Center for Technology and Aging

mHealth Technologies: Applications to Benefit Older Adults

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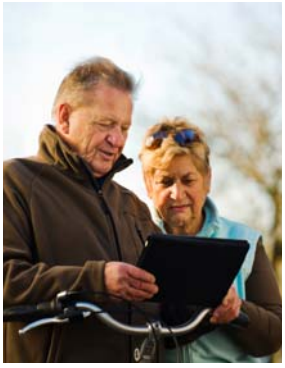

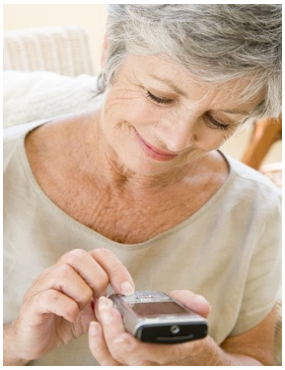

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Executive Summary

Mobile technologies are becoming ubiquitous in the U.S. and the world, changing the way we communicate, conduct commerce, and provide care and services. Certainly some of the most compelling benefits of mobile technologies are in the areas of disease prevention, chronic disease management and improving healthcare delivery. For all the advances that are occurring in mobile health, or mHealth, its full potential for one very large group of beneficiaries – older adults and the persons who support them - is only starting to emerge.

It is projected that by the year 2014 public and private healthcare providers could save between $1.96 billion and $5.83 billion in healthcare costs worldwide by utilizing mHealth technologies for health monitoring.[1] The Juniper Report further indicates that most of these cost savings could be generated by the U.S. and Canadian markets due to those countries' high healthcare costs, complex healthcare system structures, and potential for deployment of more advanced remote monitoring technologies.

To advance the use of mHealth technologies as a means of improving the health and well-being of older adults while reducing the cost of their care, the Center for Technology and Aging has initiated the mHealth Diffusion Grants Program. This paper identifies issues and opportunities related to technology-enabled mobile applications pertinent to this grant initiative, the focus of which is improving the health and independence of older adults in home, community-based settings, and in long-term care/senior residential settings. These mHealth technologies are used by patients, caregivers, and clinicians to improve self-management of care and enhance communication and information transfer between and among patients and clinicians.

This paper includes an overview of mHealth and mobile technologies that are beneficial to older adults, along with representative samples. The paper further discusses five healthcare areas that are particularly relevant to mHealth applications: 1) chronic disease management, 2) medication adherence, 3) safety monitoring, 4) access to health information, and 5) wellness. The table below presents an overview of the relevant mHealth technology applications described in this report; these should be viewed as a limited sample and not an exhaustive list, nor as an endorsement of the representative technologies.

Figure 1: mHealth Technologies
Potential Technology Applications, Examples and Outcomes

Technology Applications	Example Technologies	Potential Outcomes
▪ Chronic disease management ▪ Medication adherence ▪ Location and safety tracking ▪ Access to personal health information ▪ Communications between and among clinicians, patients, and informal caregivers ▪ Wellness	▪ Chronic disease remote patient monitors with mobile alert systems, dashboard access via internet ▪ Medication reminders and safety alerts via text, email, or smartphone application ▪ Safety and location tracking systems ▪ Personal health records ▪ Web-based social networking ▪ Nutrition, activity, and quality of life web-based monitoring systems	▪ Reduced hospitalizations ▪ Increased patient satisfaction ▪ Reduced costs ▪ Aging in place and nursing home diversion ▪ Increased self-management ▪ Improved health and wellness ▪ Increased quality of life ▪ Decreased caregiver burden ▪ Increased communication and coordination between patients, clinicians, and caregivers

Introduction

The Center for Technology and Aging is devoted to helping California and the nation more rapidly implement technologies that help older adults lead healthier lives and maintain their independence. This paper focuses on how mHealth technologies can help older adults maintain their independence, delay their transition to higher levels of healthcare, improve access to care, and foster patient-centered care that is available anywhere and at anytime. As today's older adults are more mobile than their predecessors, mobile devices are becoming an increasingly essential tool for an active population.

In February 2011, the Center launched its mHealth Initiative, which includes the Center's mHealth Diffusion Grants Program. For the purposes of the Center for Technology and Aging's Diffusion Grants Program, mHealth is broadly defined as the delivery of health-related services to patients, clinicians, and caregivers through mobile technology platforms on cellular or wireless networks. Mobile technologies can include, but are not limited to, tablets, cell phones (hardware and software), smartphones, mobile-enabled diagnostic devices, or devices with mobile alert systems.

This paper identifies and describes issues and opportunities for the mHealth Diffusion Grants Program and the broader application of mHealth to support and enhance the lives of older adults. For ease of description and categorization, this paper presents key mHealth interventions and their technologies in five overarching areas, including: 1) chronic disease management, 2) medication adherence, 3) safety monitoring, 4) access to health information, and 5) wellness.

The views presented in this position paper should be considered a starting point for discussion, and serve as a foundation for collaborative learning on the part of stakeholders who bring their extensive knowledge, experience, and innovative ideas to the diffusion of mHealth.

Overview of mHealth

The rapid expansion of mobile information and communications technologies (ICT) within health service delivery and public health systems has created a range of new opportunities to deliver new forms of interactive health services to patients, clinicians, and caregivers alike.[2] In this paper we are referring to, mobile health or mHealth, as the segment of healthcare delivery broadly defined as health-related services to patients, clinicians, and caregivers through mobile technology platforms on cellular or wireless networks. Mobile technologies can include, but are not limited to, tablets, cell phones (hardware and software) and smartphones, mobile-enabled diagnostic and monitoring devices, or devices with mobile alert systems.

mHealth changes the traditional delivery of healthcare, allowing for continuous, pervasive healthcare anytime, anywhere. With mHealth, providers, caregivers and patients have the opportunity to continuously monitor health conditions and access health information outside of the physician's office, and outside of the patient's home. mHealth interventions expand access to health information and services that promote personal wellness, preventive care, and chronic disease management, promoting efficiencies in care-management practices, and improving individual and population health outcomes. The scope and scale of mHealth interventions range from simple direct-to-individual consumer and interactive patient-provider communications to more complex computer-based systems facilitating coordinated patient care and management.[3]

The mHealth market is defined in numerous ways by different analysts. However, by any definition, the mHealth market has expanded several fold in the last few years alone, and is expected to continue to grow at a prodigious rate. According to one analysis, the market size of mHealth is projected to reach $4.6 billion by 2014 and grow to over $12 billion by 2020 (CSMG).[4] Viewed through another lens the market is expected to range from $7.7 billion to $43 billion annually (PWC).[4] A recent report in February 2011 found that revenue from just one portion of the field - digital health technology and services (including mobile devices for chronic disease management, wellness and fitness programs) - was $1.7 billion in 2010 and is projected to exceed $5.7 billion in 2015.[5]

Key Mobile Technologies, Prevalence, and Interest in Use

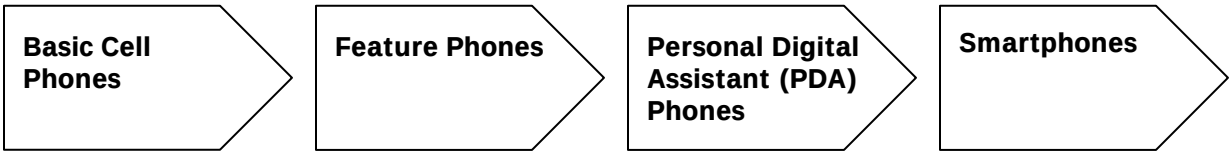
Many types of mobile technologies can be utilized for mHealth interventions, ranging from cell phones to smartphones (hardware and software), laptops to tablets, and mobile-enabled diagnostic and monitoring devices to devices with mobile alert systems. Devices vary widely in capabilities, price, and strength of evidence that they may improve patient outcomes, workflow efficiencies, and access to health information. The following sections provide a general overview of key mobile technologies.

Cell Phones

Mobile phone handsets are the most popular mobile device in use. In the U.S., mobile phone penetration is close to 90% of the population.[6] Among older adults, 78% of adults aged between 50 – 64 years and 82% of those between 65 and 74 years of age have a cell phone.[7] Cell phones vary in their capabilities across a continuum of functionality from basic cell phones to smartphones. Moving from left to right in figure 2, each phone within the continuum builds off of the functions of the previous phone.

Figure 2: Cell Phone Functionality Continuum*

Cell phones to Smartphones: spectrum of phone functionality[8]



Basic Cell Phones	Feature Phones	Personal Digital Assistant (PDA) Phones	Smartphones
Functionality: • Voice communications • Short Message Service (SMS) texting	**Functionality:** • Basic Cell Phone capabilities • Camera, mp3 player, low-resolution video, downloadable games	**Functionality:** • Feature Phone capabilities • Web-browsing • Organizing functions like calendar • Runs on proprietary operating system	**Functionality:** • PDA capabilities • Runs on cross platform operating system (e.g. Apple IOS, BlackBerry OS, Windows Mobile, Android, etc.) • Downloadable apps • Video conferencing • GPS functionality

***Adapted from the California Healthcare Foundation's Report: How Smartphones are Changing Healthcare for Consumers and Providers. April 2010*

mHealth interventions can work on multiple types of cell phones or may also target a certain type of phone. The majority of global mHealth interventions have been developed for use with basic cell phone devices that tend to be voice-centric with data-enabled capabilities such as short message service (SMS) or text messages. Popular health-related functions of SMS include health behavior reminders, prompts to schedule or confirm an appointment, notifications of a laboratory result or health status report, requests for data, encouragements or motivations to sustain a positive behavior, and educational and information resources to improve self-efficacy.

Compared to basic and feature cell phones, PDA phones and smartphones offer more advanced multimedia functions, such as video, web browsing, and health-related software applications. Ownership of smartphones with advanced data-enabled communication capabilities beyond

voice- and SMS-based interventions, such as accessing the Internet or providing location-based services, is growing in the general U.S. population,[8] but ownership among adults over the age of 50 is more limited (7% as of 2010[7]).

Smartphones are also capable of running third party applications or "apps". Apps generally refer to software applications that run on mobile operating systems for smart phones and tablets, as well as computers and laptops, such as Google Android and Apple IOS. Apps can be free or purchased from online stores and downloaded to these devices or purchased and downloaded directly from the device. In late January 2011, Apple's App store had sold over 10 billion apps.[9] As of February, 2010 there were over 5,805 health, medical and fitness applications in Apple's App Store.[8]

Figure 3: Cell Phone Technology Ownership 2010

	Cell Phone (%)	Smart Phone (%)
Total Adults 50+	79	7
50-64 years old	78	9
65 - 74 years old	82	3
75+	78	2

Source: Health and Caregiving among the 50+: Ownership, Use and Interest in Mobile Technology, AARP, January 2011.

There is significant variation in the characteristics of older adult cell phone owners. For example, among caregivers over the age of 50 who assist another person over 50 years of age, nine out of ten have use of a cell phone. But the use of mobile technology to track the health of care recipients is low in comparison. For example, only 17% of caregivers assisting people over 50 years old with activities of daily living (ADLs) or with instrumental activities of daily living (IADLs) use mobile technology of any kind in that task.[7] However, when looking at what technologies are preferred by those caregivers who are supporting persons with limitations in ADLs or IADLs, nearly 9 out 10 of those caregivers use cell phones (89%) whereas only 34% of them use a laptop or tablet computer to accomplish this task.[7]

There are also differences in how mHealth is used to assist persons with personal care needs. Only 3% of caregivers use mHealth to track whether the person they assist needs help, and 1% use mHealth to inform them if the person experiences a change in their usual routine. Thus, the potential for use of mobile technology in supporting caregiving responsibilities is very high. For example, 39% and 36% of caregivers, respectively, report that they would like to use mobile technology more effectively to support the person they are caring for. Similarly, just 3% of

caregivers use mobile technologies to track health indicators, versus 37% who would like to have this supportive tool. [7]

Laptops and Tablet Computers

The release of Apple's first iPad in 2009 sparked a surge in the use of tablets within the healthcare field, specifically for clinician use. Additional tablet competitors to the iPad were released in 2010 and 2011. The International Consumer Electronic Show, showcasing consumer electronics to industry and industry affiliates, had organizers declare 2011 to be the year of the tablet, as the Motorola tablet, Xoom, claimed the best in show device of the year.

Because tablets are portable and have advanced data access and display capabilities, use among clinicians is increasing. Key benefits of tablets identified by clinicians include improved access to EHRs and real-time patient information, and improved ability to provide patient health education information during medical appointments. Key benefits of tablets identified among older adults include use of a touch screen (especially for those with arthritis or other disabling conditions so that they can fully interact with the device as opposed to computers with keyboards) and the light weight and portability of the device.

An unanticipated market issue for laptops was just how rapidly they would be adopted by older adults. Laptop or tablet computer ownership among adults over the age of 50 reached 42% in early 2010. [7] The adoption of laptops by older adults is not just limited to younger older adults or their caregivers – a third of by persons over the age of 75 said they owned a laptop or tablet in 2010.[7]

Figure 4: Laptop/Tablet Computer Ownership 2010

	Age			
	Total Adults 50+ (%)	**50-64 (%)**	**65-74 (%)**	**75+ (%)**
Own Laptop/Tablet Computer	42	45	42	33

Source: Health and Caregiving among the 50+: Ownership, Use and Interest in Mobile Technology, AARP, January 2011.

Tablets, like Apple's iPad, have "apps" specifically dedicated for use with this device. When looking at iPad specific apps alone, there are more than 1,000 healthcare apps.

Among the advantages claimed for laptops and tablets over other forms of mHealth are the larger screen size and ease of interaction for older adult users. Video conferencing communications are beginning to emerge and are built in to these mobile technologies, allowing for improved communications between patients, caregivers, and providers.

Mobile-enabled Diagnostic and Monitoring Devices

Many diagnostic devices and monitoring devices are mobile-enabled, meaning they communicate with mobile devices or have mobile capabilities themselves. These peripheral devices can include sensors, accelerometers, remote patient monitoring technologies, and environmental monitoring technologies. Among other devices, mobile-enabled diagnostic and monitoring devices have more recently been incorporated as part of current mobile devices (e.g., cell phones) or been given the capacity to communicate with mobile devices. mHealth devices and technologies with mobile components may aggregate multiple forms of patient health data or may provide a platform to access this data. These devices may also utilize mobile technologies to be the recipients of alert notifications based on patient health information or treatment needs. As health data and programs continue to move toward cloud based systems, these mobile devices will become even more capable, convenient ways to view, access, and enter health diagnostic and monitoring information, promoting anytime, anyway healthcare.

Access to Internet

Access to the Internet using a wireless device, such as a laptop computer or cell phone, results in a greater likelihood of using the Internet to collect and share information and create content. Wireless communication to the Internet also increases the ability of older adults to be more engaged in health-related social media, such as posting comments and reviews online about health and healthcare. In 2010, 57% of American adults had a wireless connection and used a laptop or mobile phone device to access the Internet.[10] Of these, 78% looked online for health information compared with 70% of Internet users with desktop access and 59% of all American adults. But despite interest in health and the increased availability and use of mobile and online media, personal networks and healthcare professionals remain the preferred method for most adults to search for and access health information.[10]

Figure 5: Accessing the Internet

	Wireless Online (%)	Non-Wireless Online (%)
Total Adults	57	20
18-29 years old	83	11
30-49 years old	70	15
50-64 years old	42	32
65+	19	24

Source: Pew Research Center's Internet and American Life Project

Of all mobile technology options, cell phones are the mobile device of choice among people over 50. Even if mobile technology is not currently being used, a large number of people indicate an interest in wanting to do so, particularly using cell phones, for health management. Currently, 11% of people over the age of 50 use mobile technology to track health measures over time such as weight, blood glucose levels, and blood pressure, but only 4% do so to share information with a health professional. And while the actual rates for older adults to have health-related applications may lag compared to other age cohorts, the interest of older adults and their caregivers in tracking health measures is far greater in certain instances. For example, 42% of older adults are somewhat or very interested in tracking measures and 39% are interested in sharing information with a health professional.[7] If an analogy is made comparing health-related application adoption to the adoption of social networking a few years ago,[11] one could certainly project that health-related application adoption could dramatically increase in the next five years. Specifically, the Pew Study indicated that in 2005, 7% of 50- to 64-years-old and 5% of people 65-years-old and older utilized social networking. However, by 2010 individuals in the 50-to 64-years-old group had experienced a dramatic increase in utilization of social networking to 42%.[12]

Evidence Base

Although the potential benefits of mHealth are well recognized, the mHealth field is still in the formative stage of developing a rigorous evidence base of studies that demonstrate outcomes and effectiveness, much less determining what elements of mHealth have the greatest potential impact on improving health and healthcare. The most successful mHealth initiatives to date have been built on one of the less technically complex and widely used applications, SMS, which has been the prime communication medium for delivery of health behavior change interventions.[13] Among chronic disease applications of SMS-based interventions, SMS-based interventions have

demonstrated positive short-term behavioral outcomes[14] but little evidence of the ability to sustain behavior change over the long term and at scale. The simplicity of SMS has been a large part of its success in health applications.

Evidence of cell phone-based interventions in health indicate that while mHealth offers great potential and demonstrates mostly positive results, the research does not yet provide significant evidence for health impacts at scale or on a sustained basis. Cell phone-based interventions that have been evaluated have primarily involved the use of SMS-based functions across a broad range of health conditions and populations. For example, mHealth applications have been reported to benefit smoking cessation,[15,16] HIV/AIDS treatment adherence,[17] and diabetes disease management.[18,19] For the most part, mHealth interventions using SMS recognize the ability to change patient behaviors in the short-term. For example, a recent review article suggests that SMS text message-delivered interventions have positive short-term behavioral outcomes,[14] and behavior change using SMS applications in disease management and prevention was found across different ages, ethnicities, and nationalities.[20] It should be noted that, in general, cell-phone interventions have been evaluated only as standalone deployments and not as elements that have been integrated with larger, more comprehensive systems in a single deployment.

Opportunity Areas for mHealth

A large percentage of older adults are challenged by chronic illnesses, improper medication use, falls and injuries, frailty, and limited access to their personal health information – all of which can contribute to a reduced quality of life. Chronic disease management, medication management, safety monitoring, and improving access to personal health information all provide significant opportunities for the application of mHealth technologies for the older adult population. mHealth technologies can help slow progression of chronic disease and ensure continued recovery after being discharged from an acute care setting; assist with medication adherence by providing medication reminders and alerting caregivers to missed medications; alert caregivers and prompt intervention when a vulnerable older adult is injured or in harm's way; provide patient and caregiver access to personal health information, and deploying or communicating wellness and preventive care protocols. mHealth offers a broad array of methods to improve the quality of life of older adults.

It has been projected that by the year 2014 public and private healthcare providers may save between $1.96 billion and $5.83 billion in healthcare costs by utilizing mHealth technologies for health monitoring worldwide.[1] The report by Juniper Research indicates that the U.S. and Canadian markets have the potential to generate the most cost savings, because of the high healthcare costs, system structures, and more advanced remote monitoring rollouts in these countries.

Each of these opportunity areas for mHealth to benefit older adults will be described, along with several respective example technologies. Note that these opportunities and example technologies should serve as a starting point for consideration, and are not meant to represent all mHealth possibilities and technologies.

Opportunities for mHealth: Chronic Disease Management

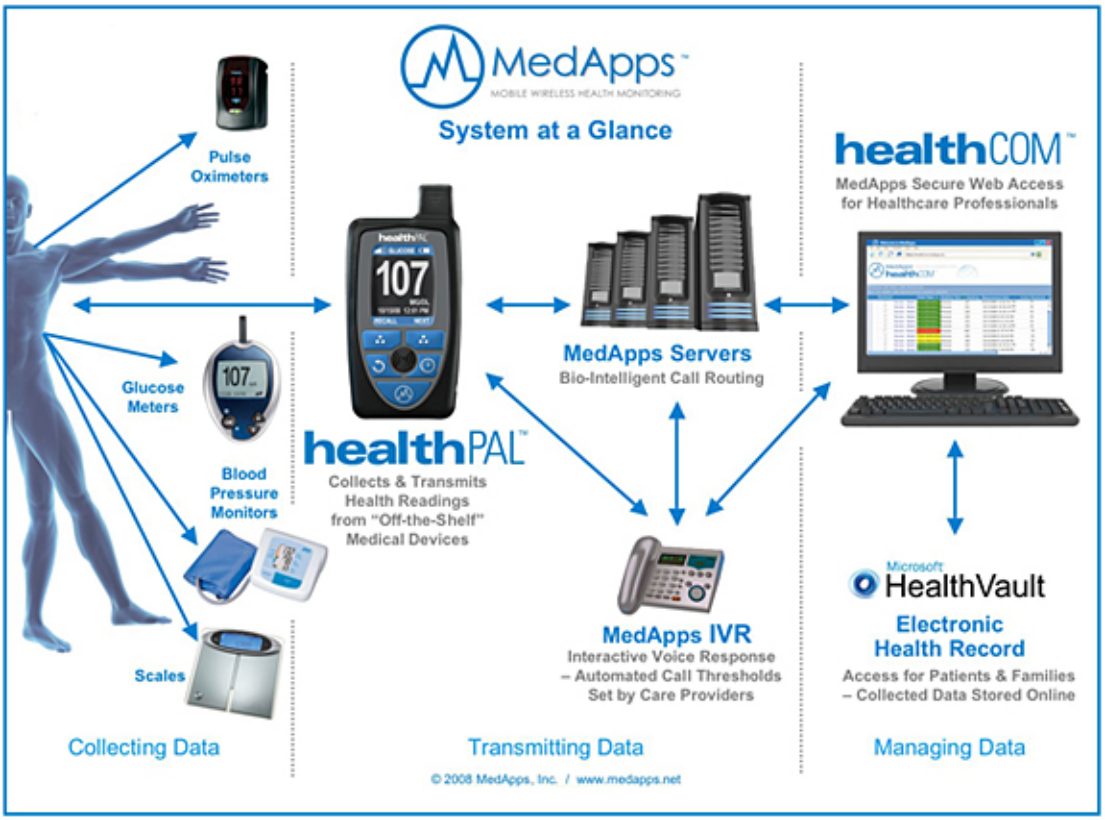
Chronic diseases exert significant human and economic costs on the health-care system, and this chronic disease burden will only grow over time. Today, nearly half of all Americans have at least one chronic condition, while a quarter have multiple chronic conditions. The prevalence of multiple chronic conditions is particularly high among older adults, with over 80% of people over the age of 65 having more than one condition, and 50% two or more.[21] The multiple conditions per individual create more complicated care management needs due to poor outcomes in the form of unnecessary hospitalizations, adverse drug events, duplicative tests, conflicting medical advice, and poor functional status. The capacity of the current healthcare system to effectively manage this growth in chronic diseases is becoming seriously challenged, particularly by critical service infrastructure constraints including a growing shortage of qualified professional caregivers. The deployment of mobile technology is one means to cost-effectively expand capacity and provide appropriate care management.

Chronic Disease Management mHealth Technologies

Through the convergence of wireless technology, the Internet, and mobile devices, mobile health offers a range of technology-enabled innovations that can support patient engagement in their personal health; it can also support chronic disease management through facilitating self-management capabilities, including medication adherence, health education, and health information access. (Detailed information on medication adherence and health information access mHealth technologies will be addressed in subsequent sections.) Available technologies provide a range of messaging, monitoring, and interactive communications functions to support interactive care processes, reduce unnecessary resource utilization, and improve care outcomes. Examples of the range and capabilities of mobile health applications include the following:

- Wireless mobile handheld device. HealthPAL (MedApps) – This application demonstrates how a wireless mobile handheld device, HealthPAL, can automatically collect data from peripheral monitoring devices in the home. HealthPAL is FDA-approved for use with blood pressure monitors, weight scales and pulse oximeters. Data are communicated to an electronic health record or the user's HealthVault account. As a result, care providers can review patient data through an enterprise-level electronic health record or a web-based patient management portal for care professionals, HealthCOM. Patients have the opportunity to be actively engaged in their own healthcare while remaining effectively connected to their clinicians by sharing information for monitoring and review. Clinicians can access data using a web-based patient management portal for care professionals.

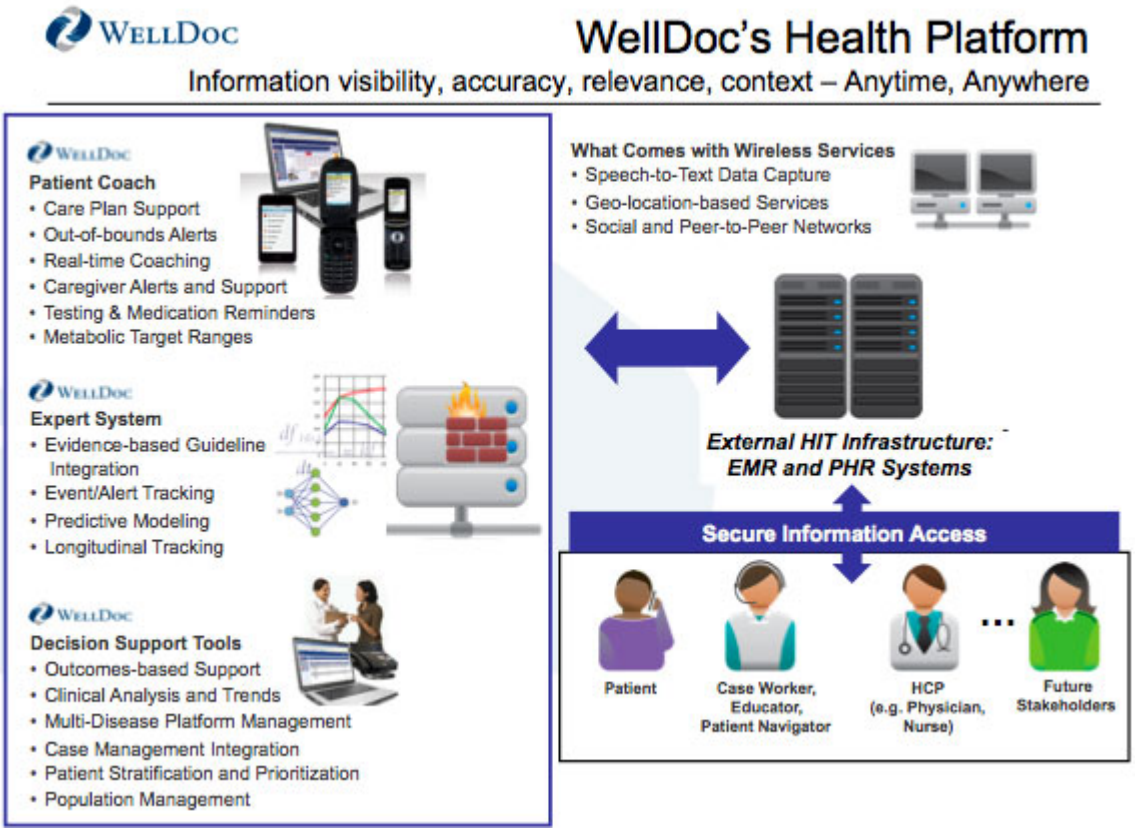
Figure 6: MedApps: HealthPAL



- In-home health monitoring system. The Ideal Life Hub (IDEAL Life) uses an in-home health monitoring system comprised of a communications hub that connects with Ideal Life peripheral monitoring devices for health management applications in congestive heart failure, hypertension, asthma, and chronic obstructive pulmonary disease. The system's FDA-approved monitoring devices are designed for individuals with chronic conditions such as congestive heart failure, hypertension, and diabetes. The system integrates with many different channels of communication, including cell phones, telephone lines, and the Internet. The company recently announced a trial involving over 100,000 people in China involving its products and service, and a collaboration with Sprint to develop, certify, and co-market a version of the IDEAL LIFE hub to transmit health data over the Nationwide Sprint Network.
- Mobile health solution for diabetes management. The DiabetesManager (WellDoc) is a mobile health solution for the management of diabetes. It provides a system to engage patients in their disease management and support improved patient outcomes through expert system and clinical decision support capabilities. The company, which is among the first mobile health solutions to receive FDA 510(k) clearance, highlights the potential

for the integration of multiple technologies in disease management through its integration of SMS with a cell phone-based diabetes management software system that interfaces with web-based data analytics and therapy optimization tools (Quinn, 2008). Evidence of outcomes reported statistically significant improvements in the reduction of HbA1c levels in patients with type 2 diabetes.[22] WellDoc is in a strategic alliance with AT&T to market and sell its DiabetesManager service to payers and providers.

Figure 7: WellDoc



- Mobile health solution for congestive heart failure. This AVIVO Mobile Patient Management System (Corventis) is designed for use in the proactive management of congestive heart failure patients, by integrating sensors with advanced computational algorithms, wireless capabilities, and a web-based infrastructure to enable early detection, prevention, and treatment of cardiovascular disease. The smart patch-like device, which adheres to a patient's chest, is capable of monitoring heart and respiration rates, levels of patient activity using an accelerometer, and the accumulation of body fluid through an indirect electrical measurement using an impedance detector. The device was approved by the FDA for use by clinicians in February 2009.

Figure 8: AVIVO Mobile Patient Management System

Opportunities for mHealth: Medication Adherence

Even though it is a large component of chronic disease management, medication adherence is broken out as a separate opportunity area from chronic disease management, because of the vast number of dedicated programs and technologies to address this issue. To this extent, the Center has viewed this as an important area so much so as to create a Medication Optimization Diffusion Grants Program that addresses medication adherence as well as medication monitoring and medication compliance.

The World Health Organization defines adherence as "the degree to which the person's behavior corresponds with the agreed recommendations from a healthcare provider."[23] Poor medication adherence can have negative consequences for individuals, families, and society because it significantly increases the cost and burden of illness. Medication non-adherence contributes to 33%-69% of medication-related hospital admissions and 23% of all nursing home admissions.[24] Moreover, the New England Healthcare Institute estimates that $290 billion of healthcare expenditures could be avoided each year if medication adherence were improved.[25]

Adherence is influenced by prior experiences, cultural factors, personal beliefs, treatment side effects, patient-provider relationships, and financial constraints. Physical, cognitive, and sensory health challenges also make adherence difficult. Mobility difficulties, forgetfulness, and diminished sight and hearing are deterrents to acquiring medications, understanding instructions, remembering to take medications on time, and reading and hearing medication-taking instructions. Because medication adherence is considered an instrumental activity of daily living, the ability to manage medications successfully is an important factor in maintaining independence among older adults and persons with disabilities.

Because adherence is dependent on many factors, a multi-pronged approach to improving medication adherence is usually most effective. Interventions include:

- Simplifying the patient's medication regimen.
- Identifying if the medication has untoward effects.
- Improving patient self-efficacy and activation.
- Providing cues or reminders to take medications as prescribed.

Medication Adherence mHealth Technologies

The number of mHealth interventions for medication adherence has been rapidly expanding in both variety and sophistication. These mHealth technologies can assist patients and caregivers with obtaining proper medication information, patient education, medication organization, dispensing, dose reminders, and notification when doses are missed.

mHealth medication adherence technologies can potentially provide one or more functions to an individual patient under a "medication administration continuum," including:[26]

- *Fill*: provides patient with information and/or instructions about the drug
- *Remind*: reminds patients to take medications – audibly, visually, or both
- *Dispense* (e.g., in the home): automatically dispenses medications, usually at certain times/intervals
- *Adjust*: adjusts medication regimen automatically if needed
- *Report*: logs date and time when medication is taken or not taken and notifies clinician/caregiver
- *Ingest*: detects whether or not a patient has ingested his/her medications
- *Metabolize*: detects whether or not a patient has metabolized his/her medication

The primary functions that mHealth Technologies can provide from the medication administration continuum are *fill*, *remind*, *dispense*, and *report*. mHealth technology interventions for these functions can include, SMS medication reminders; SMS, email, and phone calls to caregivers/clinicians when a dose is missed or to report that the dose has been taken (which can be part of a mobile-enabled diagnostic and/or monitoring device); mobile pill dispensers as standalone devices or as a connector to cell phones; and a smartphone app providing medication instructions and/or information about the drug; among others. The remaining functions from the medication administration continuum, *ingest*, *metabolize*, or *adjust*, are still largely in development and will not be addressed in this paper. Please see the Center's position paper on Technologies for Optimizing Medication Use in Older Adults for additional information on these technologies.

Pill phone medication technology. The pill phone is a cell phone software system that has *fill*, *remind*, and *report* functionality. This software was developed by Verizon in 2008 and is based off of medication information from *The Pill Book*, which has over 1,800 prescription and over-the-counter drugs listed. The software can be used on specific cell phones from Verizon, AT&T, and Sprint/Nextel, and operates on basic cell phone models or on smartphones. The FDA approved medication management software allows older adults to look up information on medications, create medication reminders, and receive reminders on the phone. General drug information can include cautions, drug interactions, side effects, and a picture of what the medication looks like. Reminders can be created around what drugs to take at what times. Older adults are able to reply to the alert saying they took the medication, skipped it, or may "snooze" the alert to receive it at a later time. Responses to these alerts are sent to an online patient record that can be accessed by patients or caregivers to track medication adherence patterns. The pill phone is now also an app, available at Apple's App Store.

Reminding and reporting mHealth program. An example of reminding/reporting functionality can be seen on Greatcall's Jitterbug cell phone. Through its proprietary apps to *remind* and *report*, the Jitterbug phone has many features appealing to older adults who are not looking for a multitude of advanced features and complex designs, but want ease of use and a simpler design and user interface. The Jitterbug has a suite of wellness and safety apps exclusive to this cell phone. The medication reminder app provided through a subscription service includes automated reminder calls, automated connection to pharmacy for refills, and an online reporting system that tracks medication use. Older adults can receive automated phone calls that remind them to take their specific medications. Automated calls can also be structured to alert older adults when they need to refill a prescription and can automatically connect them to their pharmacy. Medication adherence can be tracked for each older adult on their personal online website. This information can be viewed by the patient and shared with caregivers or their care team.

Mobile enabled diagnostic devices or monitoring devices. A number of diagnostic/monitoring devices can provide alert notifications to patients, caregivers, and/or providers if doses are missed. The notifications can be received via email, text, or a phone call. For example, The Philips Medication Dispensing System (acquired the MD-2 in 2008), organizes and dispenses up to 30 days worth of medication (depending on the dose frequency) by individualized doses into plastic cups. Patients are reminded to take their medication based on verbal and auditory cues. To safeguard against double dosing or missed doses the system will lock away the dispensed medication after 90 minutes if it has not been removed from the device. It will then alert up to four caregivers, including healthcare professionals, that a dose was missed. Alert and dispensing history are uploaded daily to a web-support system allowing caregiver and clinician review. In a study comparing the Philips Medication Dispensing Service with plastic medication boxes, use of the Philips Medication Dispensing Service was associated with reduced hospital and emergency room visits, and (where appropriate) a decrease in the number of medications taken by the patient. Automated medication dispensers seem especially beneficial for patients on warfarin therapy or those with cognitive or mental health impairments.[27]

Opportunity Area for mHealth: Safety Monitoring

To promote safety and prevent injuries among older adults, many technology developers are focusing their attention on mHealth technologies that detect and ultimately prevent falls and wandering. The incidence of falls among older adults is high, as are the associated healthcare costs. Additionally, older adults with dementia are at increased risk of both falling and wandering. In a study of 100 people with dementia, patients fell over 400 times per year[28] and estimates of wandering ranged from 6 to 100%.[29] Unsafe wandering and elopement have many negative consequences, including injury to oneself or others and even death. According to Lohr, "Falls are so harmful to the elderly and so costly to society that if falling were a disease, it would be deemed an epidemic."[30]

- Hip fractures are a major contributor to death, disability, and diminished quality of life among older adults.
- In 2004, falls were the leading cause of injury deaths among older adults and were responsible for about 14,900, or almost 43%, of all unintentional injury deaths in this age group.[31]
- Fall-related death rates rose sharply with increasing age and the greatest increase occurred after age 79.[31]
- Falls are the most common cause of nonfatal injuries and of hospital admissions for trauma among older adults. [31]
- Over 1.8 million seniors were treated in U.S. hospital emergency departments for fall injuries, and one out of four was subsequently hospitalized.[31]
- Getting help quickly after a fall reduces risk of hospitalization by 26%[30] and death by over 80%.[32]
- Those who fall are 2 to 3 times more likely to fall again.[33]

Safety Monitoring mHealth Technologies

Fall detection and location tracking technologies monitor patients in terms of their location, balance, and gait. mHealth interventions for fall and location tracking can include SMS, phone call and email alert notifications if the older adult falls or wanders outside of a designated area, mobile enabled monitoring devices can detect falls and location while transmitting information wirelessly, or fall detection and location tracking devices may be incorporated within cell phones that have GPS tracking and accelerometers. Fall detection technologies actively or passively evaluate whether a fall has taken place and alert others that an individual has fallen. Fall detection technologies include personal emergency response systems (PERS) and passive sensors. Location tracking technologies enable caregivers and others to locate older adults who are prone to wandering. Location tracking technologies employ numerous tracking techniques,

including Wi-Fi, GPS, cellular networks, and radio frequencies located in a device worn by or collocated next to the user. Tracking devices vary by tracking technique, signal activation, involvement of third parties, and level of acuity for device activation. The keys to success for these safety technologies are the patient-specific alert mechanisms and support services.[34]

Fall Detection Technologies

The primary goals of fall detection technologies are to distinguish falls from activities of daily living (ADL) and then contact authorities who can quickly assist the individual. Fall detection mHealth systems can be active, passive or a combination. Active systems, such as PERS, are devices that users must activate to obtain assistance, most commonly by pushing a button. Passive systems involve the use of sensors to continuously monitor movement, while utilizing specific algorithms and alert systems to inform caregivers and others of potential falls. Users do not need to activate passive systems as they automatically detect a fall and contact help. Motion and pressure sensors can be placed around the living facility on walls, ceilings, and floorboards, and furniture or embedded within mobile devices like cell phones, while location and position sensors, like accelerometers and gyroscopes, can be separate devices or embedded within mobile devices like cell phones, that the older adults carries themselves. Some passive systems contain a back-up active system where users can activate the device for assistance, most often by pushing a button.

Personal Emergency Response Systems (PERS). PERS are the most common form of remote monitoring device, and are central to mHealth systems. Many types of PERS require patients to activate an alarm for assistance. mHealth devices are portable (necklaces or bracelets) or are embedded within mobile devices. After activation, the device communicates with a transmitter, which relays the information to a third-party service provider at a monitoring center. Here, third parties assess the situation, contact appropriate parties for further assistance, and often initiate audio communication with the older adult through the telephone or another portable or fixed transmitter device. Users typically pay for the monitoring equipment as well as a monthly service plan for access to third-party support. Portable systems can pose a challenge to activate if an individual falls or becomes incapacitated and does not have their device on or near them. Portable PERS also require that the older adult always wear the device. Dementia or other cognitive ailments may cause the user to forget to wear or activate the device. Bulky, less attractive systems also discourage the user from wearing it, as they may find the device uncomfortable or embarrassing.

Passive fall detection technologies. A range of passive fall detection devises are based around an mHealth platform and utilize a variety of sensors, including motion and pressure sensors, accelerometers, and gyroscopes to monitor location, position, immobility, speed of motion, and

distance covered. Passive sensor technologies automatically detect falls and promptly alert the appropriate parties. Different types of sensors can be used to detect movement, including motion sensors affixed to the walls of users' homes, accelerometers and gyroscopes attached to the user or embedded in mobile devices, and pressure sensors in the floorboards underneath carpet.[35] Algorithms are utilized to set thresholds for alert notification tailored to each older adult by monitoring patterns of movement and behavior. For example, a data pattern can assist with detecting urinary tract infections through frequency of bathroom visits at night or throughout the day. Such technology also can signal that individuals may need to move to a higher acuity setting or that they should consider using mobility assistive technologies if patterns change and mobility begins to deteriorate. System dashboards integrate individual and multiple user data in an easy-to-monitor format. Dashboards can stratify alert notifications based on severity, which can be particularly valuable for assisted or independent living communities that monitor several people at once. The ability to access these dashboards via mobile devices, greatly increases healthcare workers, family and caregivers' ability to access the data anywhere.

Sensitivity and specificity of passive fall detection technologies is increasing. One study found that use of an accelerometer device can discriminate between falls and ADLs with a sensitivity of 97.5% and a specificity of 100%.[36] More recently, smartphone applications, such as Android's iFall, have emerged for fall detection. The Android phone contains a tri-axial accelerometer, which is used to monitor the user's location and position. While older adults must carry the device at all times, several variables — threshold-based algorithms; user information on height, weight, and level of activity; and unique user phone movements — are taken into account when evaluating whether a fall occurred.[37] If a potential fall occurs, iFall sends a notification to the user. If there is no response from the user, the system sends a text message to pre-specified contacts. Upon response from the contact, iFall automatically turns on the user's speakerphone and contacts medical help if needed.

Another recently developed passive fall detection technology called Wellcore, is a device that contains an accelerometer, a base station, is worn by the older adult providing coverage 24/7, and provides an online dashboard to view movement data. Smaller than an ipod, the device is worn by the older adult and can be clipped to their clothing or placed in a pocket. The device automatically uploads movement data and steps taken to an online dashboard. Movement data can be viewed by day, month, or over 90 days. Movement trends are assessed, whereby if data begins to move outside of a normal activity range, these areas are highlighted on the password-protected dashboard. If an older adult falls, the system alerts Wellcore's Emergency Call Center who then contacts the older adult by speaking through the base unit to assess the situation. If necessary, the Call Center will contact emergency services to send help to the older adult in their

home. The device also contains an emergency response button that can be pushed by the older adult if needed. Wellcore also provides fall detection services outside of the home when paired with Wellcore compatible cell phones. When the system detects a fall, emergency services are able to access the cell phone's GPS and send help to the location of the older adult. The system also alerts caregivers to the event as well.

As algorithms and sensor technologies mature in fall detection technologies, patterns may emerge that correlate to an immediate likelihood of falling. This could potentially predict when a fall will occur moments before one does and can alert caregivers or the individual themselves of the need for further assistance. Representative fall detection and prevention systems are presented in Figure 9.

Figure 9: Fall Detection and Prevention Systems

Fall Detection Systems	Active or Passive	Description	Examples
Alarm with fixed or portable receiver and transmitter	Active	Personal Emergency Response systems require older adults to activate a call button, which can either be stationary in a room or portable worn by the user. Some devices activate third party audio communication with the patient to address the situation and can contact the appropriate parties for further assistance.	Philips Lifeline, MedicalAlarm.com, MobileHelp, ActiveCare
Location and position sensors with algorithms	Passive	Sensors, like accelerometers and gyroscopes, are connected to the user and detect user's location and position in relation to the ground. Preset algorithms determine if movement is out of the scope of activities of daily living and is considered a fall. Software alerts third party or caregiver to potential fall.	Myhalo, Wellcore, Android Application iFall, Speedy, Philips Lifeline with AutoAlert, AFrame Digital
Motion Sensors and pressure sensors with algorithms	Passive	Motion sensor units are placed around the user's house or apartment on the walls or on the ground. Sensors continuously track user's motion. Preset algorithms determine whether user has fallen by analyzing immobility where users remain still in one area for longer than the allotted time. Software alerts third party or caregiver to potential fall.	WellAWARE Systems, Healthsense, BeClose, GE's QuietCare, GrandCare Systems

Location Tracking Technologies

Location tracking technologies enable providers and family caregivers to locate older adults who are prone to wandering, such as those with Alzheimer's disease and other cognitive impairments. The majority of these technologies involve the older adult carrying the location tracking device or mobile enabled tracking device, like a cell phone. These technologies vary by range and accuracy of location due to selected tracking techniques, signal activation methods, and technology support systems. Costs for location tracking technologies can include the cost of the device, plus a monthly monitoring support fee.

Currently, several location tracking devices utilize different types of tracking techniques, such as GPS, Wi-Fi (Wi-Fi Positioning Service WPS), cell towers and cellular networks, national E9-1-1 system's U-TDOA, Zigbee, Bluetooth, and Radio Frequency. Some tracking techniques work well outdoors and are less accurate indoors, while others cover a wide area or are limited in range. GPS technology location systems utilize satellites to locate individuals and can be worn directly by users or placed in cars or other modes of transportation. GPS technologies are limited in the range they are able to effectively cover, as signals are often lost or depleted in areas of high-density overgrowth, inside buildings, and in places with limited satellite coverage.

Some location tracking technologies provide an automatic stream of the user's location at various time intervals, while other devices require remote activation of the device by third parties or caregivers. The Alzheimer's Association Comfort Zone™, powered by Omnilink, provides an automatic stream of the user's location every 15 to 30 minutes. It can work with devices that use GPS, A-GPS, GSM and cellular technology to communicate location information. Family members and caregivers access information about the person's location by using the Internet or calling the monitoring center. Families can also decide on the level of monitoring needed, such as verifying location from a computer; receiving alerts when the person has traveled in or out of a zone; or seeking emergency assistance. Technologies that give providers and family caregivers the ability to continuously view the location of the older adult have the capacity to monitor mobile behavior. Location information can be available to providers and family caregivers or to third party vendors and/or the authorities. Some location tracking devices (like EmFinders and EmSeeQ) require activation through the vendor, who then provides law enforcement personnel with location information of the older adult. Other devices provide algorithms with set alerts to notify providers, neighbors, family, and friends when the older adults leaves a certain area, as with Alzheimer's Association Comfort Zone™, powered by Omnilink, SentrySilver GPS, SecuraTrac, Quest Guard, and GPS Tracking and Navigation.

Integration of multiple tracking techniques with mobile phones and other devices is becoming commonplace. Google's Latitude is a software product utilizing GPS, Wi-Fi, cell phone towers or a combination of all three, which can be used on many cell phones. Tracking can be accessed through the computer or a compatible phone by anyone given permission to see the user's location. Google location alerts can send text messages when users have moved outside of a specific area. As tracking techniques have resolution or accessibility limitations in specific areas, hardware platforms and network infrastructures that utilize multiple techniques may make attractive options for location tracking.

Opportunity Area for mHealth: Access to Health Information

The use of mobile technology to access, share, and coordinate health information has the potential to improve self-management and facilitate communication between the older adult, caregiver, and provider. Providing access to health information refers to a patient, caregiver, or provider being able to access patient-specific health information through a mobile device (often a PHR or EHR). This sharing of information may take place through a health record, social network, or in the form of sending/collecting physiological and other health data. This function also refers to providing appointment reminders to patients or caregivers, often initiated by a health provider.

Mobile technology can promote access to health information by facilitating communication between older adults, caregivers, providers as well as other older adults through the use of personal health records, online social networks as well as communication and coordination around medical appointments. Mobile technology can also be used to access more general health information through the Internet (not patient-specific), such as applications from the Mayo Clinic and Centers for Disease Control and Prevention (CDC). However, such more general uses of mobile health are outside the scope of this position paper.

Health Information mHealth Technologies

Personal Health Records Technologies

Personal Health Records (PHRs) refer to a set of technologies that help patients track their healthcare services, access important health records and manage their own health information. The patient generally controls the PHR and chooses whether to share their health information with family members, caregivers and providers. PHRs enable patients to store and share a narrative of their diagnoses and immunizations, current and past lists of medications, allergies and drug interactions, records of hospitalizations and medical procedures, and health indicators such as blood pressure. A complete summary of a patient's health information fosters self-management and coordination of care. Current applications of PHRs tend to target key functions such as: 1) storage of a patient's medical history, 2) access to vital health records, 3) support for diet changes and wellness activities, 4) assistance with chronic disease management and medication management, and 5) secure forum for patient-clinician communication.[40]

Use of PHRs have potential to reduce hospital readmissions associated with communication breakdowns between healthcare professionals, insufficient follow-up, and inadequate evaluation and continuity of care procedures.[41, 42] Deficiencies in the transitional care process significantly contribute to the high rates of readmissions.[43] Effective discharge planning engages and prepares the patient to better manage their care. Adoption of PHRs may improve post-discharge care

management if they facilitate: 1) development of a care plan to prevent future re-hospitalization, 2) identification of patients' health goals, and 3) active engagement of patients and their family caregivers in the management of their care.

Table 10: mHealth EHR and PHR Technology Examples

Technology	Description
PHRs and EHRs	
Aetna Mobile	Aetna offers its members a mobile service through any web-enabled phone that allows the user to access their PHR, view their member card, contact Aetna, find physician information, and buy health insurance, among other features.
ClearPractice Nimble	ClearPractice provides iPhone and iPad applications for users of their EMR system. The mobile applications are geared towards health providers. The mobile applications allow providers to review patient charts and information, fill or renew prescriptions, view appointments, and send messages.
Cloud PHR Pro	Cloud PHR Pro is an advanced, native iPhone client for Google Health, Google's Personal Health Record (PHR). Users can access information such as immunizations, medications, conditions, procedures, test results, and other data.
GE Healthcare Centricity	The Centricity Advance and Centricity Practice Solutions have mobile applications that are accessible on the iPhone and iPad. The application utilizes the features of the iPhone and iPad (such as scrolling and zooming), and allows physicians to access patient information and enter notes at a time/location most convenient for them.
NoMoreClipboard	NoMoreClipboard can be used by patients to create a comprehensive health record, including information such as immunizations, physiological data, appointments, medications, illnesses, insurances, and insurance information. Images and files can also be uploaded. The health record can be managed, accessed, and added to from a mobile device. NoMoreClipboard has linkages to the Microsoft HealthVault PHR.
Practice Fusion EMR	Practice Fusion is a free, web-based EHR that is one of the most widely used in the United States. Practice Fusion has paired with LogMeIn (a remote access software company) to provide access to the EHR via the iPhone, iPad, and Android platforms. Health providers can use their mobile devices to perform charting, scheduling, e-prescribing, and other functions, as well as access patient data.

Social Networking and Care Coordination Technologies

Social networking and care coordination technologies allow communities of older adults to connect, share knowledge, and provide support to other older adults and their care providers. These social networks utilize a variety of means to facilitate communication among patients including discussion groups, chat, messaging, email, video, and file-sharing. While currently

more often web-based, these social networking and care coordination programs are becoming ever more accessible on mobile devices. For example, care coordination technologies utilize SMS text or email messaging systems for medical appointments reminders, chronic disease management, and health surveys.

The benefits of providing support and exchanging knowledge, especially for patients with chronic conditions, are well studied. Online social networking emerged as a way to connect peers independent of geography. Before web-based social networking services existed, in-person peer groups like the Chronic Disease Self-Management Program© have recognized the effect of sharing experiences, exchanging knowledge, and providing support to improve health outcomes for patients with various chronic conditions. The combination of patient-centered knowledge exchange and caregiver support makes social networking a powerful platform in changing the way that healthcare is delivered, and is increasingly being seen delivered via wireless.

Social networking services connect older adults with other older adults as well as to clinicians, caregivers, researchers, health plans and suppliers. Older adults can use web-based social networking services to connect with friends and family as well as to exchange their knowledge and experiences of managing their conditions with other patients. Caregivers and clinicians can use social networks to manage and coordinate care for an older adult. Clinicians are also able to educate and promote preventive health, to collectively understand their patients' needs, and to remotely assist the patient, caregiver and family members.

Table 11 provides a sampling of currently available mHealth social networking and care coordination technologies. Applications are geared towards health providers, patients/caregivers, or both.

Table 11: mHealth Social Networking and Care Coordination Technology Examples

Technology	Description
Care Coordination Technologies (Medical Appointment Communication)	
Kaiser Permanente Texting using MobileStorm	A trial using text message appointment reminders took place at one of KP's clinics (SMS messages were provided by the mobile provider MobileStorm). 1.8% of their users opted out, but overall the program resulted in 0.73% fewer no-shows. KP is interested in doing a national roll-out of this program. KP's widely used EMR can also be accessed through Internet-enabled mobile devices.

mPro Appointment Reminders and Patient Diary Cards	mPro Care is a web-based mHealth application that enables care coordination as well as management of chronic diseases. The application is geared towards patients, providers, hospitals, and insurance companies, though the application is initiated from the provider side. Appointment reminders, medication reminders, and patient diary cards are delivered to a patient's mobile phone to aid him or her in keeping their appointments and managing chronic diseases. The service aims to achieve better health outcomes and compliance for patients, as well as better financial outcomes and efficiency for providers.
Smile Reminder	Smile Reminder provides a text messaging service that can integrate with practice management systems. The service aims to improve appointment-show rates, increase staff efficiency, improve loyalty, and positive impact financial outcomes. The service is targeted to physicians and dentists, though patients actually receive the messages. The service also offers email messages, patient portals, and surveys.
Social Networking	
Tyze	A platform that hosts personal support networks for older adults, persons with disabilities and their caregivers. Tyze offers scheduling, task planning and messaging as well as storytelling around the person at the center of the network.
Kinnexxus	Web-based platform provides a senior support network connecting older adults to each other, caregivers and professional care providers. Features include: scheduling, task planning and messaging as well as integrating with remote monitoring devices.

Opportunity Area for mHealth: Wellness

The ubiquitous nature of mobile technology also makes it a natural platform for facilitating general wellness. mHealth interventions for wellness can be categorized into several groups including fitness, nutrition, and overall quality of life.

Wellness mHealth Technologies

mHealth interventions can be used with basic cell phones as well as smart phones, and can vary widely in complexity and degree of interaction (one-way or two-way communication). Examples of mHealth wellness applications include SMS behavior modification programs on healthy eating and weight loss, wellness tips applications for smartphones and tablets, diary applications that track nutrition and calorie consumption, applications to support activities such as yoga and smoking cessation, applications that calculate body mass index (BMI) and disease risk, and mobile-enabled monitoring devices for activity level tracking. Many mHealth interventions that would work for individuals who already have chronic diseases can also be applied to maintain wellness.

Table 12 below provides a summary of several currently available mobile health wellness technology interventions, categorized according to the three main wellness functions.

Table 12: mHealth Wellness Technology Interventions

Category	Example Applications	Description
Fitness	Fitbit	The Fitbit is a small device that can be worn by the user that accurately tracks calories burned, steps taken, distance traveled, and sleep quality with the use of a 3D motion sensor. The data from the Fitbit is uploaded to a database and provides useful information about the user's daily activities. This device and its data tracking ability are similar to Wellcore (See Safety monitoring section).
	healthrageous	This application uses wireless devices to track key health metrics, and also provides automated coaching, challenges, and opportunities to earn rewards. The application also offers an opportunity to connect with family and friends as the user works to develop good health habits.
	Philips DirectLife	DirectLife is an activity program utilizing an activity monitor, personalized website, and personal coach. Users wear the activity monitor, which tracks movements and calculates energy exerted. Activity data is uploaded from the monitor to the computer and assessed on users' personalized website. A personal coach can assist with creating and adjusting activity plans and answering questions

	CalorieTracker	This application helps the user reach diet, weight loss, and fitness goals by tracking daily calories and exercise. The application includes an online food journal, weight management goals, and caloric burn calculators.
	All-in Fitness	This application provides hundreds of video clips on exercises for men and women, including yoga poses and complete workouts.
Nutrition	Nutrition Menu	This application provides nutritional information for over 93,000 food items, including restaurant menu items as well as common foods. This application also allows the user to keep a journal based on the foods they consume.
	EatRight	This application allows the user to track food group consumption, glasses of water, and sweets/fats in order to reach their diet and nutritional goals. This also helps users plan their meals according to their diet preferences.
	MyFood	This application provides nutrition data for hundreds of food, as well as serving sizes. The data for this application is based on the USDA National Nutrient Database.
Quality of Life	Livestrong My Quit Coach	This physician-approved application creates a personalized plan to help the user quit smoking. Based on the user's preferences, a plan will be created based on attainable goals. The application tracks the daily nicotine intake and cravings, as well as motivational tips and progress charts. Information can also be shared on Facebook and Twitter.
	Mayo Clinic Meditation	This application uses a clinically validated meditation method to help users feel more focused and relaxed. The application includes a short training video, music, and reminders and tips for meditation.
	Cleveland Clinic Stress Meditations	This application allows the user to practice clinically proven relaxation techniques that help the user control and reduce stress. The application features eight different relaxation techniques and is aimed at reducing the risk of developing stress-related diseases and contributing to the general well-being of the user.

The availability of such mHealth technology interventions for wellness is rapidly growing. Currently, over 250,000 health-related applications for the iPhone exist, while over 30,000 exist for the Android platform.[10] Though these numbers include applications for chronic disease management and other specific health-related purposes, many of these applications have a general wellness component or focus. Most general wellness applications are designed for use by multiple age groups, while chronic disease applications are more targeted towards older adults. The distinction between general wellness and more targeted health applications is not always completely clear, and will likely continue to blur as more integrated applications become available.

To date, few studies exist detailing the effects and health outcomes associated with these general wellness applications. However, several studies have indicated the potential for mHealth to aid in smoking cessation.[16] Going forward, general wellness applications are likely to continue to grow through direct-to-consumer mechanisms such as smartphone application stores. However, it will nonetheless be important for an evidence base to be developed around the efficacy of mHealth applications for wellness, as well as for scientifically valid and accurate information to be presented in these applications.

Discussion

There are a number of issues that are particularly pertinent to how mHealth will be deployed in the coming years, and how rapidly it will become an integral part of the healthcare system. The Center for Technology and Aging is committed to encouraging wider use of viable technologies that compare favorably on the following criteria: technology viability, population applicability, health and economic outcomes, workforce relief, stakeholder readiness, and policy and reimbursement issues.[38] Many mHealth technologies currently benefit, or have the potential to significantly benefit, a large portion of the older adult population, reduce the demands on the formal and informal workforce, and ultimately contribute to lower healthcare costs.

Technology Viability: The rapid evolution of mobile technology coupled with the rapid growth of various forms of mHealth poses both challenges and opportunities for the adoption and diffusion of mHealth. Keeping up with the requirements and standards for mobile technology platforms, software, and hardware can discourage adoption, but creating sound IT infrastructures and monitoring necessary updates while looking down the pipeline will help to ensure sustainable mHealth programs. The field may find themselves addressing these issues on the front end as the focus on the "unplatform" emerges. According to Matthew Holt, the field is rapidly reaching the point where platforms are becoming irrelevant and that successful mHealth interventions will need to be accessible on all major platforms or the "unplatform." Interoperability and data flow issues also hinder implementation. The growing role of cloud computing to track data may mitigate interoperability and data flow issues. Within this ever-changing environment, opportunity for mobile technology innovations can lead to more mhealth innovations, which in turn will ultimately lead to better healthcare for older adults.

Population Applicability: Most of the mHealth technology interventions discussed in this paper are or will be beneficial to a significant population of older adults. However, it is important to acknowledge that the 5% of the older adult population that is responsible for driving almost 50% of the costs of care[39] may be particularly hard to access through mHealth or have their healthcare needs addressed through certain mHealth interventions. Despite this issue, many older adults have access to and are using mobile technologies. The ability to use these

technologies to address healthcare needs has demonstrated appeal to older adults. The benefits that mHealth technologies can bring to persons with disabilities or chronic illnesses - to better self-manage their health conditions and thereby prevent complications and injuries, provide fall detection to those who are susceptible to falls, and provide location tracking capabilities for those with cognitive impairments who may be prone to wandering - are significant.

Health and Economic Outcomes: Credibly demonstrating improvements in health and economic outcomes is one of the largest challenges facing mHealth. Randomized, controlled trials are the gold standard for demonstrating such improvements. However, given the nascent stage of the mHealth field, many technologies lack clinical evidence while others have been studied with less robust methods, e.g., pre-post observation studies. On the positive side, many mHealth technology interventions are demonstrating positive outcomes in many care settings and across care issues, and are likely to be well suited to rapid evaluation methodologies.

Workforce Relief: In the medium- to long-term, mHealth technologies are likely to reduce demands on the ever-stretched workforce that cares for older adults — by encouraging greater self-management as well as providing more efficient communication of health information between providers, family caregivers, and older adults. The increasing interest by providers and caregivers to use these technologies to track, monitor and communicate around older adults' health has already demonstrated initial benefits to the health and long-term career workforce.

Stakeholder Readiness: Misaligned incentives in the healthcare system that have cemented fee-for-service, reactive care, and lack of reimbursement for most non in-person visits are barriers to adoption of mHealth technologies. Adoption will likely be driven by consumers who see the benefits of reduced travel and speed of communication with care providers. Consortia efforts, like the Continua Alliance and the mHealth Alliance, are bringing together diverse organizations from technology development, payment and evaluation to advance telehealth and mHealth solutions.

Policy and Reimbursement Issues: The $787 billion American Recovery and Reinvestment Act of 2009, which included $19.2 billion for health information technology (HIT), has brought EHRs to the forefront of the healthcare technology discussion. EHR adoption will be pivotal for use of integrated mHealth technologies. Data collected and accessed from these technologies can reside in an EHR and/or PHR to be accessed by clinicians and other healthcare professionals, or patients and caregivers.

Payment issues remain a powerful barrier to the adoption and diffusion of mHealth technologies. In Chapter 10 of The Federal Communication Commission's (FCC) report, *National Broadband Plan – America's Plan*, the FCC discusses the use of broadband to enable Health IT adoption by

aligning healthcare incentives and addressing short-term and long-term payment reform. The FCC provides payment reform suggestions, including: widening coverage for current reimbursement use cases with proven system-wide expenditure reduction; convening stakeholders to create study designs that will prove system-wide expenditure reductions for current and future mHealth technologies and remote health services; and encouraging Medicare Advantage plans to invest rebates in the adoption of mHealth and remote health services technologies.[40]

There is much concern about whether mobile devices used in mHealth interventions will be required to gain approval from the FDA. Some mHealth technology interventions have gained FDA approval, others are seeking approval, and others yet are waiting see whether regulation of mobile devices for mHealth interventions will occur. Other concerns around data security on mHealth devices must also be addressed. HIPAA guidelines that place restrictions on providers around sharing patient data could have a significant impact on deployment of mHealth technologies.

Appendix A: List of Abbreviations

ACC	American College of Cardiology
ADL	Activities of Daily Living
CHF	Congestive Heart Failure
COPD	Chronic Obstructive Pulmonary Disease
CMS	Centers for Medicare & Medicaid Services
CTA	Center for Technology and Aging
ECG	Electrocardiogram
ED	Emergency Department
EHR	Electronic Health Record
GSM	Global System for Mobile Communications
HIPAA	Health Insurance Portability and Accountability Act
IADL	Instrumental Activities of Daily Living
ICD	Implantable Cardioverter Defibrillator
ICT	Information and Communication Technologies
IHI	Institute for Healthcare Improvement
IT	Information Technology
PHR	Personal Health Record
RFID	Radio-frequency Identification
RF	Radio-frequency
RPM	Remote Patient Monitoring
SMS	Short Message Service
VHA	Veterans Health Administration
U-TDOA	Uplink Time Difference of Arrival
WPS	WiFi Positioning Service

Appendix B: Description of the Center for Technology and Aging mHealth Diffusion Funding Program

The Center for Technology and Aging launched the mHealth Diffusion Grants Program in early 2011. Funding under this initative is not intended to support the development of new mHealth interventions, per se. Rather, the focus is to strengthen and expand activities that are already well developed, or under development, and already have the active involvement of key partners. It is intended to build relationships between health systems and vendors to rapidly expand the use of mHealth interventions that can benefit older adults.

What is the focus of the Diffusion Grants Program?

The emphasis of the Grant Program is on expanding use ("diffusion") of technologies that already have a good track record of helping older adults. As mHealth is an emerging field, applicants that have a compelling theory-based model underlying the project are also eligible for funding. Grant applicants need to design and propose projects that have proven evidence-based or strong theory-based benefits for older adults. Applicants are expected to present a robust plan for program diffusion and scalability.

Who is eligible to apply?

Primary applicants must be:

- Non-profit organizations with a 501(c) (3) designation
- Local, State and Federal government agencies
- Universities and Colleges with 501(c) (3) designation

Consortia consisting of public and private organizations or for-profit and non-profit organizations are also eligible to apply. However, the primary applicant in any consortium must meet the above criteria.

mHealth Award:

The total pool of funding for the mHealth Diffusion Grants Program is $500,000. CTA will award up to 6 grants at up to $100,000 for each project. The **mHealth** awards will be announced to recipients no later than June 15, 2011 with an expected start date on August 1, 2011.

CTA (www.techandaging.org) supports the rapid adoption and diffusion of technologies that enhance independence and improve home and community-based care for older adults and persons with disabilities. Through grants, research, public policy involvement and development of practical tools and best practice guidelines, CTA serves as an independent, non-profit resource for improving the quality and cost-effectiveness of long-term care services.

References:

[1] Mobile Healthcare Opportunities, Monitoring Applications & mHealth Strategies 2010-2014. Juniper Research. April 13, 2010.
[2] Mechael, P.Aab, E.S., Kaonga, N.N. & Ossman, J. (2010, May). Barriers and Gaps Affecting mHealth in Low and Middle Income Countries: Policy White Paper. New York: Center for Global Health and Economic Development, The Earth Institute, Columbia University.
[3] Hanauer DA, Wentzell K, Laffel N, et al. Computerized automated reminder diabetes system (CARDS): e-mail and SMS cell phone text messaging reminders to support diabetes management. Diabetes Technol Ther. 2009;11(2):99–106.
[4] Gallelli, M., Wells, M., Peltonen, A., Groden, P. Boomers, Technology & Health: Consumers Taking Charge! Enterprise Forum Northwest. 2010
[5] Kolesnikov-Jessop, S. Do-it-Yourself Healthcare with Smartphones. New York Times. February 28, 2011. http://www.nytimes.com/2011/03/01/technology/01iht-srhealth01.html
[6] Cellular Telecommunications and Internet Association. (2010, November). mHealth Solutions. Retrieved on November 15, 2010. http://www.ctia.org/advocacy/
[7] Barrett, Linda. Health and Caregiving among the 50+: Ownership, Use and Interest in Mobile Technology. AARP Research and Strategic Analysis. January 2011
[8] Sarasohn-Kahnm Jane. How Smartphones are Changing Healthcare for Consumers and Providers. California Healthcare Foundation. April 2010
[9] Wireless Industry News. Apple App Store reaches over 10 billion downloads. January 24, 2011. Retrieved from: http://www.wirelessindustrynews.org/news-jan-2011/2355-012411-win-news.html
[10] Fox, Susanna. Mobile Health 2010. Available from Pew Internet & American Life Project: http://pewresearch.org/pubs/1767/mobile-phone-search-health-medical-information Accessed 11 Mar 2011
[11] Dolan, Brian. In Defense of mobile health app adoption, MobiHealthNews. October 28, 2010 http://mobihealthnews.com/9295/in-defense-of-mobile-health-apps-adoption/
[12] Madden, Mary. Older Adults and Social Media. Pew Internet & American Life Project
[13] Cole-Lewis, H., & Kershaw, T. Text Messaging as a Tool for Behavior Change in Disease Prevention and Management. Epidemiol Rev 2010 Jan; 32 (1): 56-69.
[14] Fjeldsoe BS, Marshall AL, Miller YD. Behavior change interventions delivered by mobile telephone short-message service. American journal of preventive medicine. 2009 Feb; 36(2):165-73.
[15] Haug, S., Meyer, C., Schorr, G., Bauer, S., & Ulrich, J. (2009). Continuous individual support of smoking cessation using text messaging: a pilot experimental study. Nicotine & Tobacco Research, 11(8):915- 923.
[16] Rodgers, A., Corbett, T., Bramley, D., Riddell, T., Wills, M., Lin, R.B., & Jones, M. (2005) Do u smoke after txt? Results of a randomized trial of smoking cessation using mobile phone text messaging. *Tobacco Control*, 14(4):255-261.
[17] Wessels, X., Nattrass, N., Rivett, U. (2007). Improving the efficiency of monitoring adherence to antiretroviral therapy at primary healthcare level: A case study of the introduction of electronic technologies in South Africa. Development Southern Africa, 24(4):607-621.
[18] Wangberg, S.C., Arsand, E., & Andersson, N. (2006). Diabetes education via mobile text messaging. Journal of Telemedicine Telecare, 12 (Suppl 1):55-56.
[19] Franklin, V.L., Greene, A., Waller, A., Greene, S.A., & Pagliari, C. (2008). Patients' Engagement With "Sweet Talk" – A Text Messaging Support System for Young People With Diabetes. Journal of Medical Internet Research, 10(2):e20.
[20] Cole-Lewis, H., & Kershaw, T. Text Messaging as a Tool for Behavior Change in Disease Prevention and Management. Epidemiol Rev 2010 Jan; 32 (1): 56-69.
[21] Improving and Extending Quality of Life Among Older Americans: At A Glance 2010. CDC http://www.cdc.gov/chronicdisease/resources/publications/aag/aging.htm
[22] Quinn, C.C., Clough, S.S., Minor, J.M., Lender, D., Okafor, M.C., & Gruber-Baldini, A. (2010, June). WellDoc mobile diabetes management randomized controlled trial: change in clinical and behavioral outcomes and patient and physician satisfaction. *Diabetes Technol. Ther*., 10(3): 160-168
[23] Kenreigh C, Wagner L. Medication Adherence: A Literature Review 2005. http://www.medscape.com/viewarticle/514164.

[24] Delate T, Chester EA, Stubbings TW, Barnes CA. Clinical outcomes of a home-based medication reconciliation program after discharge from a skilled nursing facility. *Pharmacotherapy.* Apr 2008; 28(4):444-452.
[25] New England Healthcare Institute. Thinking Outside the Pillbox: A System-wide Approach to Improving Patient Medication Adherence for Chronic Disease. A NEHI Research Brief July 2009.
[26] Rich MW, Beckham V, Wittenberg C, Leven CL, Freedland KE, Carney RM. A multidisciplinary intervention to prevent the readmission of elderly patients with congestive heart failure. *N Engl J Med.* Nov 2 1995; 333(18):1190-1195.
[27] Buckwalter KC, Wakefield BJ, Hanna B, Lehmann J. New technology for medication adherence: electronically managed medication dispensing system. *J Gerontol Nurs.* Jul 2004;30(7):5-8.
[28] Tilly J, Reed P. Falls, wandering, and physical restraints: interventions for residents with dementia in assisted living and nursing homes. www.alz.org/ national/documents/Fallsrestraints_litereview_ II.pdf. Accessed February, 1 2011.
[29] Kiely DK. Resident characteristics associated with wandering in nursing homes. Int J Geriatric Psychiatry. 2000;15(11):1013-1020.
[30] Lohr S. Watch the Walk and Prevent a Fall. New York Times. November 7, 2009.
[31] Centers for Disease Control and Prevention and The Merck Company Foundation. The State of Aging and Health in America. 2007.
[32] Gurley RJ, Lum N, Lo B, Katz MH. Persons found in their homes helpless or dead. N Engl J Med. 1996;334:1710-1716.
[33] Tinetti ME, Speechley M, Ginter SF. Risk factors for falls among elderly persons living in the community. N Engl J Med. 1988 Dec 29;319(26):1701-7.
[34] Associated Press. At-home technology can monitor seniors for safety. Available at: http:// bostonherald.com/business/healthcare/view.bg?articleid=1221632. Accessed January 9, 2011.
[35] Cosseddu P, Bonfiglio A, Neelgund R, Tyrer H. Arrays of pressure sensors based on organic field effect: A new perspective for non invasive monitoring. Conference. 2009;1:6151-4.
[36] Kangas M, Vikman I, Wiklander J, Lindgren P, Nyberg L, Jamsa T. Sensitivity and specificity of all detection in people aged 40 years and over. Gait Posture. 2009 Jun;29(4):571-4. Epub 2009 Jan 18.
[37] Sposaro F, Tyson G. iFall: An android application for fall monitoring and response. Conf Proc IEEE Eng Med Biol Soc. 2009;1:6119-22.
[38] Center for Technology and Aging. Technologies to Help Older Adults Maintain Independence: Advancing Technology Adoption; July 2009 Briefing Paper.
[39] Stanton MW. The High Concentration of U.S. Healthcare Expenditures. Research in Action, Issue 19. AHRQ Publication No. 06-0060, June 2006. Agency for Healthcare Research and Quality, Rockville, MD. http://www.ahrq.gov/research/ria19/expendria.htm
[40] mHealth's Enabling Role in Healthcare Reform. Prepared by MedApps. 2010 MedApps Inc.