td>• Clinical collaboration</td>
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<td>• Wellness, prevention and</td>
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<td>pre-emption</td>
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<td>• Risk management</td>
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<td><strong>Workflow Disruption</strong></td>
<td><strong>Access</strong></td>
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<td>• Resistance to innovation</td>
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Table 2-2. Opportunities and Obstacles of mHealth in Developing Nations.

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<tr>
<th>Opportunities</th>
<th>Challenges</th>
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<tr>
<td><strong>Enhancing Quality</strong></td>
<td><strong>Resource Capacity</strong></td>
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<tr>
<td>• Population health</td>
<td>• Clinical resource availability</td>
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<tr>
<td>• Telemedicine</td>
<td>• Infrastructure</td>
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<tr>
<td>• Wellness and prevention</td>
<td>• Technology</td>
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<td>• IT sophistication</td>
<td>• IT sophistication</td>
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<tr>
<td><strong>Convenience</strong></td>
<td><strong>Cost</strong></td>
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<tr>
<td>• Geographic reach</td>
<td>• Technology acquisition and total</td>
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<tr>
<td>• Resource utilization</td>
<td>cost of ownership</td>
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<td><strong>Cost Reduction</strong></td>
<td><strong>Access</strong></td>
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<td>• Capital efficiency</td>
<td>• Patient education</td>
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<td>• Geographic reach</td>
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Table 2-1. Opportunities and Obstacles of mHealth in Developed Nations.

Table 2-2. Opportunities and Obstacles of mHealth in Developing Nations.
reducing care facility visits due to exacerbation of the patient’s condition as a result of inadequate or inefficient care.

Consider the case of chronic heart-failure, a disease that afflicts about 5 million people in the United States.\textsuperscript{6} mHealth can enable monitoring of cardiac function, blood pressure, weight and fluid status in these patients for better management of their disease in order to reduce emergency room visits, hospital stays and nursing home needs. Indeed, there are already established companies\textsuperscript{9}, as well as a few start-up vendors\textsuperscript{7} pursuing mobile opportunities for heart disease.

Similar possibilities exist for other chronic diseases. A list of top 10 chronic diseases proposed in Topal\textsuperscript{9} includes Alzheimer’s, asthma, breast cancer, COPD, depression/mood disorders, diabetes, heart failure, hypertension, obesity and sleep disorders. In each case, monitoring a suitable set of biomarkers enables better management of the disease for improved outcome. Here again, there are already start-ups that are specifically targeting these opportunities.\textsuperscript{10}

However, the impact of mHealth solutions on quality of care is not limited to chronic diseases. Emergency medicine can for example leverage mHealth solutions, enhancing trauma care through rapid communication of health information from the field to a care center.\textsuperscript{2} mHealth solutions also can be used for screening purposes (e.g., vision,\textsuperscript{11} high-risk pregnancy,\textsuperscript{12,13} gait,\textsuperscript{14} etc.).

Medication compliance is an example where mHealth solutions are being deployed by start-ups to enhance therapy and save cost; noncompliance currently costs the US healthcare system around $300 billion annually.\textsuperscript{15} Another area is health education; this application of mHealth in developing countries has been ongoing in the last decade.\textsuperscript{1}

mHealth solutions can also be used for therapy applications—often in the form of communicating a course of action—and monitoring adherence quality and therapeutic impact. An example of this type of application is rehabilitation due to trauma, sports injury, stroke, etc.\textsuperscript{16} Integration of mHealth capabilities with other health information technology is natural. mHealth solutions also provide opportunities to reduce errors through workflow improvement and real-time checks.\textsuperscript{2}

Finally, the use of mHealth can result in development of rich databases for various diseases and for provision of care itself.\textsuperscript{17} These databases can be mined to derive new insights for improving care and enhancing outcomes. An important characteristic of these databases, not currently available, is that the data is gathered \textit{in situ} (i.e., during the course of a patient’s normal life routine). Such data is more representative of the patient’s health condition than data taken at a specific time and place (e.g., blood pressure at a doctor’s appointment where the patient is often nervous). Coupled with genetic sequencing to identify patients at risk for a given disease, mHealth solutions can be deployed to monitor such risk groups, bringing about a new paradigm in providing care (i.e., personalized, preventative care).\textsuperscript{9}

**Improving Convenience**
mHealth is expected to improve convenience for patients and caregivers by enabling pervasive access. Here, the use of the term “caregiver” is intended to include the patient’s social network (e.g., family members and friends). A byproduct of such improved convenience is enhancement of the quality of care.
Traditionally, patients and clinicians have had to come together physically, restricting their interaction to a specific time and place. As a result, the patient’s life quality and work productivity are adversely affected due to residence time in a care facility, in particular when this residence time is extended.

Where mHealth solutions can be deployed, patients may go about their lives while still under care, freeing the patient from frequent visits to the care facility. This mobility is even of benefit in a care facility, where upon check-in, an mHealth solution can be deployed on the patient for requisite monitoring, freeing the patient to move about.

mHealth solutions can also significantly impact clinicians. Most obvious is the impact on the quality of life of the clinicians (i.e., affording them additional opportunities for their personal and leisure activities). Such improvement in their quality of life enhances their mood and alertness—significant contributors to their work performance and quality of care as a result.

Perhaps less obvious is the leverage that mHealth solutions can generate in the provision of care in the face of a growing patient-to-clinician population. An increasing shortage of clinicians (e.g., doctors, nurses, therapists, etc.) is a serious concern in healthcare; pervasive connectivity resulting from mHealth solutions will allow clinicians to be connected to patients anytime, anywhere. As a result, clinicians can potentially minimize their unproductive time (e.g., transit times from one location to another) and maximize their availability (i.e., providing care is less of a burden in terms of restricting their location and available time).

The pervasive connectivity that has given rise to an increasing group of mobile knowledge workers is bringing about a similar trend in the clinician ranks, in particular when mHealth solutions are integrated with other health IT solutions. Integration of mHealth with clinical decision support systems, for example, will allow diagnosis, therapy and monitoring of an increasing number of patients, amplifying the productivity of the clinical workforce.

Finally, mHealth solutions are being conveniently and naturally integrated with a patient’s social network for improved care. An obvious application area is aging-in-place (i.e., keeping senior citizens in their homes longer). Pervasive connectivity and unobtrusive sensors allow family members to care for their loved ones while, for the most part, going about their daily lives. The social connectivity made possible will be of significant benefit to the elderly, who are usually alone in their homes.

Other applications include engagement of a patient’s social network to enhance adherence to a therapy regiment. For example, blood-sugar level readings of a diabetic patient can be reported to designated family members who can encourage the patient to maintain an appropriate diet. Weight loss is another area of application where one’s social network can help improve outcomes. Another application area is to make the patient part of a social network in which individuals are competing for better health outcomes.

**Extending Reach**

mHealth is expected to extend the reach of care by enabling possibilities in diagnosis, therapy and monitoring at a distance and/or in places otherwise difficult to reach. There are instances in which qualified care is not available at a patient’s location. The
most obvious of these instances in the developed countries is rural areas, whereas this situation in developing countries may also include urban areas.

An example of effective use of an mHealth solution at a distance is high-risk pregnancy monitoring.\textsuperscript{13} It is clearly inconvenient for a pregnant woman in a remote location to travel to a medical clinic for fetal heart rate and contraction monitoring in order to assess risk. Often this screening test has to be repeated over a 24- to 48-hour window, which requires the patient to make repeat trips to the clinic.

Technology is readily available that enables a wearable fetal heart rate and contract monitor, equipped with broadband wireless connectivity.\textsuperscript{13} The patient can wear the instrument at home, with the data sent real-time to the remote clinic for risk assessment. In fact, the user interface may be extremely simple, allowing the instrument to arrive in mail and be deployed by the patient,\textsuperscript{13} an attractive possibility for other mHealth solutions as well. Other opportunities for extending the reach of care are in emergency medicine/trauma,\textsuperscript{4} vision screening,\textsuperscript{11} rehabilitation,\textsuperscript{16} chronic disease,\textsuperscript{4} etc. (i.e., instances in which health data can be collected at the point of care and analyzed remotely for a given care scenario.)

Another example is reaching into underserved communities without sufficient access to care. In some cases, such underserved communities may be less open to outside care providers due to social, religious and/or cultural constraints. mHealth solutions can be deployed by trained community personnel (worker or volunteers), while diagnosis, therapy and monitoring is performed remotely. The convenience afforded clinicians by mHealth solutions can potentially promote more volunteer work from them and further facilitate the provision of care to such underserved communities. A beneficial byproduct can be developing databases of disease information for communities that would otherwise not be studied. In particular, effects of characteristic traits commonly present among the community members can be studied in a natural way as the databases become rich.

Finally, geographic reach is an issue in circumstances that prevent care providers from arriving at the point of care. Natural disasters and armed conflicts can constrain access to care, even though the physical distance may be minor. mHealth solutions can often be deployed at the point of care through a variety of techniques, extending reach in these circumstances.\textsuperscript{22} Provisions for mHealth solutions can be stocked ahead of time, for example in the case of transportation. If not deployed ahead of time, the provisions can be delivered at the time of need, using means commensurate with the circumstances.

**Reducing Cost**

mHealth is expected to reduce cost by keeping patients out of care facilities through preventive care solutions and timely diagnosis, as well as by reducing errors and amplifying the productivity of healthcare providers. The opportunities to keep patients out of care facilities were underlined previously. Reducing reliance on and need for care facilities leads to cost savings in terms of patient care and capital investment. Visits to and residence time at a care facility are expensive due to human resource and infrastructure costs inherent in operating a care facility, which are recouped from patients (or the healthcare coverage provider of the patient). They also result in out-of-pocket expenses and productivity costs to the patients.
To the extent that mHealth solutions are deployed for preventative care, cost savings become substantial because of significant reduction in consequential acute episodes. Preventative care application is one of the most significant opportunities for mHealth, since solutions have the potential to be non-intrusive to the patient (or manageable with respect to their intrusion on the daily life of the patient).

There is a potential to reduce errors through the utilization of mHealth solution since these solutions can be rich in data and seamlessly interface with health IT systems. The richness of data (for continuous or more periodic monitoring) not only provides more information on the state of the patients’ health, but also allows identification of inaccurate data through trend analysis.

For example, data collected over a 24-hour period can identify lifestyle factors that affect a patient’s health with respect to the specific condition under study. At the same time, examining adjacent readings and considering the possibility of the related biomarker changes in the measured time interval can identify anomalous data. Seamless interface with health information systems is possible due to the electronic nature of data from mHealth solutions. Errors related to data recording, manipulation and archiving are reduced when human factors are removed and processes are automated. Elimination of human factors through automation also saves labor cost, usually resulting in a net savings.

Finally, mHealth solutions enable the units of clinical workforce to cover a large population of patients through automated monitoring. Once an mHealth solution is deployed, data is transmitted into health information systems automatically. Clinical decision support systems can identify instances that require clinical attention. Clinical involvement can be structured to efficiently deploy available workforce capabilities—for example, in a pyramid structure, from many trained technicians looking at incoming data to a progressively smaller number of physician assistants, nurses and doctors making related medical decisions.

**OBSTACLES IN THE ADOPTION OF mHEALTH**

Obstacles to the rate of adoption of mHealth include availability of the technology, acquisition and ownership cost, regulatory efficiency, reimbursement policy, clinical education, demonstrated outcomes and patient awareness.

**Technology Availability**

Technology availability refers to the extent and richness of solutions possible to a wide range of medical problems. The availability of technologies that can be employed in the enrichment and application of mHealth are at different stages of evolution, namely:

**Technologies currently unavailable:** These technologies are either at a conceptual level or have not yet been invented. An example here is the non-invasive, early detection of cancer.

**Available technologies:** These technologies are in the research/development phase. Although their proof of concept has already been established, these devices or applications are not yet available for medical use. An example of this is motion analysis through accelerometers. Although the use of accelerometers in medicine is not
new, their incorporation in cell phones has sparked the imagination of engineers and developers working on mHealth solutions. As these technologies become available, it can be predicted that the field of fall detection, posture identification and motion analysis will experience rapid growth.

Another example is the development of electrocardiograms in a wide variety of form factors. The heart has the most noticeable electrical activity of all the body’s organs, so it is not surprising that technology to detect its activity continues to expand. Due to the relative low cost of development and implementation of electrocardiogram solutions, its applications in fields like cardiology and sports medicine will grow quickly.

Proven technologies: These technologies are on the market, either as complete systems or as components. The immediate growth of mHealth solutions is facilitated by these technologies. Examples of these include wireless Holter monitors, weight scales, blood pressure cuffs and glucometers.

Development and growth of mHealth, for the most part, relies on proven and available technologies. At the same time, there are investments in start-ups companies and solutions that are pursuing applications requiring development of technologies at the conceptual level.

Acquisition and Ownership Costs
Acquisition and ownership costs refer to the risks and costs associated with purchasing mHealth solutions and operating/maintaining them, respectively. (Hereafter, the use of the word “cost” is intended to also include risk as appropriate.) A risk inherent to the adoption of solutions built on continuously evolving technologies is obsolescence. One aspect of obsolescence is the need to periodically upgrade a solution, which can be costly (i.e., both in terms of direct upgrade costs and indirect costs associated with integration and/or training). Tied to this hurdle is the increasing cost of maintenance, since older technologies are less readily supported. Another aspect of obsolescence can be even more costly (i.e., when business models are built on a given technology solution which has to compete with emerging, less expensive solutions addressing the same need). A good example of this is mHealth solutions for arrhythmia diagnosis.

In an emerging field driven by high technology, many new solutions are developed and brought to market by start-ups. In some cases, when the technology risk has been overcome, large companies acquire a start-up’s solution and integrate it into their own offering. When this does not happen, the risks associated with the business viability/success of a start-up (including from competition) add a meaningful element of cost to the solution. As a result, initial uptake of a solution may be slow until there is sufficient confidence that the entity not only has a winning solution, but also is a robust supplier. Additional potential costs associated with start-up solutions are risks associated with manufacturing quality, supply volume and customer support services.

Acquisition of new technology also has a potential cost due to an increase in the liability of the healthcare provider prescribing the related medical solution. Examples of this type of potential cost are often seen in the drug industry, due to unforeseen complications of the use of a pharmaceutical agent and its use in patients. Given the
infancy of mHealth solutions, this type of potential cost may be meaningful until the field matures.

**Regulatory Efficiency**

Regulatory efficiency refers to the time and cost associated with obtaining approval for specific solutions to particular medical problems. Authorization for the commercialization of medical devices, including mHealth solutions, lies with the Food and Drug Administration (FDA).

There are three steps to approval of a device-based medical product/solution for commercial use, which also apply to mHealth solutions. First, there shall be a determination that the product/solution is a medical device according to the FDA’s definition, and not a drug or biological product regulated by any other component of the FDA different than the Center for Devices and Radiological Health (CDRH).\(^{24}\)

Second, there shall be a classification into Class I, Class II or Class III. Depending on the characteristics and intended use of the product/solution, this classification is critically important, as it defines the level of controls that will be considered for approval.

Third, there shall be a selection of the appropriate marketing application (i.e., Premarket Notification [510k], Premarket Approval [PMA] or Exempt Device), depending on the class of the device and the existence of predicate devices. (Readers are encouraged to study the FDA’s published information\(^{25}\) and consult with a regulatory expert at the start of a development initiative.)

In the case of a 510k application, which is often the approach many device-based product/solution developments take, the FDA has 90 days to respond. It is important to note that this internally imposed FDA timeline is not for approval, but the opportunity for the agency to respond to a request. Depending on the quality of the 510k application and the data presented, the FDA may require one or more communications with the applicant before it renders a final decision on the application.

In the case of mHealth solutions that incorporate wireless connectivity, there may be regulatory requirements by the Federal Communications Commission (FCC) that need to be considered. Wireless connectivity and mobile computing bring with them connectivity reliability and data security issues that are particular to mHealth. Connectivity reliability includes confidence in the ability to transmit data when needed/intended (i.e., addressing connectivity drops due to lack of coverage or electromagnetic interferences), including assurances that data is transmitted completely and without error. Data security issues relate to the confidence that the data being transmitted is not breached during transmission. They also relate to security of access to a generic mobile device, which is at a high risk of data loss or breach. However, the financial industry has addressed data security issues in mobile platforms, which can be leveraged for mHealth as well. HIPAA governs patient data security requirements. This act establishes the electronic protected health information (e-PHI), electronic exchange and privacy and security of health information (45 CFR Part 160 and Part 164, Subparts A and C.)\(^{26}\)
Reimbursement Policy
Reimbursement policy refers to covering the cost of utilizing mHealth solutions, particularly when used for prevention, which is a great application opportunity for mHealth, but usually not reimbursable (although that situation is changing.) Reimbursement by Medicare or commercial insurance carriers underlies the business model of the US healthcare system. Due to related agency agreements, the reimbursement policies are intertwined with the regulatory aspects of approval of a medical product/solution. The Centers for Medicare & Medicaid Services (CMS), is the federal organization that ultimately approves the reimbursement for a product/solution, including medical devices cleared or approved by the FDA. (For special cases, such a medical device classified under investigational device exemption [IDE], the reader should consult the FDA or a specialist in the field.)

It is important to note that the CMS has no authority over commercial health insurance carriers and their policies. It is, however, customary for commercial health insurance carriers to utilize the guidelines of the CMS for their reimbursement policies. These policies are based on a fee-for-service reimbursement model, which is functional under the traditional physician-patient healthcare model. However, the current reimbursement models do not cover preventive medicine strategies initiated in the private sector. This situation can impose restrictions in the business models of mHealth solutions, as some of the strongest use cases are to enable individualized preventive medicine. (See Chapter 6 and Chapter 7 for more on reimbursement.)

Clinical and Health Education
Clinical education refers to the need for health providers to adopt mHealth solutions and know when and how to deploy them. Just because an mHealth solution is available does not mean that it will be widely adopted by clinicians. Even with gold-standard studies, it can take up to 10 years for the completion of knowledge transfer and the diffusion of innovation into clinical practice. Education is necessary to make mHealth solutions visible to the clinical community, as well as to provide training for its use cases.

Where an mHealth solution displaces an established clinical practice and/or business model, there may be more resistance to adoption. There is also the paper-based workflow that currently underlies inter- and intra-organization communications, referrals and handoffs. mHealth solutions’ integration into current workflow is a barrier to overcome. Finally, the use of mHealth solutions for preventative medicine is an area that requires training of and adoption by the clinical practice.

On the patient side, health education plays an important role in the prevention of disease. This is particularly crucial in rural areas and in underdeveloped communities. One of the most popular examples in this area is the US initiative “text 4 baby.” This text service provides accurate and professional health information to women during pregnancy and after delivery.

Tuberculosis monitoring and supervision of adherence to medication treatment has been successfully implemented in Thailand, where healthcare workers are given a cell phone to call patients and remind them to take their medication. Another example is controlling the spread of HIV infections in communities where AIDS is endemic, such as in sub-Saharan African communities where nearly 1,000 babies are
infected daily with HIV through mother-child transmission.\textsuperscript{30} Due to high prevalence and limited resources, sub-Saharan Africa is a target community to deploy educational initiatives for patients. As the control of the spread of HIV is based on patient behavior modification, it is expected that campaigns tailored for specific geopolitical areas will have a significant effect in reducing the impact of the disease.

**Demonstrated Outcomes**

Demonstrated outcomes refer to clinical or field studies that show the efficacy of mHealth solutions. Several successful projects have been launched around the world and have provided positive results. Project Masiluleke in South Africa, launched in 2009,\textsuperscript{31} provides services for tuberculosis and HIV patients. The solution, comprised of text messaging and planned virtual call centers, delivers approximately 1 million messages every day, 365 days a year. This initiative has already proved to increase to 350 percent the number of phone calls to the system’s hotlines.\textsuperscript{1}

In Uganda, a program from AED SATELLIFE uses wireless enabled surveillance technology, which has been reported to reduce costs and improve outcomes resulting in faster and more accurate diagnoses in common diseases and more complicated cases, which would normally be referred to higher level medical facilities.\textsuperscript{32} Alerta DISAMAR, launched by the Peruvian Navy with support of the US Navy, has shown great value in reporting a wide variety of medical conditions of public health interest.\textsuperscript{1} FrontlineSMS is a multinational initiative offering “bulk” texting for healthcare solutions with NGOs in mind. FrontlineSMS has successfully deployed several remote campaigns in Africa and Latin America.\textsuperscript{1,33}

The wireless Affectiva Q Sensor is a device that evaluates the level of stress of an individual based on electrodermal changes. The sensor is currently being tested for efficacy to treat post-traumatic stress disorders. Initial clinical studies funded by the US Department of Veterans Affairs have shown positive results for wireless stress detection combined with breathing therapy.\textsuperscript{34}

**Patient Awareness**

To date, healthcare providers have primarily controlled the interpretation of medical data. However, increasing focus on self-management of health, including preventative measures, is changing this trend. Solutions that impact a consumer’s quality of life are playing an important role in creating consumer health awareness, leading to better informed patients. In these solutions, the consumer self-monitors a particular condition and modifies behavioral patterns to obtain a desired result.

An example of a consumer health solution is wireless activity monitors, which in combination with calorie intake monitors and/or weight monitors, can facilitate weight loss in a sustainable manner by helping the subject to change lifestyle. (See Chapter 4.) As consumers become better informed about their health, motivated to self-manage and interested in preventative measures, they will naturally begin to seek mHealth solutions whenever possible.
CONCLUSION

Ubiquitous connectivity and computing have together brought about increasing mobility, allowing engagement in many activities—such as work, entertainment, shopping, socializing, gaming, etc.—anytime, anywhere. This trend promises to infiltrate healthcare and bring about improvements in quality, convenience, reach and cost of care. mHealth solutions are based on the convergence of four pervasive technologies—unobtrusive sensing, wireless communication, ubiquitous computing and social networking. They can be used for diagnosis, therapy and monitoring of health conditions by tracking relevant biomarkers, managing treatment regiments and monitoring progress—while the patient goes about his/her daily life. Deployments of mHealth solutions to manage chronic disease patients and facilitate preventative care hold tremendous promise in reducing cost, while improving quality of care.

Of the opportunities that compel the adoption of mHealth solutions in the developed world, cost is perhaps the most important. The reason is that quality of care is already quite acceptable, convenience is viewed as a “nice to have” and reach is not often a pressing need. However, the growing cost of healthcare is not sustainable and must be addressed. In the developing countries on the other hand, reach is a critical factor in providing care, while cost is also important due to resource limitations.

Because of its significant potential, the emergence of mHealth as a staple of care delivery is almost a certainty. More difficult to forecast is its rate of adoption, which will depend on technology availability, acquisition and ownership cost, regulatory efficiency, reimbursement policy, clinical and health education, demonstrated outcomes and patient awareness. Of these challenges, regulatory efficiency, reimbursement policy and demonstrated outcomes are likely the three most important factors.

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Case Study 2A

USING TABLET COMPUTERS TO IMPROVE CLINICAL WORKFLOW AND INFORMATION SECURITY

By Terrell W. Herzig, MSHI, CISSP

INTRODUCTION

The University of Alabama at Birmingham (UAB) is home to a world-class medical center that has been serving the state for more than 50 years. UAB, widely known for top-notch medical education and innovative research activities conducted by faculty members, continues to garner significant research funding from the National Institutes of Health (NIH). With grants totaling over $22 million, UAB ranks 19th in NIH funding among all institutions of higher education, and 11th among public institutions. Nine UAB hospital medical specialties are among the nation’s top 50 in the 16 categories evaluated in 2010 by US News & World Report, and three others are classified as high performing.

GOALS AND OBJECTIVES

With more than 7,800 UAB users averaging 471,000 logins a month, UAB clinicians are constantly looking for tools and resources to improve workflow and provide more efficient access to medical information. With the increasing availability of portable devices, particularly tablets, they were eager to explore the possibility of using these devices within the clinical environment.

Many issues had to be considered. The device’s form factor had to be functional, but retain portability. Battery life needed to extend for entire shifts or long sessions in the operating room. Devices had to be capable of being sanitized and, in some cases, sterilized. Tactile interfaces had to be sensitive enough to work under a fluid shield or with a gloved hand. Would the current wireless infrastructure be sufficient to support adequate roaming capabilities? Could the devices be used within the care environment while preserving privacy and information security? Who would pay for and support the devices?

PILOT PROJECT DESIGN AND TESTING

The original request to perform a pilot study on tablet devices in a clinical setting was made by physicians and nurses in the surgical intensive care unit (SICU). Several SICU clinical staff served on the health system’s clinical informatics teams and were familiar with the clinical workflows because of their participation in the design and build of the EMR system. Other team members included representatives from nursing informatics, anesthesia informatics, server support,
desktop, network and information security. The teams were small, but represented both the clinical and technical support viewpoints.

After determining the workflows to be tested, a checklist was assembled detailing the areas to which the devices would require connectivity; the applications that the devices would need to access; the clinical staff needing access and how the devices would be deployed; those who would purchase and maintain the devices; the evaluation criteria; and the instruments required to determine efficacy of the pilot. Since information security had recently completed an enterprise-wide mobile device risk assessment as part of its routine risk evaluation process, this assessment was used by the technical teams to refine the infrastructure needs for the pilot study.

Once functionality determinations were completed, device selection criteria were created to decide which devices could fulfill the needs of the pilot. These criteria focused on organizational needs and data management rather than selecting devices based on their popularity. For this pilot, the Apple iPad was chosen.

**CHALLENGES**

The next step was to address the challenges in meeting the goal of ensuring the processes created or modified would be repeatable, consistent and well documented. The first challenge involved issues related to device ownership. Two models were developed. One, which involved the organization purchasing the devices, would afford organizational control over the device, resulting in tighter deployment, configuration control and technical security settings. In addition, the help desk could be adequately trained to provide support for a limited number of devices. While this model initially sounds attractive to an organization, it comes with a set of problems. Mobile devices are not cheap and the technology changes rapidly. New devices come to market annually, while existing models disappear. As the number of devices within an organization increases, so do the costs of purchasing, supporting, inventorining, tracking and replacing the devices. Many organizations that struggle to cope with changes in the desktop environment could crumble under the rapidly changing support models for mobile devices. Finally, the organization may still find users purchasing and using their own devices if they are indifferent to the organization’s device choice(s).

The second model examined the personal purchase and ownership of the devices. Organizations commonly receive requests from users to utilize their personal devices for both work and private needs. At first glance, the personal ownership model appears to afford lower costs to the organization for initial purchase, technical support and reduced inventory costs. However, this model may raise issues regarding security, device configuration and device policy (especially with regard to the use of sensitive data). To further confound the ownership model, during planning discussions additional issues were identified that required answers at the corporate level. Aside from limitations in configuration control and the obvious security implications, what are the legal ramifications if an incident
occurred which required confiscating a personally owned device? Would users report possible breaches that involved their personal devices?

While it first appears that an organization would benefit from a reduced burden for technical support and the inventory of personally owned devices, closer examination reveals conflicting facts. Regardless of who owns a mobile device, users are not likely to know if a technical problem is the result of an infrastructure component or the device itself. The result is a triage call to the organization’s help desk. Regarding inventory, the organization remains responsible for knowing what devices exist and how they are used within their environment. Lastly, when individuals invest substantial personal funds to purchase a device, they are less likely to upgrade and purchase additional devices even though they know the devices have short lifecycles. Then the organization faces legacy mobile application issues similar to those experienced with legacy desktop and mainframe environments.

The health system architecture underwent a major upgrade prior to its EMR rollout in 2008. With the substantial investment in equipment to support clinical systems and the drain on datacenter resources, the health system made the choice to adopt virtual technologies. Much was gained by this transition. The creation of virtual servers facilitated a reduction in physical equipment while increasing disaster recovery and co-location capabilities. The workflow evaluations conducted during the EMR planning stages provided insights on how clinicians would need to interface with the electronic systems. The result was another deployment that provided substantial support for mobile devices years down the road.

This was technically feasible due to the investment in a Citrix Secure Gateway system and creation of a virtual desktop for each clinician. Any mobile device having a Citrix receiver mobile application could be interfaced to the virtual desktop or the Citrix Secure Gateway, allowing access to the clinical environment while keeping data in the datacenter. Thus, a robust wireless infrastructure was created to allow extensive access point deployment, multiple virtual local area networks (VLAN) per access point, and a robust wireless intrusion detection system. This infrastructure made configuration of the mobile device to the wireless environment both secure and manageable.

RESULTS

The initial pilot study, conducted over a six-month period, involved the organization purchasing tablet devices for participating clinicians. Although a baseline allowing either personally or organizationally owned devices was created, it was important to control the study’s environment to gain repeatable results. Evaluation and analysis of the study’s effectiveness were determined by focused interviews with clinicians and technical staff.

The pilot project focused on two key applications. The first was clinical access to the EMR. The tablet computers provided reliable access to the patient record. However 18 percent of the group found the device to be inefficient for keying data. Like most EMR systems, a mobile application to the system did not exist. (Readers familiar with EMR systems will note the sheer volume of data on
EMR screens.) Two physicians who reported being uncomfortable with zooming to view and enter information in the clinical applications dropped out of the pilot study. The UAB Medicine application development team added functionality to the Cerner I-View to help alleviate difficulties with viewing this part of the EMR. The revision particularly benefitted the clinical staff in Anesthesia and the ICUs.

The second application targeted by the pilot was the anesthesia clinical system, which is a web-based environment providing access to dashboard data, on call staff, operating room schedules, paging and clinical patient record data. Because of the web design, the site was easier to use and met with a 92-percent approval rate.

An unplanned success story evolved around improvements to billing workflows. Before the clinical staff had full-time access to the tablet device, billing workflows were measured in days and were based around numerous paper logs and forms, which required multiple interactions with staff. Being able to electronically record key data provided faster distributions and approvals, narrowing the billing work from days to hours.

Support and training were managed through the Anesthesia Department and received high ratings for contributing to the pilot study’s success. Anesthesia Informatics representatives already worked closely with the clinicians in the pilot and provided a pre-existing level of comfort.

The pilot project has been deemed a success by all parties involved and has generated numerous requests for enterprise-wide deployment. Once UAB finalizes the issue of ownership, the pilot is expected to be deployed into operations.