IMPROVING COMMUNITY WELLNESS, HEALTHY CHOICES, AND HEALTH EQUITY THROUGH MOBILE HEALTH

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eHEALTH INITIATIVE
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Introduction

This report describes ways in which mobile health (mHealth) tools and technologies are used by adults to enable healthy eating, active living, and psychosocial support. Over the past several years, the Foundation for eHealth Initiative (FeHI) has researched how technology can support patients and healthcare providers to prevent, manage, and treat chronic conditions across the continuum of care. Funded by the Aetna Foundation, this report describes trends towards the consumerization of healthcare and demonstrates how mHealth can empower people to make healthy choices and improve health and wellness at an individual and population level. A series of case studies illustrates successful approaches to the design, implementation, and use of mHealth that enhance wellness efforts, and reviews some key challenges and barriers that remain to be addressed.

The field of mHealth is arguably still in a nascent phase; though the rapid growth of mHealth applications and platforms suggests significant interest from consumers and developers, as well as the positive impact the tools can have on improvements in health, wellness, and psychosocial support.

Methodology

This report was informed by qualitative mixed-methods research between May and December of 2014. Under the oversight of a multi-stakeholder Technical Advisory Group composed of experts in mHealth, user design, public health, and research, the Foundation for eHealth Initiative (FeHI) conducted an environmental scan of current practices, strategies, and approaches to the design, implementation, and use of mHealth among adults aged 18 years and over. Given the nascent stage of mHealth, we sought to be inclusive about the types of technologies under consideration. However, research generally excluded mHealth tools that were not intended to promote health/wellness or prevent disease – in most cases, clinical disease management was not included, nor were tools that were not deemed credible or trustworthy. After reviewing online reports and peer-reviewed publications, FeHI interviewed 20 key informants to obtain additional information and fill in gaps where literature was sparse. A full list of Technical Advisory Group members, Peer Review Advisory Group and key informants can be found in Appendices A, B and C.

Overview

Broadly, mHealth involves the use of mobile computing and communications technologies in healthcare and public health.[i] mHealth encompasses a vast array of use cases, tools, and users. Cell phones, text messaging, smartphones, mobile applications, personal digital assistants, tablets, mobile-enabled websites, connected devices and wearables have all been used by patients and providers for healthcare purposes.

For clinicians, mHealth tools can enable enhanced data collection over a large cohort of patients. Healthcare providers can apply clinical decision support to data collected from mobile sources to identify abnormal or concerning trends that could indicate the presence or worsening of a patient's condition. Mobile technologies also open new channels for patient-provider communication, potentially reducing the need for in-person visits for routine disease management.

For patients, mHealth can facilitate information seeking and awareness of symptoms and conditions. mHealth presents new opportunities for self-management of care, including tracking and monitoring of biometric data.[ii] A plethora of mHealth tools exist to assist consumers in healthy living, nutrition, weight loss, and exercise.

Mobile device users have already embraced smartphones, mobile applications, and wearables for healthcare. Thirty-three percent of adult consumers use their phone to look for health information and approximately 30 percent of commercially-insured adults use mobile apps to manage their health, weight, nutrition, and fitness.[iii,iv] In the first half of 2014 alone, usage of health/fitness apps available for iPhone/iPad platforms increased by 62%.[v] Approximately 16 percent of apps are designed for health, wellness, and healthy living. Of the adult consumers who access health-related smartphone apps, healthy eating (49%) and fitness (48%) are the most common purposes.[vi] However, apps have also been developed to support disease diagnosis, medication management, information-seeking, disease management, and smoking cessation, among other uses.[vii] Market research estimates approximately 10-15 percent of American adults own a wearable device to track their physical activity, the majority of which are fitness bands (61%) and pedometers (17%).[viii]

Unlike other health information technologies which may require the user to participate from a fixed location, mHealth is by definition, mobile. Consumers can easily carry mHealth solutions wherever they go, which helps to increase the potential reach of healthcare

interventions. In fact, much mHealth research has focused on the developing world, where mHealth has been used to expand access to educational materials, improve disease awareness, enhance data collection, track disease, and monitor compliance with treatment protocols.[ix] The ubiquity of mobile devices enables mHealth to reach populations that may otherwise lack access to healthcare services, such as racial and ethnic minorities, rural and low income groups. In fact, Hispanic and African American populations are more likely to access health information and track their health with a smartphone.[x]

Setting the Stage for mHealth

In recent decades, broad societal changes have profoundly altered the healthcare landscape of the United States. For example, the increase of individuals with one or more chronic diseases has forced government, healthcare providers, and consumers to reevaluate traditional paradigms of care. Concurrently, advances in technology enabled by the internet have empowered consumers while delivering new tools capable of disrupting healthcare delivery. Combined, these forces have contributed to the rapidly increasing use of mobile technologies in the healthcare space.

Health Trends and the Burden of Chronic Disease

Within the past 20 years, there has been a dramatic increase in obesity and chronic disease across the US. Today, approximately 35 percent of adults are obese and 70 percent are overweight. Rates of obese and overweight children and adolescents have more than quadrupled.[xi] Being obese or overweight has immediate and long-term detrimental effects on health and correlate with higher rates of chronic comorbid conditions (e.g. diabetes, cancer, heart disease, stroke, and depression), disability, and mortality. Chronic conditions are costly to manage and significantly increase the risk of health-related complications, hospitalizations, readmissions, and productivity loss in the workforce.[xii] Chronic care accounts for approximately 75 percent of total health care expenditures, and the annual cost of chronic disease is projected to rise by five trillion dollars over the next forty years.[xiii] While advancements in medicine have enabled chronically ill individuals to live longer, the healthcare system has been unable to effectively manage and treat their conditions in an economically sustainable manner.

As a result, government, healthcare providers, and consumers have increasingly turned their attention to upstream prevention of obesity and chronic disease by addressing health and wellness before these conditions arise. Behavioral risk factors such as physical

inactivity, poor nutrition, alcohol and tobacco use, high blood pressure and cholesterol, stress, depression, and being overweight or obese can contribute to and compound chronic disease.[xiv] These risk factors can be mitigated by appropriate health interventions, education, and tools that support healthy lifestyle and behavior change. However, a healthy lifestyle is not always an easy adjustment to make or sustain – particularly in the face of diseases that may require an individual to regularly alter routine behavior, monitor health, and adhere to complex treatment regimens. Chronic disease can also give rise to feelings of grief, fear, anxiety, anger, and depression which limit an individual's ability to effectively cope with their condition.

Consequently, an important function of healthcare services is to support, encourage, coach, and inform consumers to adopt healthy behavior and better self-manage their conditions. Unfortunately, encounters with healthcare providers today are often infrequent and limited, leaving little time to sufficiently address healthy behavior change. Moreover, many high-risk, vulnerable, and/or chronically ill populations encounter barriers to appropriate healthcare - such as stigmatization, social isolation, and fear - which inhibit access.

Rise of the Empowered Consumer

Consumerization is another major factor that is having a powerful impact on American industries. Enabled by advances in IT infrastructure, internet broadband, and wireless connectivity, customers of the hospitality, retail, banking, and travel industries are increasingly empowered to make informed decisions about the services and products they choose to consume. Online tools and websites now provide a wealth of information on cost, availability, and quality that was previously inaccessible to most individuals. Consumerization has upended traditional business practices and led many industries to redesign their products around consumer needs such as personalization, accessibility, portability, transparency, usability, and cost.

Until recently, healthcare has been slow to respond to the forces of consumerization. However, in the wake of market, societal and governmental pressures to reduce costs and improve outcomes, the healthcare system is showing signs of a comprehensive transformation towards a value-based, patient-centered paradigm of care. Recognizing that much of what constitutes good health takes place beyond the confines of the healthcare system, providers and insurers have sought to develop and implement tools that enable patients to access care how, when, and where they desire. In only a short period of time, clinicians and hospitals have adopted health information technologies like electronic health record systems and telehealth to increase the coordination, communication, and quality of

care, even in remote areas. Patient portals, personal health records, and remote monitoring devices are beginning to bridge the gap between a patient's home and clinical settings while involving patients in the process of care delivery. Consumers have access to an unprecedented amount of data on hospital performance and quality, and can compare their experience with healthcare services with their peers over the internet. And, innovative organizations are now recognizing the growing ubiquity of using mobile devices provides a transformative environment supporting new tools to meet consumer healthcare needs and create consumer empowerment and accountability.

What's a landline? Growth of Smartphones

Today, more than 91 percent of adults in the United States own a mobile device, a majority of which are smartphones. The proliferation of mobile devices has been driven in part by the declining costs of technology, cellular plans, and wireless connectivity. Between 2011 and 2014, smartphone ownership among the general population grew from 38 percent to 58 percent. Early generation smartphones were primarily purchased by more affluent, younger, urban, and Caucasian populations, but as the market has matured, smartphones are increasingly purchased by minority populations: lower income, elderly, rural, and ethnic minority consumers. Hispanic and African American populations are more likely to use a smartphone for text messaging, Internet access, to send/receive email, and to download mobile applications than Caucasians.[xv] Mobile devices have grown so common that nearly 20 percent of all Americans use a mobile device as their primary source of internet access.[xvi]

Table 1: Smartphone Ownership (2012-2014) [xvii]

Smartphone ownership			
Age	**2012**	**2013**	**2014**
18-29	66%	79%	83%
30-49	59%	67%	74%
50-64	34%	45%	49%
65+	11%	18%	19%
Community type	**2012**	**2013**	**2014**
Urban	48%	59%	64%
Suburban	49%	59%	60%
Rural	29%	40%	43%
Annual Income	**2012**	**2013**	**2014**
< $30,000	35%	43%	47%
$30,000-$49,999	42%	52%	53%
$50,000-$74,999	56%	61%	61%
$75,000+	68%	78%	81%

As device ownership has soared, various industries including healthcare have sought to connect with consumers through mobile technologies. In fact mHealth has emerged as a new sector of healthcare where mobile devices and associated technologies are leveraged to augment care, effect behavior change, and increase access to medical services.

Case Studies of mHealth in Action

As mHealth continues to develop, consumers and healthcare providers alike will grow more comfortable using mobile technologies for healthcare. As such, it is important to reflect on the experiences of those currently implementing mHealth technologies. Below is a series of case studies demonstrating examples of the use of mHealth to facilitate consumer behavior change and contribute to improvements in health, wellness, and psychosocial support. While these case studies stand as examples of largely successful uses of mHealth, they also depict some of the persistent challenges developers have faced in designing and implementing their tools.

Center for Connected Health: Tailoring Patient Feedback

The Center for Connected Health serves as an innovation lab for Partners HealthCare, devising solutions in response to the needs of Partners care providers to improve clinical outcomes, efficiency, and quality. The Center recently tested a smart learning algorithm designed to improve physical activity, nutrition, and A1C among diabetic patients. The tool incorporates data from multiple sources including the wearable Fitbit activity tracker, and provides tailored feedback to the user prompting them to be more active. Early results suggest higher rates of physical activity and reductions in blood glucose among users.

Kamal Jethwani, the Center's Corporate Manager for Research and Innovation, described some of the key challenges the Center faces in developing its solutions. Foremost are technological aspects, such as interoperability and user capabilities. Patients and healthcare providers alike are frequently unsure of how to best use the new tools at their disposal. On the healthcare provider side, "many are not trained yet what to do with the growing frequency and volume of data that we're collecting, or how to apply to decisions." As a result, developers must take care to present data in a compelling format to easily facilitate decision-making. Integrating data into the healthcare provider's workflow (usually through an Electronic Health Record) is essential, but the number of available devices and platforms to integrate with poses a significant barrier.

Another important challenge is maintaining privacy and security as data is generated and shared. Jethwani explained, "a lot of times we're shackled to the types of technologies or platforms that we can use because others may not be HIPAA-compliant." Jethwani believes that education can help overcome patient and provider concerns about privacy and security.

Finally, transitioning a new solution from development to production and use can be difficult. Jethwani has found that some although some tools are successful in a test environment, "it may not be representative of the final production environment." The aforementioned concerns about privacy and interoperability add an additional layer of complexity which may not be accounted for in test scenarios. For its diabetes tool, the Center sought to mitigate these concerns by leveraging Fitbit, a tool Jethwani views as "the most open in terms of data integration capabilities and user-centered design."

Welldoc: Supporting Chronic Disease Management

Welldoc is a comprehensive platform with a range of features supporting both patients and healthcare providers in chronic disease management. For patients, Welldoc offers a mobile application and web portal. Users can track self-care data such as blood glucose levels, medications, and nutrition information, and the platform can provide customized feedback based on the user's data. On Welldoc's well-known diabetes management platform, for example, a patient might be prompted to answer questions about why their blood glucose value had fallen below a predetermined threshold.[xviii] On the provider side, Welldoc offers access to patient data supplemented with clinical decision support tools such as reporting capabilities and analytics for measuring trends in treatment response over time.

Unlike many other apps, Welldoc's platform is approved by the US Food and Drug Administration (FDA) and must be prescribed by a physician. Chris Bergstrom, Welldoc's Chief Strategy & Commercial Officer, suggested that FDA approval has helped drive use of the tool. "It helps communicate that this is safe, effective, and trustworthy – and that the product does what it says it's going to do. Patients want to have something recommended by a doctor and doctors like to have influence over what tools their patients use." Bergstrom stressed the care Welldoc takes in developing its products, which are informed by human factors analysis and pilot demonstrations, incorporate evidence-based practices that are subsequently translated into algorithms, and are supported with clinical trial evidence demonstrating outcomes. Ultimately, Welldoc seeks to ground its products "on a behavioral psychosocial framework so that we're speaking to the patient in the right way and tone, and that our objectives are mapped to stages of behavior change, whether we're trying to express empathy, improve health literacy on a topic, or uncover behavioral motivations, deterrents, or obstacles to be addressed."

Bergstrom believes this process contributes to Welldoc's success because it follows two guiding principles: (1) to add value to data to improve outcomes and (2) to give patients

the tools and data they need to motivate behavior change from within, rather than relying on external incentives. For Welldoc, relevancy is key. "Every time a patient enters data, they receive information back immediately. And even when data is not entered, Welldoc will be looking at trends and patterns to deliver contextual feedback longitudinally."

Dacadoo: Integrating Multiple Data Sources

Dacadoo is a Swiss company founded in 2010 to provide users with a tool to score their health and create benchmarks for improvement. It is a strong example of the power of integrating multiple sources of data for healthcare purposes.

The Dacadoo mobile application generates a composite health score for users based on self-reported data about lifestyle, physiological indicators, and mental health. Dacadoo supports integration of data from third-party apps and wearable devices and utilizes findings from cardio- and cerebrovascular risk studies and quality of life questionnaires to help determine where an individual falls. Health scores range from 1 to 1,000 and fluctuate in real-time based on a user's activity. Users can compare their personal scores with others to benchmark performance. The app's Health Navigator analytics engine offers tailored messages and personalized feedback to support behavior change.

Manuel Heuer, Dacadoo's Vice President of Technology, described how the app communicates with users to create a positive feedback loop. For nutrition tracking, the app may prompt users at random times to gauge food intake and behavioral indicators. Likewise using a group of methods, developed by personality/social psychologists, known as ecological momentary assessment (EMA), Dacadoo also offers EMA questions to understand emotional and mental health. "On the feedback side, it could be a basic notification that simply informs the user that their health score has changed, because if you see that, you might be motivated to change or continue a certain behavior."

Dacadoo employs self-determination theory, a theory of human motivation which posits that feelings of autonomy facilitate behavioral modification.[xix] The application offers gamification features designed to support a sense of autonomy and competence, as well as peer-based support. Users can complete activities to unlock achievements and awards, or compete with peers on challenges to climb public leaderboards. Together, health score benchmarking, tailored notifications, social interaction, and gamification combine as a platform that Heuer believes can help users become more self-disciplined and motivated. "It's a mix of various types of targeted feedback – and we believe that's important for successful behavior

change. You really have to understand what's going on for an individual to change their habits."

Heuer highlighted privacy as a fundamental barrier to mHealth. He noted that there seems to be a lack of awareness about privacy among disease and wellness tool developers, and that the landscape is "fairly open" from a regulatory perspective. Dacadoo is committed to providing users with "complete control and ownership of their data." The company carefully assesses third party tools before integrating them with the platform. "We use a device first to figure out how accurate it is and how easy it is to use and adopt from a user perspective. Data needs to be open, but it should also be secure. We do preliminary reviews of privacy policies, and look at how data is being shared and what types of security policies are implemented."

CHESS: Supporting Addicts When and Where They Need It

Through grant funding from the Robert Wood Johnson Foundation, The Center for Health Enhancement Systems Studies created a patient and healthcare provider platform to re-envision addiction treatment. Called the Addiction Comprehensive Health Enhancement Support System (A-CHESS), the platform delivers a smartphone-based program aimed at reducing risky drinking and preventing relapse.

A-CHESS leverages self-reported data to determine whether users are at-risk of a lapse or relapse according to Marlatt's Relapse Prevention Theory. Users are given a weekly survey based on the Brief Alcohol Monitoring Index (BAM), which includes protective and risky behaviors related to drinking (e.g. quality of sleep, mood, recent substance use, etc.). The app can be configured to send notifications to a user's counselor if BAM scores exceed a predetermined threshold. Users also have access to online support services, including educational materials, a computerized cognitive-behavior therapy program, peer discussion groups, and expert Q&A. With permission, the smartphone app can enable geolocation capabilities to push alerts to users when they approach high-risk areas where they have consumed alcohol in the past. Finally, the app incorporates a panic button, which sends personalized support messages to the user and alerts to key individuals in the user's social network when activated.[xx]

Andrew Isham, a researcher at the Center for Health Enhancement Systems Studies, described the three levels of support offered by A-CHESS as immediate/automatic, peer-based, and clinical engagement. According to Isham, the three layers interact such that "it's

okay if somebody falls through one or two of them, because another part of the safety net will catch them." Isham particularly emphasized the importance of peer support. "We did a study of 45 veterans who had all been readmitted at least 12 times to a Veterans Affairs (VA) hospital. We were able to reduce readmissions by more than 60% and I think the key was peer support. When one of the patients was identified as high risk, even if it was in the middle of the night, their peer group was notified and several people would quickly converge and reach out to the individual in question." In fact, social relatedness is an essential component of the Self-Determination Theory. "We are creating social supportive networks, and we're trying to address social relatedness in a virtual environment. People ultimately care about other people and validation from other people, not from a machine"

In the future, Isham hopes A-CHESS will evolve to target users more personally. "We discovered that a lot of the data generated by the app could be used for predictive analytics. We could locate somebody with Marlatt's model by looking at use patterns and found that location data and use patterns could be used to predict lapses." Additional research will help the Center for Health Enhancement Systems Studies correlate key outcomes or indicators of interest with a user's data to hone interventions and improve results.

Isham identified challenges including concerns about privacy, which he believes will be worked out "once enough convenience and value are made clear to the customer or patient," and funding. In the current research environment, controlled trials are the standard path for grants which are essential to research and development of systems like A-CHESS. However, clinical trials are not necessarily the best tool to evaluate the more flexible uses of mHealth tools. Isham shared an example related to the peer support functionalities of the A-CHESS system. In a typical online discussion-based environment, a very small number of users contribute a disproportionate amount of content. Most users are passive participants. With enough overall users, a relatively small number of leaders can generate enough content that the "lurkers" still obtain value. A randomized controlled trial can severely restrict the number of users of a given tool. In a trial, "we're trying to build a rich, supportive virtual environment for maybe 100 people, but we only have two people who are positioning themselves as leaders of the group." As a result, developers have difficulty scaling their platforms and selling them to users. "Patients value the participation of healthcare organizations and treatment agencies, but the structures that they're working under aren't set up to pay for this kind of thing. So we're fighting a multi-front battle on the commercial side trying to figure out how to not only sell a product to consumers, but also get larger organizations to buy-in."

Key Features, Functionalities & Best Practices

The four case studies provide valuable insights into the development and design decisions involved in mHealth that can contribute to acceptance, use, and ultimately, to improved outcomes. Key themes include:

Research & Development

The relative immaturity of the field of mHealth means that developers have fewer established resources to help guide the design and use of mobile tools. Whereas the practice of medicine has a long-standing body of experience and literature from which the medical profession can draw upon to craft new interventions and deliver effective care, it is still unclear how consumers interact with their mobile devices and which strategies for improving health will resonate with users. As a result, many of the developers we spoke with emphasized the research and development decisions they believe have contributed to the success of their tools.

Grounding Features in Evidence-based Practices

One strategy, described by Heuer (Dacadoo) and Isham (CHESS) is to ground the features of mHealth tools in existing evidence-based practices. Dacadoo relies in part on cardio- and cerebrovascular risk studies and scientifically accepted questionnaires to generate health scores. Isham discussed two evidence-based theories used by the A-CHESS system which identify protective and risky behaviors related to drinking: Marlatt's Relapse Prevention Theory and the Brief Alcohol Monitoring Index, which serve as the basis for a questionnaire about user behaviors.

The National Center for Telehealth & Technology (T2) operates a variety of health-related mobile applications and websites in conjunction with the Department of Defense (DoD) including Moodtracker, an app which functions as an electronic diary to provide military service members with a simple tool for psychosocial support. T2's Deputy Director for mHealth, Julie Kinn, PhD described the developmental process behind Moodtracker: "our current method is to use evidence-based content and tools that have been shown to be efficacious in other settings, add them into a mHealth framework, and then test them for user acceptance, usability, and feasibility before release." Although outcomes data from Moodtracker is not yet available, Kinn believes the comprehensive developmental process has contributed to broad usage. She estimated that the app is used at least 10 times per download, which is "tremendous for a mobile app."

In other cases, established practices of the healthcare industry may not sufficiently meet the needs of mHealth. The traditional standard of the randomized controlled trial, in particular, was frequently derided as cumbersome and ineffective for mHealth interventions. Andrew Isham touched on the difficulties of evaluating important features like peer support in a traditional research context.

Modifying Programs Over Time

mHealth developers often prefer to use iterative or continuous processes to test their products. Voxiva has launched several successful sms-based mHealth programs including Text4Baby, which sends informational text messages promoting maternal and child health to users three times per week. Pamela Johnson, Voxiva's Chief Health Officer, discussed the importance of modifying mHealth programs over time. "Mobile health enables us to conduct continuous research to evaluate outcomes and tweak an intervention appropriately."

Erika Poole is Assistant Professor of Information Sciences & Technology at Pennsylvania State University's College of Information Sciences & Technology. Her research has focused on how mobile devices can enable behavior change. Like other interviewees, Poole is critical of applying traditional research standards to mHealth. "HCI [human-computer interaction] is very much about process and the experience of using technology, whereas a clinical study on the use of a mobile app won't look at those factors."

Applying Human Factors Principles to mHealth

Medstar Health's National Center for Human Factors & Healthcare applies human factors principles to healthcare and mHealth. The Center uses a rapid-cycle approach to research. Prototypes can be developed and fielded in a few days, and the entire lifecycle of development can be completed in as few as four weeks. This enables the Center to quickly incorporate lessons learned into Medstar Health's product development.

Instead of translating existing concepts into mobile tools, some developers have worked to build a new knowledge base for the use of mHealth. John Torous, a physician in the Department of Psychiatry at the Harvard School of Public Health, noted that "there is very little data on if or how passive sensors can translate into clinically valid proxies." In other words, because mHealth technologies are so new, more research is needed to understand how the data collected by smartphones correlates with behavior and health.

Open mHealth is a non-profit organization dedicated to deriving clinical meaning from digital health data and solving this very problem. Open mHealth seeks to correlate data that's

easily collected on mobile devices, such as activity and location data, with behavioral biomarkers for specific conditions. According to Deborah Estrin, the company's co-founder, Open mHealth "helps clinical researchers develop algorithms to turn passively collected data into useful, actionable clinical indicators." She believes that "to the extent that we can identify signals of behavior from things we can capture digitally, technology offers the opportunity to observe changes in that behavior."

Usability

Research and development is crucial for informing the design of a given mHealth tool, which in turn can greatly contribute to its overall effectiveness and use. One of the more alarming findings about mHealth is that consumers often abandon tools after a relatively short period of use.[xxi] As such, continued and sustained consumer engagement is of utmost importance to realizing the potential of mHealth.

Developers described varying strategies for encouraging sustained use of their tools. Some honed in on ways to make interventions easier on consumers. Partners HealthCare, for instance, chose to use Fitbit for their mobile-enabled diabetes management program because it is known for user-centered design and already owned by many consumers.
Alternatively, T2's Moodtracker app attempts to ease the process of journaling. According to Julie Kinn, "Rather than recording information about emotional status on paper, which can be both embarrassing and difficult to accomplish on a daily basis, the app features sliding scales for tracking mood and behavior."

Providing Easy Access

Likewise, Talkspace aims to make psychosocial support more accessible. Talkspace is an online tool and mobile application offering therapy sessions by video conference and chat. Talkspace's Head of Clinical Development, Nicole Amesbury, views technology as a resource that "allows a lot of people to get therapy that was previously unavailable because of stigma or other traditional barriers like inclement weather, childcare issues, or transportation." In this sense, the mobility of the platform drastically improves access and empowers users. "They become advocates of their care and receive support faster. A large number of people drop out of face-to-face therapy, but we don't see that with Talkspace because the therapy is accessible and isn't disruptive to their lives."

Understanding the User

To increase use, it is also important to carefully consider who the tool is intended for. Tracking may help some individuals better manage their health, but as Erika Poole indicates, "many people don't grasp basic health literacy concepts, let alone apply numerical or computational data to decision-making." Lisanne Brown, Director of Evaluation & Research at the Louisiana Public Health Institute (LPHI) offered a cautionary tale about a community-based mHealth program to help consumers at-risk for diabetes lead healthier lives. The fourteen week program sought to use text messaging to prompt participants to set health goals and engage in physical activity. The program enrolled 1,400 participants in greater New Orleans. However, few participants completed the program; only 200 completed a follow-up survey. Brown called the drop-off "precipitous" and acknowledged the program's messages weren't necessarily culturally appropriate or targeted, which potentially reduced their value: "Communication wasn't personalized or contextualized to specific user profiles or activity, which is something to think about in the future."

Features That Resonate

Another key approach to encouraging the use of mHealth tools is to offer features that resonate with users and effectively help them accomplish their objectives for healthy living and behavior change. Through our analysis, we've identified a series of basic functionalities used by mobile technologies to drive improvements in healthy living, wellness, and chronic disease management:

- **Educate** user about their health/wellness
- **Track** user-entered data (activity, behavior, mood, health) and **Display** results and trends
- **Prompt** user with actionable reminders and alerts
- **Share** information, as appropriate, between users, providers, and social networks
- **Motivate and coach** user with goals, support, and services

Educate

Mobile tools can contribute to information-seeking by delivering high-quality, vetted content to users at their convenience. An IMS Institute for Healthcare Informatics review of health-related mobile applications found that two-thirds of consumer focused applications offer health information.[xxii] Educational materials can inform consumers about important topics including nutrition, physical activity, specific conditions and symptoms, and where to find appropriate healthcare services, among others. Mobile educational materials can help fill the gap between the healthcare provider's office and home, where information relayed by the provider during an encounter may be lost or forgotten.

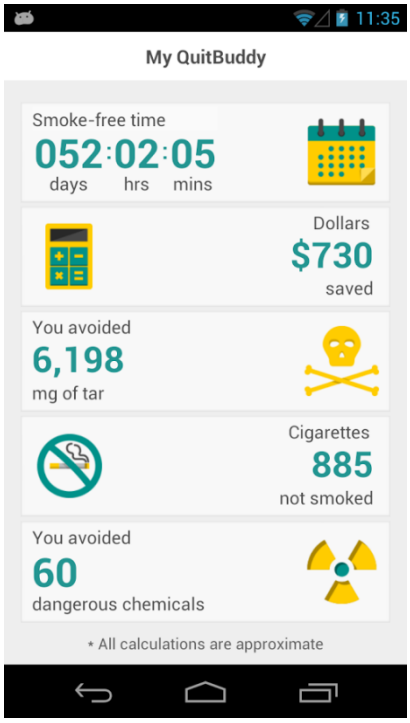
Sample text from Text4Baby
Image credit: http://www.cdc.gov/flu/partners/success-text4baby.htm

Mobile tools deliver educational information in a variety of formats. The A-CHESS system offers a repository of addiction-related educational materials as well as links to selected internet-based resources. Voxiva's Text4Baby initiative sends text messages with information about child and maternal health to participants throughout the week. Results from a pilot study suggest the program's participants felt more prepared for motherhood and improved attitudes toward alcohol consumption during pregnancy.[xxiii]

ICANFIT is a mobile-optimized website that seeks to assist a particular population, older cancer survivors, in obtaining information about physical activity. Informed by interviews and focus groups with older cancer survivors, their family members, health educators, and providers, the site addresses the gap between existing resources and the specific needs of this population. For example, older cancer survivors may have physical limitations that impinge on their ability to be physically active, which are not often taken into consideration by conventional educational materials.

Track and Display

Tracking is another popular mHealth feature and has been embraced by consumers. In fact, 69 percent of U.S. adults track at least one health indicator for themselves or a loved one. Forty-six percent of trackers believe that tracking health indicators has changed their



MyQuitBuddy's Progress Tracking Display
Image credit: http://fs01.androidpit.info/a/a1/61/quit-now-my-quitbuddy-a161ac-h900.jpg

approach to maintaining health and 34 percent say that tracking has affected healthcare decision-making.[xxiv] Especially for prolonged activities like weight loss or chronic disease management, tracking enables consumers to measure progress over time, remain motivated, and test the impact of behavior change or treatments. When shared with healthcare providers, tracking data has been shown to help patients reduce the incidence of asthma attacks, reduce discomfort with Crohn's disease, stay engaged in their care, and alert their healthcare provider to changes in their health.[xxv]

Mobile applications like T2's Moodtracker and Robbin, a tool for breast cancer patients developed by The Innovation Center of Mental Health & Technology at the Trimbos Institute feature tracking capabilities to support mental health and well-being. The MyQuitBuddy mobile application was created by the Project Factory to help lower income users quit smoking. It tracks a user's progress toward smoking cessation in meaningful terms to encourage sustained efforts; rather than simply displaying the number of days an individual has been smoke free, it shows an estimate of how much money the user has saved, how many dangerous chemicals and milligrams of tar have been avoided, and how many cigarettes haven't been smoked. Project Factory's Group Executive Director Jennifer Wilson reported that the app has been downloaded more than 300,000 times and 39% of users remain smoke free after 6 months. "There are a number of users who have been smoke-free for more than a year but still open the app to remind themselves of the fact that they are smoke-free. It's extraordinary how many people use the app to continue to reassure themselves or other people."

EmotionSense is another example of a tool which seeks to enhance the relevance of tracked data to encourage behavior change. The mobile application combines passive data collection and user-generated data to measure psychosocial health and emotional behavior. Throughout the day, the app prompts users to input data about their mood and activities. EmotionSense contextualizes these responses with passive data on movement and socialization captured by the smartphone's sensors to enable users to determine how their moods change over time and relate to activity.

The way in which information is displayed can contribute to both usability and effectiveness of a mobile tool. Trimbos Institute's Director of Innovation & Health IT, Katherina Martin Abello views mHealth technology more as a facilitator than a solution: "Robbin has worked particularly well not because of the technology – sensors, GPS, or otherwise – but because we're getting closer to patients." In this sense, mHealth tools function as new type of "presentation layer" upon which to reach specific populations with information and support.

Developers emphasized deliberate decisions about how information is displayed. In addition to MyQuitBuddy's unique methods for tracking progress, the app's dashboard is shaped like a person to help users feel more personally connected. Images and icons are accessible and playful, and content is written for a population with less education. Likewise, ICANFIT was designed with pictures, colors, and graphic meant for an older population. The decision to create a mobile-optimized site rather than an application reflects the technological heterogeneity of the senior population. Rosie Webster, PhD, a Research Associate at the University College London's eHealth Unit noted, "For us it's a lot easier to design a website that's mobile responsive and scale it to different screen sizes. It's important to not only think about the behavior you're trying to change, but also the content that you're trying to deliver and the most appropriate format or method to do so."

Tracking User Data – T2's Moodtracker
Image Credit: http://t2health.dcoe.mil/apps/t2-mood-tracker

Visually displaying in graphs or charts can help users stay engaged and identify trends. Julie Kinn remarked, "Patients don't often recognize when they're improving, especially if you're dealing with depression and it's difficult to see that progress has been happening." To improve a user's ability to recognize their progress, Moodtracker displays results as graphs which can be saved and printed to share with healthcare providers. EmotionSense utilizes graphical displays to not only communicate how mood and activity interrelate, but also drive use. "We made the second version of the app more attractive. We spoke with a number of interaction designers and added a light form of gamification in which prolonged use of the

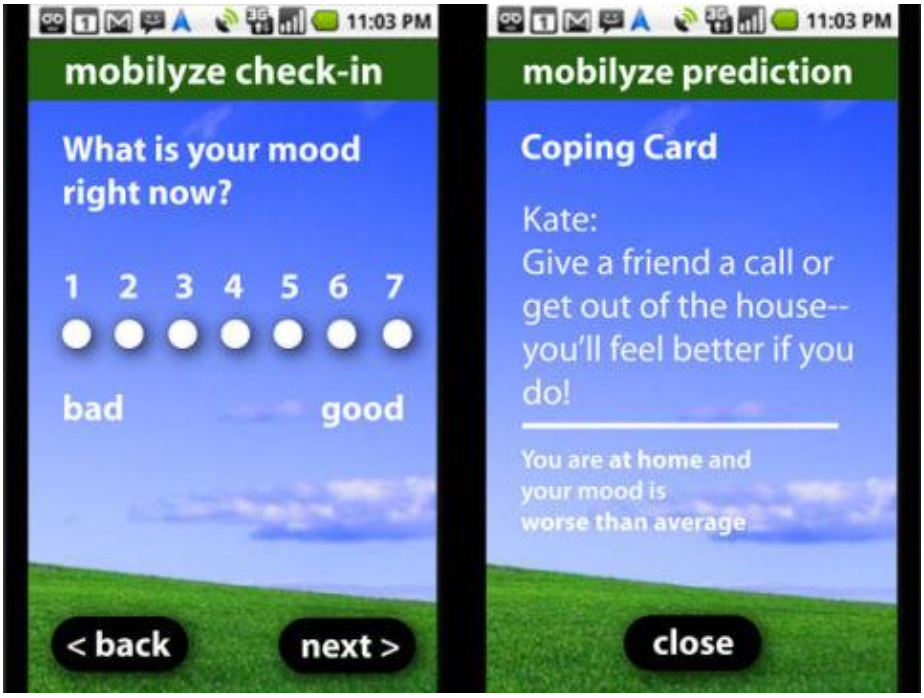
app unlocks new feedback displays," said Neal Lathia, a Senior Research Associate at EmotionSense.

Prompting Action

Education, tracking, and display are relatively simple mHealth capabilities. Although sufficient for some consumers, others require more robust functions to help interpret data and motivate behavior change. Peter Kung is Director of Strategic Technologies at UCLA Health where he coordinates strategic growth initiatives across service lines and technologies. Kung views mHealth as a gateway through which data can be captured, analyzed, and applied to enable health and wellness. Above all, Kung emphasizes the importance of decision-making to mHealth: "what's going to be really effective is the interpretation of information by a clinical team or consumer so that they can take action."

A-CHESS's location-based alerts, for example, add an additional layer of support to users beyond tracking behavior patterns related to alcohol use. Furthermore, A-CHESS can engage a user's counselor with notifications if their behavior indicates a potential relapse. Isham noted that in the future, A-CHESS may expand to offer greater contextual awareness and predictive abilities to prompt users to change their behavior before they consider drinking.

Similarly, Mobilyze is a mobile application that can leverage passive data collection via a smartphone's internal sensors to generate actionable information to improve mental health, depression, and well-being. It is being developed by researchers like David Mohr, who directs the Center for Behavioral Intervention Technologies at Northwestern University. Mohr calls this ability "context sensing." For example, "if we want people to be more active and do more things that are enjoyable, we can use location-based information to find out where they're going, and then nudge them towards healthy decisions." Mohr says Mobilyze can reliably detect a number of states of being and then deliver suggestions or positive feedback to prompt users toward healthier behaviors (e.g. prompt a user to visit a nearby coffeehouse instead of staying in on a Saturday).



Mobilyze Data Entry and Prompt
Image Credit: http://pop.h-cdn.co/assets/cm/15/06/480x360/54cfd0f781fad_-_smartphone-shrink-01-0212-de.jpg

As mHealth becomes increasingly integrated into care, tools should also seek to improve clinical decision-making on the part of healthcare providers. Kamal Jethwani remarked on the need to better train healthcare providers about how to use data generated by mobile devices, to create functions that deliver data in formats which support clinical action, and to incorporate mHealth data into existing workflows such as EHRs. Like A-CHESS, many mHealth interventions approach the issue by triggering actionable alerts for members of a user's care team. T2 recently received funding to incorporate Moodtracker into a clinical program that would extend the application's functionality to automatically alert a care team when scores hit a particular threshold. Welldoc offers a host of healthcare provider-centric tools, such as clinical decision support, reporting, and analytics to track trends in user data.

Share Information for Social Support

Technology advances have created new pathways for individuals to connect with one another on a global scale. In healthcare, social media and online peer networks can support information sharing, peer-to-peer communication, patient-provider communication, and motivate behavior change. Social support has been shown to help patients reflect on their

condition, improve accountability for achieving goals, and improve their psychosocial well-being.[xxvi] mHealth tools frequently incorporate social components to foster the types of supportive environments that help create a sense of community and competition to drive healthy behaviors.

The cornerstone of the Robbin application is its social networking features. The Trimbos Institute's Director of Innovation & Health IT, Katherina Martin Abello, summarized these as, "once you open Robbin, it displays a mood wall where people can share with each other thoughts, exercises, information, and experiences – similar to Facebook posts, likes, gifts, and comments." Martin Abello believes that by incorporating these components of peer motivation, people are more likely to use the application instead of turning to other platforms like Facebook or Twitter for information or support.

A-CHESS, Dacadoo, and MyQuitBuddy also leverage social networking. One of A-CHESS's most successful features is the ability to define a peer group which will be notified when a user is identified as having a high risk of relapse. This both increases a user's accountability to others and offers an opportunity for trusted peers to intervene to help prevent risky behavior. Dacadoo can show a user's health score in comparison to others to encourage friendly competition, especially among specific groups using the application like employers who promote corporate wellness programs within their organization. MyQuitBuddy features an online forum for information sharing and motivation. Participants can discuss strategies for quitting smoking and encourage others to continue to avoid cigarettes.

Motivate & Coach

By tailoring content to a user's individual circumstances, mHealth tools can enhance the value of educational information and tracking functionalities to guide users toward healthy decision-making. Using a consumer's data, rather than sending generic messages of support, can increase resonance with the user and raise the likelihood that they will act. Other tools seek to motivate users by enabling them to set goals or by rewarding specific behaviors.

Text4Baby features interactive tools to deliver more tailored content, such as a flu shot reminder that prompts a user to respond with a reason if they don't intend to obtain a vaccination. If the user replies that the shot is too expensive, for instance, the service will reply with information about where to find low-cost or free vaccinations. The Partners HealthCare Center for Connected Health's diabetes management program sends highly

personalized motivational messages to users. Messages are personalized to the extent that they take into account a user's activity for a given month. One might say 'Great job this month! We saw that you had really high activity over the past few weeks but right now seems to be a low week. Here are a few tips to get back into action.' According to Kamal Jethwani, "Hyper-personalization was one of the features that were most compelling for patients because they wanted to stay on track to avoid disappointing the perceived human being."

Likewise, Chris Bergstrom emphasized the impact of Welldoc's coaching features. "Every time a patient enters data, they receive information back immediately through real-time coaching or personalized feedback." Even when users aren't actively entering data, Welldoc's platform is analyzing longitudinal results to deliver new information. In a controlled trial comparing Welldoc's coaching alone to coaching combined with clinical decision support for healthcare providers, blood glucose levels improved for both groups (the combined arm improved by a greater amount) leading Bergstrom to conclude, "Patient coaching on its own is effective. We can tell physicians that if they don't have the time or resources to apply decision support within their workflow, they can just start with the coaching feature of WellDoc for their patients and it's still going to help them."

Additionally, tools like Dacadoo and MyQuitBuddy employ gamification techniques to motivate their users. Dacadoo mixes health score benchmarking and personalized notifications with the ability to publicly unlock achievements and awards. MyQuitBuddy includes social gamification elements to share progress with others and measure personal progress against past quit attempts. Upon opening the app for the first time, the user is prompted to set a target quit date. Jennifer Wilson credited these features with repeated use of the application, even when the user is unable to quit smoking after the first attempt: "We find that when people slip up, they often don't restart the app initially but then come back to it later. Successful people might have had to make two or three attempts, but they kept trying with the app."

Dacadoo Achievements

Image Credit:
http://info.dacadoo.com/product/engagement/

Challenges and Barriers

As a growing industry, mHealth faces a number of barriers and challenges, not least of which is the difficulty of demonstrating outcomes. Research on mHealth effectiveness – if it occurs at all - often occurs in small pilot tests, trials, or programs that are not always feasibly designed for wider deployment. To date, evaluation frameworks have not been standardized, making it difficult to systematically measure design, effectiveness, or scalability at a population level.[xxvii] Recent systematic reviews have also suggested that most mHealth studies do not employ high quality methodologies and few are able to consistently produce significant clinical benefits.[xxviii]

Untested

Despite the popularity of mHealth apps, more than 95% remain untested in a clinical setting and are not yet fully regulated by the FDA.[xxix] Of the 16,000 mHealth apps, more than half have been downloaded fewer than 500 times, with only five apps accounting for 15% of all downloads.[xxx] It is difficult for current scientific evaluation methodologies to build an evidence base and keep up with the pace and volume of apps that are regularly introduced to the marketplace. The traditionally slow pace of research approval, development, and implementation could not contrast more with the rapid, agile, iterative world of technology, design, and innovation in which many mHealth developers reside.

Difficulty Comparing Products

On the consumer front, it is also difficult to discern the quality of one product compared to another. With so many products (such as apps) to choose from and so little data from which to base their decisions, consumers are left with few other options but to rely upon word-of-mouth or consumer rating schemes. However, there currently is no consensus on how to rate apps, much less a composite score that would address different aspects of a tool (e.g. usability, impact on health, incorporation of evidence-based theories or models, etc.). Early efforts by some organizations such as Happtique have attempted to curate a library of certified and recommended apps for specific use cases – however, to date these initiatives have largely proven unsuccessful. In Happtique' s case, their efforts to create a certification program for health apps have been setback due to a number of security flaws identified during random evaluation process. Nonetheless, there is a clear need for an authoritative body of experts to provide guidance in the marketplace; more than 34 percent of cellphone users recently reported they would increase app use if doctors actively recommended it.[xxxi]

Privacy and Security Concerns

Furthermore, concerns about the privacy and security of mobile tools may limit adoption. Fewer than one-third of the 600 most popular health applications in the iTunes and Google Play stores have defined privacy policies, and 66 percent of privacy policies do not focus on the app itself, but on a developer website, all services offered by a developer, or topics unrelated to the app.[xxxii] Because apps frequently access or store user data, they are at risk for potential damage in the event of privacy or security infringements such as data manipulation or leaks.[xxxiii] All four case studies touched on the importance of maintaining patient privacy given the lack of regulation of mHealth tools.

Incorporating into Provider Workflow

Like consumers, healthcare providers must also contend with limited information about the design, usability, effectiveness, and protective policies of mHealth solutions. In addition, mobile data presents new challenges to healthcare provider workflows. Existing health information systems, like EHRs, are not usually designed to integrate data from mobile devices. If a healthcare provider wants to view data generated by a patient, they would have to use a separate application or system, potentially interrupting the established workflow. According to Katherine Martin Abello at the Trimbos Institute, "Instead of investing resources, staff, and money into the creation of content, you have to instead focus on interoperability and technical aspects to make sure the app works with specific systems that a user or professional might own."

Funding

Finally, funding is another notable issue, for both healthcare providers and developers. Current reimbursement structures rarely compensate healthcare providers for care delivered via mobile tools. As such, healthcare providers lack financial incentives to test and use mHealth. For developers, creating a mobile tool and demonstrating its effectiveness can be a costly and time-consuming process, particularly when the tool is aimed at supporting a specific user population. Robbin is designed specifically for breast cancer patients. In the Netherlands, where the Trimbos Institute is located, there may only be 1,500 cancer cases a year. Even if each patient paid $2 to download and use an app like Robbin, it wouldn't generate much revenue to reinvest or further develop new technologies.

Toward the Effective Use of mHealth: Recommendations

Despite these challenges, it's likely that mHealth will continue to play a more prominent role in healthcare in the future. The sheer number of consumers that can be reached via mobile devices suggests mHealth has vast potential to spread high-quality information and contribute to healthier consumer behaviors. Tools that are careful to utilize evidence-based practices continuously test for efficacy, offer features and functionalities to drive use and motivate consumers, and clearly outline policies for protecting user information will be well poised for adoption by both consumers and healthcare providers.

Even in its early stages, mHealth holds the potential to drive the evolution of healthcare by democratizing healthcare in a way that brings the power of knowledge and technology to the hard to reach masses using the widespread access, affordability and customization of mobile devices and apps. In order to continue this trajectory, the following recommendations should be adopted:

Investment in Research

mHealth tools and apps have demonstrated early promise in terms of empowering consumers to better manage their health, make better health choices and provide their healthcare providers with a more complete picture of their lives outside of their offices. However, additional research and testing is needed to better determine the efficacy of mHealth tools in terms of accurately treating and managing chronic health conditions.

Regulations and Certifications

As mHealth tools and apps begin to play a more prevalent role in terms of managing consumers' health, some government regulations may be necessary. The Food and Drug Administration (FDA), Office of Civil Rights (OCR) and the Federal Trade Commission (FTC) should play a role helping to ensure clinical efficacy and protection of individual health data need to be in place. However, it will be critical to maintain a balance to ensure policy does not stifle innovation. In addition, the current marketplace also has no mechanism to certify patient-generated data. Patient-generated data could be extremely valuable in the care and treatment of individuals. There is a need to explore the appropriate use and acceptance of patient-generated data into provider records.

Reimbursement

Private payers are beginning to explore alternative payment models to reimburse providers for their use of mHealth tools. Currently, there is no known reimbursement structure in place by the Centers for Medicare & Medicaid Services (CMS) to reimburse healthcare providers who engage and utilize mHealth tools and apps to make clinical decisions. The expansion of mHealth into the healthcare delivery system will require a new reimbursement model to support and compensate healthcare providers for the time and resources required when using these tools and apps; and to accept process and make use of the information they produce.

Tools for Consumers to Make Informed Decisions

Increased health literacy is needed as consumers become more empowered over their own health. In order to make better informed decisions, consumers need to have access to information that is provided in a clear and understandable way; and in a way that is embeds good health practices into day-to-day life. It is also recommend that a ratings system of mHealth tools and apps to increase the ability of consumers to make informed decisions based on clinical efficacy be developed and maintained.

Continued Monitoring

This paper demonstrates early indicators of success in the mHealth space. However, these early successes largely occur within a controlled environment. It is important that ongoing annual reviews occur that can help to assess trends and identify likely future scenarios that are desirable to improved health outcomes versus future scenarios that could be negative or dangerous. Because technology, social practices and science evolve and change so quickly, their impact on mHealth is very difficult to predict. Continued studies of the marketplace can help us focus on positive advancements and discourage or regulate against negative developments.

Conclusion

Mobile technologies have emerged as one potential avenue for impacting behavior change by empowering consumers with tools they can use to support healthier lifestyles and disease management outside of traditional healthcare settings. With continued funding, research, education, and establishing the right balance of the ease of sharing health data against privacy and security regulations, mHealth could play a key role in bringing consumers and healthcare providers together to jointly address reaching the triple aim goals of the healthcare industry. In today's society we have seen have mobile devices have changed the way we manage our schedules, finances and personal relationships – how we manage our healthcare should be no different.

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APPENDIX A

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