# Empowering the Aging with Mobile Health: A mHealth Framework for Supporting Sustainable Healthy Lifestyle Behavior

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**Abstract: Healthcare providers are shifting to a value-based model that acknowledges the importance of a healthy lifestyle for managing chronic disease and mental health. This approach empowers patients to adopt and/or sustain healthy lifestyle choices through the use of innovative technologies—providing beneficial ways of delivering health literacy, self-monitoring, and patient–provider collaboration. Such pathways have the potential to enable healthy lifestyle management for a growing U.S. cohort—the "baby boomer" generation (BBG)—who are at risk for developing heart disease, stroke, arthritis, high cholesterol, and diabetes, etc. In this paper, we argue for a new mHealthy lifestyle management (MLM) model that uses mobile health technology as a means to engage BBG consumers in ways that establish their role in self-care and decision-making, as well as patient–provider collaboration that can significantly impact sustainable healthy lifestyle behaviors. By merging the domains of health informatics and human factors psychology, MLM addresses the complex challenges associated with patient–provider collaborative work, while offering a healthcare framework to BBGs in their quest to self-manage a physical and/or mental healthy lifestyle. A MLM use-case highlights the challenges and**

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**solutions for team-based clinical counseling. Finally, recommendations for future MLM tools are outlined that support patient access to personal health eTools, information, and services. (Curr Probl Cardiol 2019;44:232–266.)**

## Mobile Health Support for Healthy Lifestyle Management

In the rapid evolution of healthcare, patients continue to ask providers to shift from volume-based care (ie, fee for service) to a value-based reimbursement structure (ie, fee for value), which is a "population health" approach.[1] However, for healthcare providers to shift to such a model, a clear understanding of the relationship between population health and healthy lifestyle management (HLM) is required. Such an approach not only benefits the patient, but incentivizes providers and healthcare services to deliver quality care (at the lowest cost)—while providing patients a lifestyle management approach with the greatest potential to improve their personal health.

Synonymous to HLM refers to a systematic and personalized approach to the management of chronic diseases, such as coronary heart disease, diabetes, hypertension, etc. Stonerock and Blumenthal (2017) state that "although there have been significant advances in the prevention and management of chronic diseases, it is widely recognized that an unhealthy lifestyle (ie, health behaviors such as smoking, dietary habits, and physical inactivity) plays an important role in the onset and course of many chronic diseases." They argue that although physicians may prescribe behavioral changes, "getting patients to actually adhere to these recommendations can be quite challenging. Moreover, even when effective pharmacologic, behavioral, and psychological interventions are available, motivating individuals to initiate and maintain lifestyle interventions can be difficult" (Stonerock and Blumenthal, 2017).

With a commitment to the goals of HLM, the extraordinary proliferation of mobile devices (to improve healthcare outcomes) has provided increasing promise for patients and healthy lifestyle seekers.[2] For example, as societies worldwide address the need to care for their aging population, they are increasingly look to mobile health (mHealth) as a means to assist with access to health services, particularly for impoverished and rural populations that are managing chronic conditions.

We propose that mHealth will play an increasing role in engaging patients in HLM,[3] as well as for motivating them to actively participate in their medical care and long-term personal healthcare management. U. S. Census Bureau data reveal that those 65 and over will rise from 40 million in 2010 to 72 million in 2030.[4] While the United States is currently focused on access to care, other countries view mHealth as having the potential to build health-centered communities and reduce healthcare expenditures. Across Europe and China, and within other developing countries, mHealth is viewed as a solution to expand healthcare delivery and address a variety of health-related issues experienced by an aging population.[5,6]

The problem is that many providers have not yet moved beyond legacy solutions formulated from the perspective of regulatory requirements for patient engagement.[7] There are, however, new approaches that can empower patients to adopt and sustain healthy lifestyles through the use of innovative technologies—providing beneficial ways of health monitoring and patient−provider collaboration, with increasing health literacy. Such pathways to wellness have great potential to enable, as well as expedite HLM, which is especially critical for a growing cohort of the U.S. population—referred to as the "baby boomer" generation (BBG), those born from 1946 to 1964.[8−10] According to the U.S. Census Office, 78 million baby boomers (and 34 million of their parents) are at risk for developing chronic diseases, such as heart disease, stroke, arthritis, high cholesterol, diabetes, and allergies.[11] Because age is associated with deteriorating health, over 60% of BBG have already been diagnosed with at least one chronic medical condition.[12] For example, the Centers for Disease Control and Prevention (CDC), report that by 2017, the percentage of adults with diabetes has increased with age, reaching a high of 25.2% among those aged 65 years or older. CDC also reports that the total diabetes cases for 45-64 is currently 14.3 million, with 12 million among those greater than 65.[13]

Due to a number of factors, such as healthcare reform, higher costs for healthcare services, and the ever-expanding population of an unhealthy BBG, a "perfect storm" is forming that is contributing to an unprecedented need for transformational change in healthcare delivery. The need is urgent, while the opportunities are great as to how emerging technologies can be brought to bear in yielding truly impactful advances in patient self-care. For example, compelling new evidence in mHealth research is pushing the boundaries of how to both engage and empower patients and/or consumers in ways that establish their role in the area of self-monitoring—a central activity in care-team collaboration. Such

engagement will embed the self-health decision-making process as an established practice within a broader healthy lifestyle framework. Recognition that BBG patients need to be engaged in their own healthcare is a first step in the direction of reassigning and redesigning the interactions between them (as consumers) and their healthcare providers.

In this paper, we propose an integrated model by which mHealth, as one (of several) healthy lifestyle solution, holds considerable promise in empowering BBGs as they attempt to sustain a healthy lifestyle behavior throughout their lives.[14] The framework we propose addresses the complex problem space of patient and provider collaborative work. Such work embodies the vision that through merging domains of healthcare information management and healthcare human factors, BBGs can be supported in their quest to self-manage a healthy lifestyle. In the context of HLM, we give particular attention to healthy lifestyle choices[15] that can lead to better self-management of physiological and psychological disease, as well as cognitive processes that can support healthy lifestyle behaviors. We also highlight research gaps around understanding the target audience, their health needs, and contexts of mHealth use. Such an approach is multidisciplinary,[16] from the research disciplines of health informatics, public health, and human factor psychology.

## Who is the Baby-Boomer Healthcare Consumer?

The CDC describes the BBG as a relatively affluent part of a growing middle class, and as active and physically fit. Interestingly, however, they are also considered as placing a strain on social welfare and the healthcare system—particularly, an economic burden to the younger generations.[17] It is also reported that BBGs tend to deny issues surrounding their own aging. For example, they do not see retirement as a time to slow down, but rather as a chance to lead a more meaningful life, find fulfillment, and do things they have always wanted to do (Gillon, 2010)[94]. Furthermore, due to their relative affluence, they express preferences for their own healthcare needs in ways earlier generations never conceived. At each life milestone, BBGs are influencing change—not only because of the size of the cohort, but because of their demands as consumers of healthcare products and services.[18]

While the oldest BBGs have already retired, are on Medicare, are more likely to have health and disability issues, are less affluent, and have more time available to manage their health needs—the younger of the BBGs are still employed and tend to be more economically stable, regardless of the fact that health insurance continues to be a top concern[19] (Smith,

2014). In addition to the increasing influences of health consciousness in the United States, this younger group is more focused on preventing chronic conditions through adoptive technologies, rather than managing them through the existing healthcare system.[20]

Even though BBGs have been exposed to more technology than previous generations, their receptiveness to all available health technology is uncertain.[21,22,20] Other research, however, suggests that BBGs are ready to accept innovative health technologies, such as the use of smartphone apps and mobile devices, websites to obtain health information, and home monitoring for limited time periods.[21] This is supported by a recent report by the Pew Research Center that states that 76% of persons aged 65 years and above own a cell phone (smartphones, 18%), and 48% of those 75 and older own a cell phone.

We argue that there is still-to-come, an overwhelming interest in personalized health services and the adoption of mobile health technologies that facilitate independence and an active lifestyle. For example, the field of consumer health informatics recognizes that ultimately, BBGs are consumers of the healthcare products and services, as well as healthy-lifestyle seekers and beneficiaries of advances in health information technology (HIT).[24] Similarly, consumer health informatics researchers (and the eHealth technologies they design) are increasingly collecting and analyzing health information to identify BBG health needs.

To this point, BBG health needs are a priority, as well as their empowerment as health consumers. In this way, their transition to healthy behaviors will provide added prevention and confidence in their quest to successfully self-manage chronic conditions via the most advantageous healthy lifestyle choices.[25] This effort will increase their accessibility to health data,[26] and integrate research outcomes into a healthcare information system that supports health-related decision-making.[27] Hence, the goal is to afford quicker solutions to improving BBG health by aggregating, visualizing, analyzing, understanding, and applying patient health data.[28]

## mHealth Technology

Smartphones have obtained a special status, being an influential force in human and societal development—oftentimes being indistinguishably interwoven with every part of people's daily activities. For this reason, the ubiquitous nature and functionality of mobile devices, is challenging our prior assumptions about their role in shaping personal health. As such, we should identify them as HLM tools that have the potential to

transform the way people take ownership of their health. For example, the success of MyFitnessPal, and mobile apps like it, is due to their ability to evoke motivational behaviors through self-monitoring, which from a patient's perspective embody the principles of *engagement*, *empowerment*, and *sustainment*.[29–31]

mHealth refers to health-centered mobile computing that includes wireless, medical sensor and communication technologies, and applications (apps) that are used in smartphones, tablets, and other mobile devices.[32] Currently, the function of mHealth technology includes chronic disease management, wellness planning, health promotion, among others. Depending on the app, mHealth supports health-related activities using both text messaging platforms, apps, sensors that track vital signs and health activities, and cloud-based computing for collecting and analyzing health data. A 2014 report from the Research2Guidance (2014) Research Group (2014)[99] notes that mHealth mobile apps have more than doubled over the last two and a half years, reaching more than 100,000 apps.

mHealth serves a variety of purposes, with functions that depend upon the technology type and consumer population. Each function is associated with an array of interactive tools that allow the patients to access their health data in multiple forms. These functions include diagnostics, event tracking, data collection, decision support, communication, and education.[33] Although the range of tools highlights the expert-level of the mHealth user, the tools are often generalizable to match the needs of the specific patient–consumer. These functions are also designed to support a collaborative relationship between patients and providers. Ultimately, the intention of their working relationship is to support patient progress, particularly in becoming activated and empowered in the management of sustainable healthy lifestyle behaviors.

## A Case for Patient Empowerment—*The Sustainability of Healthy Behavior*

Although progress has been made through the use of patient portal technologies and ad hoc interventions to increase health literacy,[20] there is an imperative need to enhance our views on HLM. To do so, we argue that there is a need to move toward patient empowerment as a sociopsychological construct, with mHealth as a powerful influencer of health behavior.[34] We argue that consumer health technologies, such as mHealth, be increasingly leveraged to produce patient motivation that leads to constructive health actions. That is to say, a life-long healthy lifestyle can only be achieved through perpetual engagement, leading to

sustainable healthy behavior. Such long-lasting empowerment can then directly impact one's daily lifestyle with regard to food choices and nutrition, regular exercise, cognitive and behavioral therapy (if needed), and overall health management and planning.

For example, research continues to show the strong correlation between chronic diseases and depressive disorders. Reports predict that by 2020, "depression is expected to be second only to heart disease as a source of the global burden of disease."[35] As such, acknowledging their relationship is important to providing quality healthy lifestyle management care. In sum, patient engagement requires the support of providers and healthcare organizations to: first, understand the personal needs, complexities, and contextual factors that affect a patient's health choices[36]—and second, a vision and commitment to applying mHealth as an essential tool in patients' progress in achieving their holistic goals of healthy lifestyle practices.

## *Engagement*

Although patient engagement is widely recognized as one of several factors for successful population health management, research outcomes have been limited and inconsistent[37,38] (Pray et al., 2013).[98] Merriam-Webster (2018)[102] defines, to "engage" (for engagement) as "holding one's attention and inducing one to participate." Engagement in personal healthcare management may include activities such as reading, understanding, and acting upon the health information received. This form of health literacy provides the impetus for working more effectively with their primary care physician in identifying appropriate HLM options. Such shared decision-making can have considerable impact on the quantity and quality of care outcomes.[39]

Current measures of patient engagement have often shown to be subjective, tapping into patient levels of satisfaction, and perception of decision-making, rather than the impact and outcomes of their participation.[40] Studies also suggest that barriers to productive engagement may be low health literacy marked by a general lack of knowledge and understanding of personal health. Conversely, research has demonstrated that patient-centered communication and active engagement of patients and families (in the process of planning and implementing change) are associated with improved healthcare management, greater clinical effectiveness in primary care,[41] and overall improvement of population health. Hence, it is critical to support patient health engagement through credible and accessible information, as well as families in their role as caregivers and motivators of a healthy lifestyle.[42]

## Sustainment

The ultimate goal of patient engagement is the sustainment of a living that is centered on healthy choices throughout the life of an individual. Sustainment is the long-term maintenance of health management behaviors.[43] Research suggests that sustainment of healthy behaviors is necessary for reducing costs and reaching desired health outcomes−−both of which influence patient experience.[44,45] Hence, given the challenges around engagement, HLM has placed limited emphasis on the sustainability of a healthy lifestyle. Nevertheless, the notion of sustainment is not a new concept in the addiction literature. In such applications, it is key to relapse prevention for smoking, drug, and alcohol use.[46] Sustainment refers to an ongoing effort on the part of the patient to make decisions about their health, whether in service of maintaining a healthy lifestyle or managing chronic illness. Current literature suggests that patients who face day-to-day responsibilities of self-care may develop a deeper knowledge about their condition,[47] which is needed to support an engaging and sustainable healthy life.

## Empowerment

The theory of empowerment, in the context of attaining key health goals, suggests a need to leverage one's personal and social-context of resources. Empowerment might also include an awareness of the need to participate in health care decisions.[48] As noted, health literacy and knowledge can be a factor at the core of empowerment. Researchers have examined the hand-in-hand relationship between knowledge and empowerment.[49] This suggests that knowledge is a critical component to empowering the patient to take an active role in healthcare decision-making. If engagement refers to a patient's active participation and sustainment refers to the long-term maintenance of that participation—then, empowerment should embody the necessary self-enabling that one must acquire for a protracted life of health and wellness.

The primary contextual influencers of empowerment include: (1) personal motivation related to access to health information, health literacy, and health preferences, (2) social support systems and online communities, and (3) environmental opportunities that enable patients to ask questions, acquire options, and make decisions. Potentially, all aspects of the patient context can be directly impacted by mHealth. Given the aim of mHealth to provide functions associated with information delivery, it is a technical means for patients to more rigorously interact with online communities and to collaborate with healthcare providers. Moreover, it is

critical to understand how mHealth technologies can work effectively to empower patients, especially as they age and increasingly need specialized care services.

Finally, we argue that patient empowerment is a prerequisite for patient participation, activation, and sustainable healthy behaviors. Patient activation can best be characterized as an incremental journey that lasts a lifetime rather than as a binary condition—that is, when a patient "is or is not" compliant. Activation occurs when a patient and their care team have bidirectional communications regarding health needs and a mutual agreement of health goals—both of which lead to collaboration and participatory decision-making. Since health providers only have intermittent interaction with patients, traditional models of care are not sufficient to support patients in sustaining day-by-day healthy lifestyles.

## The mHealthy Lifestyle Management (MLM) Model—*An Integrated Approach*

When addressing MLM, researchers often speak about the behaviors associated with these activities.[50] However, behaviors are just the outward observable actions taken within the world. What is critical is the cognitive processes that take place in the thinking of those who seek to improve their health.[51] Even with appropriate reasoning, patients often struggle with the necessary motivation to arrive at their desired behaviors. The field of psychology has long recognized that examining outward behavior is insufficient for understanding human decision making—and thus, offers a valuable perspective on engagement and sustainable behaviors.

At the core of human factor psychology, researchers recognize that complex systems are comprised not only of the individual, but the context (or environment) in which the individual's work takes place.[51] Historically, healthcare human factor psychology has focused on the cognition and/or behavior of providers. More recently, however, researchers have extended their interests to include the patient as an active participant in the healthcare system.[52,53] As such, a "systems perspective" highlights the context in which an interrelationship exists between patient cognition and patient behaviors.[34,54] By understanding cognition, context, and the reasons why patients become engaged and/or motivated in healthy lifestyle activities, we can receive considerable insight into the barriers they face in sustaining such practices.

Lippa, Klein, and Shalin (2008)[96] highlight the need for understanding patient cognition when examining and attempting to influence behaviors.

They found that those with poorly controlled glucose struggle with self-management behaviors, stating that failure to achieve such control appeared to "stem not from lack of motivation or intelligence, but rather from insufficient understanding of self-care." For example, they note that "participants did not understand the role of exercise in glucose control and therefore were unmotivated to increase their level of exercise" (p 85). They later argue that these patients exemplify three trends found in the cognition of poorly controlled self-managers: (1) "oversimplification of rules (ie, bread is bad; vegetables are good), (2) poor understanding of the purpose of recommended self-care, and (3) little understanding of the functional dynamics of glucose control" (p 85). This study emphasizes the need to capture patient cognition (in this case, comprehension of their disease) to understand behavior.

Our multidisciplinary approach to addressing this complex problem space of patient and provider collaborative work includes the merging of two perspectives. Below, we present two models from the domains of (1) healthcare information technology and (2) healthcare human factors—from which we construct an integrated framework.

## *The Healthcare Information and Management Systems Society (HIMSS) Patient Engagement Framework*

The *Patient Engagement Framework,* proposed by the National eHealth Collaborative and HIMSS,[55] depicts the patient journey across a five-step eTools continuum of engagement related to the meaningful use of eHealth (see Fig 1). The process begins with the lowest level of engagement (*Inform Me*) through receiving information, and ends with the final destination of healthcare providers supporting e-communities (*Support My eCommunity*). From the most basic forms of patient education, to engaging patients to employ positive healthy lifestyle behaviors that require specific actions, to self-care functions that enable the patient to both monitor and manage their health, to empowering patients to collaborate with a variety of healthcare providers that are invested in their personal health choices.

The theoretical underpinning of the HIMSS framework holds that a successful healthcare system is the effective engagement of the patient in their healthcare. Strengths of the model include its progressive step-by-step layering of support that leverages a diversity of HIT and a range of human and health systems. What the framework overlooks, however, are contextual influences and the nonlinear nature of one's progress as a HLM patient. Such factors have an impact on successfully progressing

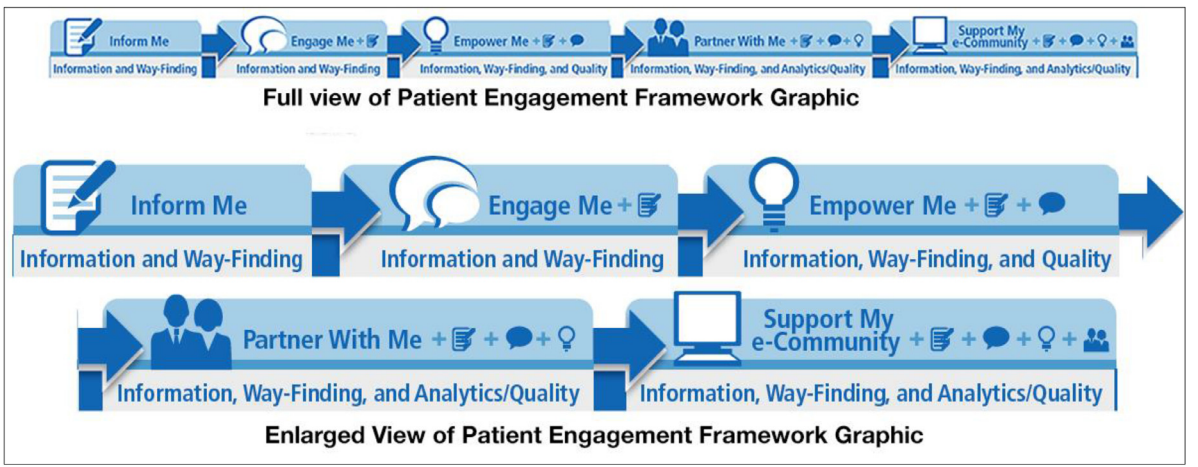


**FIG 1.** Functions of mHealth from the Patient Engagement Framework,[55] 2014.

through the model. In other words, multiple environmental factors can affect patient progress, which are not addressed in the HIMSS framework. To bring the model more in-line with the real-world patient experience, we sought out the Systems Engineering Initiative for Patient Safety 2.0 (SEIPS 2.0) model, first proposed by Holden and colleagues.[52]

Even 3 years after the release of the HIMSS Patient Engagement Framework, many healthcare organizations are not far beyond the first stage of "Inform Me." According to a recent report, *KLAS Patient Engagement 2016*,[56] the organization's effort to engage patients has not yet significantly impacted patient health. Instead, many organizations are still focused primarily on meeting administrative goals (eg, government regulations, staff efficiency, etc.) rather than empowering patients with a range of available eTools that can improve health outcomes. Patient portal technology has been adopted by 94% of the participants in the KLAS study, but only 17% reported that such portals have had a significant impact on patient health.

## The Role of Systems Engineering in Patient Safety

Cognitive systems engineering (CSE) [51] and human factors have a tradition of studying system complexity by putting humans at the center of the environment, which is often marked by technology, people, and work (or human activity). Examples of theories, principles, and practices include situated action,[57] naturalistic decision making,[58] distributed cognition,[59] and others. Suchman, in presenting her theory of situated action, notes that the physical and social aspects of the environment shape human activities. She was specifically concerned with dynamic environments that include human−technology interaction—laying the groundwork for subsequent work in complex systems. One such model is SEIPS 2.0, which is in line with the CSE tradition. (For graphic, see N764JMILLER (2015).)

SEIPS 2.0 identifies both the patient and healthcare providers as central in the work system. SEIPS 2.0 was specifically designed to account for patient engagement in consumer HIT and introduces the concept of patient activities or "work." The model recognizes three types of work processes: (1) professional work, in which patients and families are not actively involved, (2) patient work, in which healthcare professionals are not actively involved, and (3) collaborative patient−professional work. Collaborative work represents activities in which professionals and nonprofessionals work together. In addition, by representing a feedback loop, SEIPS 2.0 suggests that processes and performance within the system are

not linear. As a validated human factor model for healthcare, SEIPS 2.0 has been embraced by both patient safety administrators and educators.[60–63] The model has also been useful in analyzing cases of medical error or harm and to identify contributing factors from the seven system categories: organization and management, work environment, team, task, individual, patient, and external environment.

SEIPS 2.0 is based on evolving healthcare trends that account for patient engagement in consumer health IT. The system structure was modified to identify, among other things, both patients and healthcare professionals as key agents in the work system. SEIPS 2.0 has three foci: (1) *Systems Oriented*—human (health) performance outcomes are the result of interaction with the sociotechnical system in which the person lives, (2) *Human-Centered*—both individuals and groups of people are central in a healthcare work system, and as such, efforts must be taken to support people throughout the work system design process that best fits their capabilities, limitations, performance needs, and other characteristics, and (3) *Design-Driven*—human-centered design (*and improvements*) of activity structures and processes, when grounded in validated human factors science and practice, can improve patient, provider, and organizational outcomes. Also, the notion of leveraging one's personal resources is also consistent with how empowerment is defined by the Systems Engineering Initiative for Patient Safety (SEIPS) model,[64] particularly regarding the influence of internal and external forces on human behavior.[49]

Despite the existence of many effective methods to design mHealth for patient, professional, or patient–professional work, the implementation of these methods is challenging. Specifically, patient-reported information may be a function of health literacy and patient activities may be emotionally laden, embarrassing, or difficult to self-report—making reliability and validity a concern. They may occur frequently and/or on an ad hoc basis (eg, an unplanned snack), in private places, and at all hours of the day and night. Holden et al.[97] describe these and other challenges[65] as well as mitigating strategies.[66]

## The Integrated Model: mHealthy Lifestyle Management

We propose an integration of the SEIPS 2.0 and HIMSS models. At the core of the *Work System* is the HIMSS framework, depicted by a spiral (N764JMILLER (2015)). The *persons* and/or *patients* are the starting point and center of human activity. All health-centric activities begin here and continue around the spiral through each of the five HIMSS eTool stations. As noted, the HIMSS framework includes five layers of

increasing complexity, with linear processes that support iterative patient engagement. At the same time, the HIMSS spiral is embedded within the three SEIPS 2.0 sections, including—the Sociotechnical Environment (outer circle) representing the work system (1), which moves into Performance and Processes (2), and finally, to Collaborative Outcomes (3)—with the option of utilizing the feedback loop for any necessary adaptation of the process.

As outlined by Holden et al., and followed by our integrated model, *person(s)* are central to the work system emphasizing that design must support human activities.[67] Specifically, in patient-centered healthcare, person(s) represent individual clinicians, patients, family caregivers, etc., as well as groups or teams of clinicians, family members, faith-based communities, mental wellness counselors, etc.—all of whom do the "work" of managing patient well-being, whether related to physical or mental healthcare tasks.

In addition to person(s), we have reduced the Sociotechnical Environment (Work System-1) to four basic factors: (1) *Health Tasks*, include human actions within the greater work process, regardless of their difficulty, complexity, or range of variety. (2) *Health Tools and/or Technologies* are the artifacts that people use during their activities to assist in the activity, for example, in the healthcare domain this would include health information technologies, medical devices, mobile health applications, including their design, usability, accessibility, automation, portability, ubiquity, and functionality. (3) *Health Organization(s)* refers to external entities and/or institutions that influence work schedules, staff management and training, policies, and resource availability, community groups, communication infrastructure, living arrangements, family roles and responsibilities, interpersonal relationships, culture, social norms, and rules. (4) *Health Ecosystems* include the internal environment, referring to the physical environment: lighting, noise, temperature, physical spaces, and air quality, and the social environments. Here, external environment refers to the ecological and policy factors, as well as a number of external forces that can impact performance outcomes.[52]

Given that SEIPS 2.0 is a framework that highlights system complexity and HIMSS focuses on patient engagement (via mHealth), the two models are complementary, filling in the gaps for one another. As is summarized in **Table 1**, we describe HIMSS as a model that addresses the question of What?—based on its focus on technology as a vehicle for patient engagement. We also label the SEIPS 2.0 model as How? and Why?—as it focuses on processes (How?) and contextual features (Why?). We present this comparison to illustrate the complementary

**TABLE 1.** Contributions from HIMSS and SEIPS 2.0

| Integrated models | HIMSS What? | SEIPS 2.0 How/Why? |
|---|---|---|
| 1. Concrete, specific examples of "Work" | X | |
| 2. Explicit definition of what is a process or outcome | | X |
| 3. Person-centric | X | X |
| 4. Complex sociotechnical system | | X |
| 5. "Work" is continuous | | X |
| 6. Technology-centric | X | |

fashion in which the models integrate—further strengthening the argument that a multidisciplinary perspective is key to understanding complex healthcare problem spaces, particularly for the aging and/or those with chronic and mental health diseases.

**Figure 2** illustrates the MLM model—feedback loop, which is an integration of the HIMSS and SEIPS 2.0 models. To align with the cyclical nature of the HLM process, we used the (black and gray) spiral and circle to visualize the HLM process, which augments the SEIPS 2.0 framework. Also, we added the central form of the black spiral to signify the increasing levels of patient sustained engagement, as described in the HIMSS framework. MLM is the fusion of individual and system healthcare factors.

Using **Table 2**, we further explored the convergence of the HIMSS and SEIPS models by overlaying, comparing, and identifying their relation to meaningful use—specifically to mHealth applications to professional work, patient work, and collaborative work. Specifically, Table 2 depicts how each of the five stages of HIMSS align with each "work type" of SEIPS 2.0. That is, the table represents the HIMSS levels (along the vertical) and mHealth examples with healthcare professional, patient, and collaborative work (along the horizontal). Evident from this representation is the role of the patient (as consumer) at each of the five levels.

# Applying the mHealthy Lifestyle Management Model

## *Contextualizing the Design of mHealth for the BBG Consumer*

Despite the prevalence of mHealth consumer technology, mobile health designers continue to struggle to recognize their target audience. In part, this is due to challenges that researchers face in grasping the complexity of user needs and requirements from a human factors

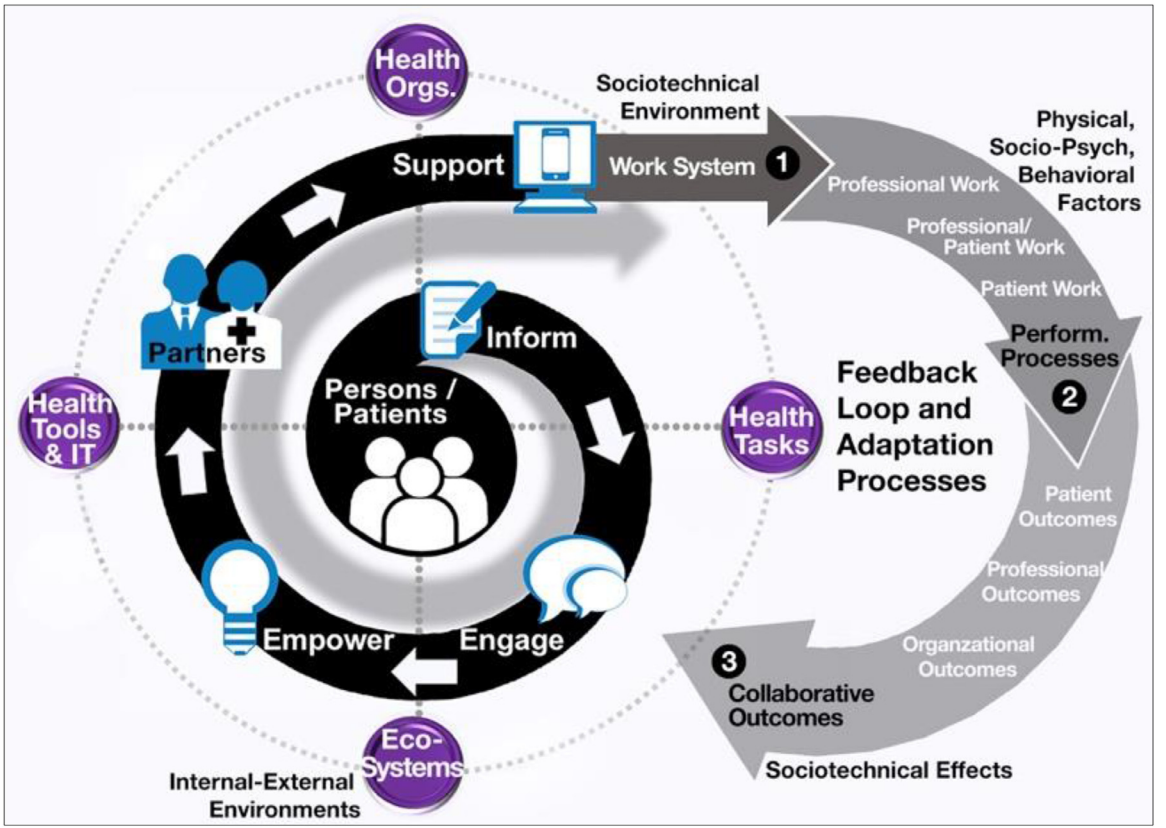


**FIG 2.** Illustration of the mHealthy Lifestyle Management Model—feedback loop: an integration of the SEIPS 2.0 and HIMSS models.

**TABLE 2.** Illustrates the relationship between the HIMSS stages with the three types of work of the SEIPS 2.0 model

| HIMSS | Applying mHealth to empower BBG patients | SEIPS 2.0 | | |
|---|---|---|---|---|
| 5 Levels of meaningful use | | Professional work | Patient work | Collaborative work |
| 1 INFORMMe | *Condition-specific Education*—such as prescribed delivery of: (a) Treatment, (b) medication, (c) healthcare coverage, (d) wellness clinics, etc. | None (if delivered thru IT) | Receiving general information | None |
| ↓ Inform and Attract | | | | |
| 2 ENGAGE Me | *Patient specific education*—such as care instructions, med reminders preventative services, follow-up appointments: (1) eHealth tools[a] that engage patients by tracking fitness, food consumption, pregnancy, healthy life style practices, sharing of progress and health milestones on social media. (2) Other engagement opportunities might include: online forms like patient profiles, schedule a clinic, refill a prescription, appointment reminders and medication follow-up, and access to view and download EHR.[b] | None (if delivered thru IT) | Receiving patient-specific information | None |

(*continued on next page*)

**TABLE 2** (*Continued*)

| HIMSS 5 Levels of meaningful use | Applying mHealth to empower BBG patients | SEIPS 2.0 | | |
|---|---|---|---|---|
| | | Professional work | Patient work | Collaborative work |
| ↓ Retain, Interact, and Attract | | | | |
| 3 EMPOWER Me | *Patient-generated health data*—such as symptom assessments, care experience, and self-managing diaries: (1) eHealth tools that empower patients by means of transmitting patient records, providing eTools to integrate the EHR with patient PHR,[c] rating their providers, hospitals and other healthcare organizations and accessing quality and/or safety reports on other providers and/or organizations, (2) eHealth tools that empower patients by generating health data that can be uploaded into the EHR, including: care experience, symptom assessments, self-management diaries, etc., and interoperably integrating with a health information exchange. | Receiving patient-generated information | Generating information | Discussion of healthcare options |

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**TABLE 2** (*Continued*)

| HIMSS | Applying mHealth to empower BBG patients | SEIPS 2.0 | | |
|---|---|---|---|---|
| **5 Levels of meaningful use** | | **Professional work** | **Patient work** | **Collaborative work** |
| ↓ Create Synergy and Extend Reach | | | | |
| 4 PARTNER with Me | *Shared decision-making*—such as preference-sensitive care and informed choice and/or consent: eHealth tools that provide patients the ability to partner and collaborate with providers to: (1) *Obtain*: (a) wellness and advance care planning, (b) patient-specific predictive models and/or indicators, (c) EHR clinical trial records, (2) *Generate*: (a) shared decision making related to sensitive care, (b) adherence reporting of medications, self-care, and wellness, (c) Home monitoring devices and tele-medicine, (d) directives regarding physician orders for life-sustaining treatment, (3) *Integrate*: (a) clinical trial records and (b) public health reporting. | Providing options, listening, selecting options | Asking questions, voicing concerns, selecting option | Collaborative decision making |

(*continued on next page*)

**TABLE 2** (*Continued*)

| HIMSS | Applying mHealth to empower BBG patients | SEIPS 2.0 | | |
|---|---|---|---|---|
| **5 Levels of meaningful use** | | **Professional work** | **Patient work** | **Collaborative work** |
| ↓ Inform and Attract | | | | |
| 5 SUPPORT<br>My e-Community | *E-community support*—such as eTools and e-visits that provide support: (1) care comparisons (costs and/or quality) of providers, treatments, and medications, (2) e-visits and eTools, (3) patient access and/or use of published record and distribution of record among care team, (4) care team-generated data related to shared care plans and team outcomes, and (5) Collaborative care such as Chiropractic, alternative medicine, dentistry, and home care, and (6) off and/or online community support forums and resources for all care team members, including caregivers, clergy, family and/or friends, and counseling services. | [Yes] | [No] | [?] |

[a] eHealth tools refer to a combination of online and mobile apps and devices that support individuals, families, and communities in healthcare.

[b] Electronic health records (EHRs) focus on the total health of the patient—going beyond standard clinical data collected and contained in the Electronic Medical Record in the provider's office. EHRs are also designed to share information with other health care providers and specialists. As such, they contain information from all the clinicians involved in the patient's care (Garrett, 2011)[93]

[c] Personal health record (PHR) is a record of health data related to the care of a patient that is maintained by the patient, including an individual's medical history, patient-reported outcome data, lab results, data from devices such as wireless electronic weighing scales or collected passively from a smartphone.[101]

perspective.[68,69] Although developers of HIT are increasingly giving more attention to a human-centered design approach, there is still a need to improve their understanding of mHealth experience design.[70] The lack is also due to a deficient vision of personalized mHealth products that can support sustainable healthy lifestyle choices.[71]

To counter these challenges, there has been considerable research in the area of design and evaluation of complex sociotechnical systems across domains. For example, early applications of human factor design practices have been applied to autonomous aerial vehicles[72] and neonatal intensive care unit space design [73] strongly highlights their benefits. As noted, CSE is a system-thinking set of human factor methods concerned with understanding how experts make decisions in complex environments to inform human-centered solutions.[74] In addition, with the focus on patient-centered-care, the patient is no longer a passive agent, but an active participant in medical decision making.[75] In sum, the MLM model was developed to conform to complex healthcare environments, in which decision making takes place, including understanding consumer health needs, contexts of use, and the impact of patient daily activities.

## *Meet Sam—Applying MLM to a Day-in-the-Life of a Baby-Boomer*

To illustrate the healthcare needs of an aging baby-boomer, we present a scenario of what might be a typical patient—Sam, whose concept of a healthy life is about to change. Sam is a third-generation male who lives in Chicago. Sam is 66 and rather old fashion when it comes to technology. He only recently purchased a smartphone because of the urging of his wife—and especially his daughter, who is away at college and wants to communicate with her dad via texting.

Regarding his health, Sam is well overweight, with a body-mass-index at almost 30, with slightly elevated blood pressure. He has been repeatedly warned by his doctor that unless he begins to exercise and modify his daily food choices, he may need to begin blood pressure medication. Equally problematic is that Sam is now in a pre-type 2 diabetes stage due to his lack of dietary management. Lastly, because of a prior work-related head injury, he has a slight cognitive disability related to memory. In all, between his general health condition and his cognitive disability, Sam experiences mild depression. Thus far, Sam has been able to manage without antidepressant medications. At the same time, however, Sam has noticed, over the last 2 years, that his memory is worse and his bouts with

depression are more frequent. This has left him wondering what he can do to improve his overall physical and mental health.

For Sam, like many BBGs, there are other challenges related to the ongoing conflict between his desire to achieve a sustainable healthy lifestyle and those external forces that breakdown his ability to achieve measurable progress. In his struggle to make proper lifestyle choices, he has slowly come to understand that there are three external unhealthy lifestyle enablers that he must overcome: (1) Influencers: those around Sam that unknowingly and unintentionally (negatively) influence him because of their sedentary lifestyle and or poor food choices, (2) Manufacturers: food corporations who bombard Sam everyday with enticing low quality food ads through TV and Internet commercials, and (3) Distributors: grocery stores that offer Sam an abundance of processed food choices as he casually strolls down the food aisle. Unfortunately, Sam is one of millions of BBGs who face these common daily obstacles. For some, they have little effect, but for others (like Sam), they contribute to an ongoing battle to maximize healthy lifestyle choices.

For this reason, BBG consumers need a vision, a support team, and the necessary tools that will enable them to achieve their health goals. Such support is intended to guide and empower them toward sustainable actions that lead to healthy lifestyle practices and disease management. Sam's physician has recommended that he meets with a HLM coach. In so doing, their first meeting focuses on a review of the MLM framework and how it will inform Sam as they work toward the goal of sustainable healthy behaviors.

Also, Sam's HLM provider (or health coach) has a deep knowledge of the principles and practices of HLM adherence and ways to measure, including maintaining behavior change, such as initiating and sustaining exercise (Stonerock and Blumenthal, 2017).[100] In Sam's case, his health coach applied the work of Miller and Rollnick,[76] who highlight an effective counseling approach that uses a motivational technique called "motivational interviewing." This health counseling method is a patient-centered conversational approach to behavior change that focuses on provider−patient collaboration and patient ownership of "motivation for change." Miller and Rollnick encourage providers and HLM counselors to avoid viewing people with "addictions as disturbed, dishonest, or illogical actors," who are "uninformed or already motivated." Rather, they suggest that health counselors recognize and promote patient autonomy, while attempting to understand their behavioral choices. By adhering to a patient-centered systematic strategy that engages patients in behavior change, providers will avoid alienating the patient, decrease resistance,

**TABLE 3.** Briefly outlines the four important factors that Sam's HLM coach reviewed

| Topics of HLM learning | Focused HLM benefits for Sam the baby boomer |
|---|---|
| Provider education | Encourages Sam to participate in a culture of shared information and decision-making with his HLM coach. This includes the coach's responsibility to hear Sam's needs and health goals. |
| Patient education | Provides Sam access to credible information and formalizes the patient role as a partner and in shared decision-making. |
| e-visits and eTools | Prepares Sam with the knowledge to incorporate mHealth technologies (appropriately design mobile apps) into his healthy behavior routines. |
| Patient-generated data | Facilitates the professional care team (including Sam) to accept patient-generated data as valid for care planning (ie, glucometer or patient reported problems and/or symptoms). |

with the positive outcome of making healthy behavior change more likely.

During Sam's first meeting with his HLM coach, they focused on four important factors related to understanding health management (see Table 3).

From their first meeting, Sam learned about several important concerns related to his personal health condition, while increasing his health literacy and management around these conditions. He also learned how to utilize personalized healthcare services to communicate his needs and preferences, while understanding his options for prevention, medication, and intervention—and the risks associated with each. With the help of his health coach and the MLM framework, Sam adopted new technologies that allow him to monitor and manage his existing chronic conditions. For example, Sam's coach asked him to download two mobile apps. The first will help Sam monitor his exercise, food choices, and weight. The second will help monitor and manage low moods and anxiety by discovering new and better ways of coping.

In sum, these technologies will support Sam with (1) medication reminders, (2) patient-generated data (that is delivered to the care team), and (3) real-time data on health conditions (that is delivered to both patients and providers). These factors are grounded in a collaborative effort that includes patients, professional care teams, and community participants. As a BBG health consumer, Sam has taken his first steps to apply self-care HLM as a means to extend the quality of life into his 80s, and perhaps 90s. From Sam's first several meetings with his HLM coach, he continues to express an excitement, expectation, and receptiveness to innovative approaches that can empower him to maintain health and manage chronic conditions.

# Discussion

## *Recommendations for Moving Healthy Lifestyle Management Forward*

Two questions that best frame current HLM challenges to empowering BBGs to live a healthy lifestyle address the matters of patient adoption of mHealth solutions and empowering patients with collaborative-centered work.

### *Why Do We Need to Understand the Target BBG Patient for the Effective Adoption of mHealth?*

Although technology diffusion is advancing among BBGs, barriers continue to exist related to mHealth options with which they have limited knowledge and motivational issues. For example, Roque and Boot[77] warn of many older adults, particularly those with a low socioeconomic status and cognitive disabilities—who have adopted the use of PCs and smartphones at a much lower rate than the adult population.[78] At the same time, however, they argue that with adequate training, technology acceptance can reduce frustration and increase ease of use. On the other hand, research has demonstrated that senior adults with mental illness (and limited technical abilities) were successfully able to adapt to the use of a tailored self-management smartphone intervention[79]—while a comprehensive study (2079 records) demonstrated that mHealth (tablets and/or smartphones) was viable and reliable tool for senior patients with mental and cognitive disorders. The researchers argued that none of the participants (in any of the studies) had difficulties using the technologies noted. In sum, mHealth should be personalized, as it is not a one-size-fits-all solution. Previous work on patient experience recognizes that health teams should meet the patient where they are.[45] This means that it is imperative that we understand the BBG's pathology relative to the contextual features and constraints of their health in order to design a personalized mHealth solution.

A key to success with the BBG population is increasing their experience in using mHealth solutions and addressing their perceptions on security and appropriateness of mHealth. Once they adopt, they tend to be reliable users of this technology.[21] For example, adoption of mHealth solutions among older BBGs may include a range of technical challenges, for example, semantic interoperability between disparate devices, scalability in linking healthcare providers to end-users, universal availability, management and ownership of medical and

health data, and determining who is managing all the patient personalized data and/or information (Kruse et al., 2017).[95] Important to note is that the oldest among BBGs have not adopted the social media support tools that younger age BBGs embrace.[21] To encourage adoption of interactive mHealth solutions, providers and health care teams must educate their patients on the technology and how to leverage its power to support behavior change.

Finally, although attitudes toward adoption of smartphones (and other key mHealth tools) are shifting, providers must extol their virtues and benefits for supporting healthy lifestyle change. This can be done by providing success stories of past mHealth users. For example, in a study to assess the effects of a mobile coaching system on glycated hemoglobin (HbA1c), findings significantly demonstrated that the intervention resulted in greater 12-month declines in HbA1c, compared with the usual care of patients 55 years of age or older. These results provide an example of how mHealth can effectively support individualized treatment and patient−provider communication for older adults.[80]

*What Approaches Should Be Used to Achieve BBG Empowerment and Life-Long Sustainable HLM?*

Patients cannot fully achieve healthy lifestyle decision-making (especially in the context of disease management) without a collaborative relationship with a provider and/or HLM coach. That is, in a patient-centered world, the provider is part of the "context" in which the patient conducts "patient work." Also, traditional research focuses on provider work. However, in recent years, there has been an intense focus on patient work and human activity. As such, there is a growing need for researchers and clinicians to incorporate their findings into the greater knowledge about HLM, particularly the need for collaborative work that can significantly contribute to patient empowerment.[52]

For example, the domain of addiction research has historically recognized that collaborative work and sustainment is central to recovery.[81] It is important to leverage such preexisting evidence to progress in the use of mHealth technologies. Also, to support a more patient-centered system, the domain of human factors takes into account two factors in healthcare: (1) the target audience and the context for designing solutions that address barriers and limitations, and (2) the importance of facilitating collaborative patient−provider work.[74] This approach should be extended and applied to HLM—thereby empowering BBGs to more effectively achieve healthy lifestyle goals.

## BBG Expectations—The Future of the Care Continuum

Ongoing advances in mHealth and healthcare services will eventually impact the BBG's quest to extend their lives, both in years and quality. In part, these advances in tools, systems, and services are related to three "access" factors—all of which are evolving.

*Anywhere Healthcare*

BBG seekers of advanced medicine will demand health services (via remote technologies) that are ubiquitous, affordable, personalized, intelligent, and easily accessible. Such technologies will include virtual eHealth, such as telehealth. Such technology will extend the point of care and virtual diagnostics via remote monitoring. Also, mHealth supports smartphone plug-ins, direct wireless uploads to patient EHRs, and wearable and ingestible remote sensor monitoring. Additional mHealth support may also include the proliferation of healthy lifestyle mobile apps, as well as attachments that replace traditional checkups and self-tracking used by insurance providers to reward healthy lifestyles[82] (IMS Institute, 2015).[23]

*Transparent, Intelligent, and Evidenced-Based Medicine*

BBGs, as consumers of mHealth, will expect timely, free, and open access to (all) personal health data that is longitudinal and aggregated across a ubiquitous care-continuum of multiple healthcare institutions and providers. The OpenNotes movement formally began in 2010, with an exploratory study at Beth Israel Deaconess Medical Center (Boston), Geisinger Health System (Pennsylvania), and Seattle's Harborview Medical Center.[83] The study included 105 primary care doctors who invited 20,000 of their patients to read their notes via secure online portals. Their findings suggest that the clinicians had limited workload increases, while the patients gave overwhelmingly approval of the practice of sharing all the notes in their personalized record. The findings demonstrate that very few of the patients were either worried about or confused about what they read. Rather, full disclosure provided helpful insight, and a feeling of being more in controlling their health and healthcare. By 2017, there are more than 20 million patients in the United States who have full access to their personal health records and notes, in approximately 20 health systems. BBGs should understand that this implementation and practice is rapidly accelerating, while having a transformative effect on patient−provider relationships and collaboration.

Expectations will also include intelligent systems that support data-driven evidenced-based decisions and recommendations, which can be

corroborated by their personal physician.[84] Both patients and HLM seekers will expect mHealth that provides automated (big) data analytics through smart and accessible health services that improve cost-effectiveness and customer service. For example, the electronic health information exchange might provide patient access to their own health information—including the ability to capture and aggregate multiple sources of clinical data for performance measurement.[85,86]

Finally, BBGs will increasingly expect tools that expand their population health insights through a "precision medicine" platform that predicts more accurately a personalized treatment and prevention strategy for a particular disease, rather than for the average person. It is "precise" because it is powered by patient data.[87,88]

*Coordinated Collaboration Care*

The average BBG healthcare consumer will increasingly expect access to complex healthcare ecosystems that provide greater coordination and consistency between various providers and services. This includes communication with personal computing and mobile systems in and/or during general patient care. This also includes health solutions that they can integrate into a normal HLM plan[89] (Arena, Lavie, Cahalin, et al, 2016).[92] Paired with coordinated healthcare, collaboration will be essential for quality of care and mHealth innovation that seeks to overcome existing healthcare (services) fragmentation and communication breakdown. In sum, mHealth innovation will help to link a range of healthcare specialists, general practitioners, and healthcare systems.[90]

## Conclusion

In this paper, we propose the notion that mHealth can support the patient, provider, and collaborative work necessary to sustain the healthy behaviors of the baby-boomer generation. We also highlighted the need for a more thorough understanding of the "work" conducted by patients and providers, individually and collaboratively. The work and their relationships constitute a multidisciplinary perspective to study both behavior and cognition in support of BBG MLM. However, more research is needed to understand how to tailor mobile technologies to be more readily adopted by BBGs and used to sustain healthy lifestyle practices that can truly empower the older generation.[21]

While it appears that some technologies may be rejected by BBGs, providers, care teams, and health coaches should educate and promote such tools. By first identifying one's healthy lifestyle goals, it is possible

to target mHealth technologies for any particular user group. However, as argued above, existing healthcare services do not account for patient decision-making, context, and the nonlinear aspects of human life. To leverage mHealth tools, new MLM models must be relevant to BBG needs, roles, and contexts of normal daily use.[91] Such a framework (as illustrated above) will offer insight about how mHealth technologies can support collaboration between the patient and the care team.

Finally, for patient-centered work in the public health sectors to progress, strategic planning must include collaborative efforts that contribute to sustained patient health. To achieve significant advancements, providers should move beyond mere informing to MLM coaching that leverages the benefits of mobile technology or other eHealth systems. With assistance from the MLM model proposed, a roadmap to assist providers and healthcare teams can become more successful in empowering BBG patients as they navigate the challenges of life—and in their quest to achieve a long and healthy lifestyle.

## Conflict of Interest

The authors have no conflicts of interest.

## REFERENCES


1. Dysinger WS. Lifestyle medicine practice: exploring workable models. *Am J Lifestyle Med* 2016;10:345–7.
2. Hoque R, Sorwar G. Understanding factors influencing the adoption of mHealth by the elderly: an extension of the UTAUT model. *Int J Med Inform* 2017;101:75–84.
3. Faiola A, Holden RJ. Consumer health informatics: empowering healthy-living-seekers through mHealth. *Progress Cardiovasc Dis* 2017;59:479–86.
4. Vincent GK, Velkoff VA. *The Next Four Decades: The Older Population in the United States: 2010 to 2050 (No. 1138)*. US Department of Commerce, Economics and Statistics Administration, US Census Bureau; 2010.
5. Niehaves B, Plattfaut R. Internet adoption by the elderly: employing IS technology acceptance theories for understanding the age-related digital divide. *Eur J Inf Syst* 2014;23:708–26.
6. Sun Y, Wang N, Guo X, Peng Z. Understanding the acceptance of mobile health services: a comparison and integration of alternative models. *J Electron Commerce Res* 2013;14:183–200.
7. Irizarry T, Dabbs AD, Curran CR. Patient portals and patient engagement: a state of the science review. *J Med Internet Res* 2015;17(6):e148. https://doi.org/10.2196/jmir.4255.
8. CDCP—Centers for Disease Control and Prevention. *The State of Aging and Health in America 2013*. Atlanta, GA: Centers for Disease Control and Prevention, US

Department of Health and Human Services. Available at: https://www.cdc.gov/aging/pdf/state-aging-health-in-america-2013.pdf; 2017.
9. Owram D. Born at the Right Time: A History of the Baby-Boom Generation. University of Toronto Press; 1997.
10. U.S. Census Bureau. Population profile of the United States: 2000 Available at: https://www.census.gov/population/pop-profile/2000/profile2000.pdf; 2017.
11. Mather M, Jacobsen LA, Pollard KM. Aging in the united states. Population bulletin. *Popul Ref Bureau* 2015;70(2).
12. Knickman JR, Snell EK. The 2030 problem: caring for aging baby boomers. *Health Serv Res* 2002;37:849–84.
13. CDC—Center for Disease Control. National Diabetes Statistics Report 2017: Estimates of Diabetes and Its Burden in the United States. Available at: https://www.cdc.gov/diabetes/pdfs/data/statistics/national-diabetes-statistics-report.pdf; 2017.
14. Klasnja P, Pratt W. Healthcare in the pocket: mapping the space of mobile-phone health interventions. *J Biomed Inform* 2012;45:184–98.
15. Mohr DC, Schueller SM, Montague E, Burns MN, Rashidi P. The behavioral intervention technology model: an integrated conceptual and technological framework for eHealth and mHealth interventions. *J Med Internet Res* 2014;16(6):e146. https://doi.org/10.2196/jmir.3077.
16. Pagoto S, Bennett GG. How behavioral science can advance digital health. *Transl Behav Med* 2013;3:271–6.
17. CDC—Center for Disease Control. Vital statistics of the United States, Vol. 1: Natality, Table 1-1—Live births, birth rates, and fertility rates, by race (United States, 1909−2003). AARP Public Policy Institute Available at: https://www.cdc.gov/nchs/data/statab/natfinal2003.annvol1_01.pdf; 2017.
18. Holliday N, Ward G, Fielden S. Understanding younger older consumers' needs in a changing healthcare market—supporting and developing the consumer market for electronic assisted living technologies. *Int J Consumer Stud* 2015;39:305–15.
19. Smolka G, Multack M, Figueiredo C. *Health Costs and Coverage for 50-to 64-Year-Olds* AARP Public Policy Institute Available at: https://www.aarp.org/content/dam/aarp/research/public_policy_institute/health/Health-Insurance-Coverage-for-50-64-year-olds-insight-AARP-ppi-health.pdf; 2012.
20. Smith A. *Older Adults and Technology Use* Pew Research Center, Internet and Technology. Available at: http://www.pewinternet.org/2014/04/03/older-adults-and-technology-use/; 2014.
21. LeRouge C, Van Slyke C, Seale D, Wright K. Baby boomers' adoption of consumer health technologies: survey on readiness and barriers. *J Med Internet Res* 2014;16(9):e200. https://doi.org/10.2196/jmir.3049.
22. Martin LG, Freedman VA, Schoeni RF, Andreski PM. Health and functioning among baby boomers approaching 60. *J Gerontol: Ser B* 2009;64:369–77.
23. Aitken M, Patient adoption of mHealth: Use, Evidence and Remaining Barriers to Mainstream Acceptance. Parsippany, New York: IMS Institute for Healthcare Informatics, 2015.

24. Jung M, Ramanadhan S, Viswanath K. Effect of information seeking and avoidance behavior on self-rated health status among cancer survivors. *Patient Educ Couns* 2013;92:100–6.
25. Tennant B, Stellefson M, Dodd V, et al. eHealth literacy and Web 2.0 health information seeking behaviors among baby boomers and older adults. *J Med Internet Res* 2015;17(3):e70. https://doi.org/10.2196/jmir.3992.
26. Slack WV, Safran C, Kowaloff HB, Pearce J, Delbanco TL. A computer-administered health screening interview for hospital personnel. *MD Comput: Comput Med Pract* 1995;12:25–30.
27. Wood FB, Lyon B, Schell MB, Kitendaugh P, Cid VH, Siegel ER. Public library consumer health information pilot project: results of a National Library of Medicine evaluation. *Bull Med Libr Assoc* 2000;88:314.
28. Hagel J, Brown JS, Samoylova T, Keith J, Hoversten S. A Consumer-Driven Culture of Health: The Path to Sustainability and Growth. Deloitte University Press7. Available at: https://dupress.deloitte.com/dup-us-en/industry/health-care/future-of-us-health-care.html; 2017.
29. Asimakopoulos S, Asimakopoulos G, Spillers F. Motivation and user engagement in fitness tracking: heuristics for mobile healthcare wearables. *Informatics* 2017;4:5.
30. Millington B. Fit for prosumption: interactivity and the second fitness boom. *Media, Cult Soc* 2016;38:1184–200.
31. Young SD, Holloway IW, Swendeman D. Incorporating guidelines for use of mobile technologies in health research and practice. *Int Health* 2014;6:79–81.
32. Park LG, Beatty A, Stafford Z, Whooley MA. Mobile phone interventions for the secondary prevention of cardiovascular disease. *Prog Cardiovasc Dis* 2016;58:639–50.
33. Labrique AB, Vasudevan L, Kochi E, Fabricant R, Mehl G. mHealth innovations as health system strengthening tools: 12 common applications and a visual framework. *Global Health: Sci Pract* 2013;1:160–71.
34. Critchley CR, Hardie EA, Moore SM. Examining the psychological pathways to behavior change in a group-based lifestyle program to prevent type 2 diabetes. *Diabetes Care* 2012;35:699–705.
35. Murray JL, Lopez AD. *The Global Burden of Disease*. Boston, MA: Harvard School of Public Health; 1996.
36. Dute DJ, Bemelmans WJE, Breda J. Using mobile apps to promote a healthy lifestyle among adolescents and students: a review of the theoretical basis and lessons learned. *JMIR mHealth uHealth* 2016;4(2):e39. https://doi.org/10.2196/mhealth.3559.
37. Kennedy A, Rogers A, Chew-Graham C, et al. Implementation of a self-management support approach (WISE) across a health system: a process evaluation explaining what did and did not work for organisations, clinicians and patients. *Implementation Sci* 2014;9:129.
38. Shortell SM, Poon BY, Ramsay PP, et al. A multilevel analysis of patient engagement and patient-reported outcomes in primary care practices of accountable care organizations. *J Gen Intern Med* 2017: 1–8.
39. Coulter A. Patient engagement—what works? *J Ambulatory Care Manag* 2012;35:80–9.

40. Kupfer JM, Bond EU. Patient satisfaction and patient-centered care: necessary but not equal. *JAMA* 2012;308:139–40.
41. Wilson A, Childs S. The relationship between consultation length, process and outcomes in general practice: a systematic review. *Br J Gen Pract* 2002;52:1012–20.
42. Carman KL, Dardess P, Maurer M, et al. Patient and family engagement: a framework for understanding the elements and developing interventions and policies. *Health Affairs* 2013;32:223–31.
43. Ory MG, Lee Smith M, Mier N, Wernicke MM. The science of sustaining health behavior change: the health maintenance consortium. *Am J Health Behav* 2010;34:647–59.
44. Fries JF, Koop CE, Beadle CE, et al. Reducing health care costs by reducing the need and demand for medical services. *New England J Med* 1993;329:321–5.
45. Hibbard JH, Greene J. What the evidence shows about patient activation: better health outcomes and care experiences; fewer data on costs. *Health Affairs* 2013;32:207–14.
46. NIDA—National Institute on Drug Abuse. Drugs, brains, and behavior: the science of addiction Available at: https://www.drugabuse.gov/publications/drugs-brains-behavior-science-addiction/preface; 2017.
47. Taylor D, Bury M. Chronic illness, expert patients and care transition. *Sociol Health Illness* 2007;29:27–45.
48. Shearer NBC. Health empowerment theory as a guide for practice. *Geriatr Nurs (New York, NY)* 2009;30(Suppl):4–10.
49. Camerini L, Schulz PJ, Nakamoto K. Differential effects of health knowledge and health empowerment over patients' self-management and health outcomes: a cross-sectional evaluation. *Patient Educ Counsel* 2012;89:337–44.
50. Loef M, Walach H. The combined effects of healthy lifestyle behaviors on all cause mortality: A systematic review and meta-analysis. *Prevent Med* 2012;55:163–70.
51. Hollnagel E, Woods DD. Joint Cognitive Systems: Foundations of Cognitive Systems Engineering. CRC Press; 2005.
52. Holden RJ, Carayon P, Gurses AP, et al. SEIPS 2.0: a human factors framework for studying and improving the work of healthcare professionals and patients. *Ergonomics* 2013;56:1669–86.
53. Valdez RS, Holden RJ, Novak LL, Veinot TC. Transforming consumer health informatics through a patient work framework: connecting patients to context. *J Am Med Inform Assoc* 2014;22:2–10.
54. Rutten GM, Meis JJ, Hendriks MR, Hamers FJ, Veenhof C, Kremers SP. The contribution of lifestyle coaching of overweight patients in primary care to more autonomous motivation for physical activity and healthy dietary behaviour: results of a longitudinal study. *Int J Behav Nutr Phys Activity* 2014;11:86.
55. CPFC—Center for Patient and Family-Centered Care. HIMSS (Healthcare Information and Management Systems Society) patient engagement framework. Available at: http://www.himss.org/himss-patient-engagement-framework; 2017.

56. Cherrington A, Buckley C. Patient engagement 2016: no silver bullet; strategic approach needed Available at: https://klasresearch.com/report/patient-engagement-2016/978; 2017.
57. Suchman LA. Plans and Situated Actions: The problem of human-machine communication. Cambridge University Press; 1987.
58. Klein, G., Calderwood, R., & Clinton-Cirocco, A. (1985). *Rapid Decision Making on the Fire Ground (KATR-84-41-7)*. Yellow Springs, OH: Klein Associates Inc. Prepared under contract MDA903—85-G—0O99 for the US Army Research Institute, Alexandria, VA.
59. Hutchins E. Cognition in the Wild. MIT Press; 1995.
60. Gurses AP, Marsteller JA, Ozok AA, Xiao Y, Owens S, Pronovost PJ. Using an interdisciplinary approach to identify factors that affect clinicians' compliance with evidence-based guidelines. *Crit Care Med* 2010;38:S282–91.
61. Karsh BT. Carayon P. Smith M. et al. (2005). The University of Wisconsin-Madison Multidisciplinary Graduate Certificate in Patient Safety. Agency for Healthcare Research and Quality, Rockville, MD.
62. Pronovost PJ, Goeschel CA, Marsteller JA, Sexton JB, Pham JC, Berenholtz SM. Framework for patient safety research and improvement. *Circulation* 2009;119:330–7.
63. Sittig DF, Singh H. Eight rights of safe electronic health record use. *JAMA* 2009;302:1111–3.
64. Carayon P, Hundt AS, Karsh BT, et al. Work system design for patient safety: the SEIPS model. *BMJ Qual Saf* 2006;15(Suppl 1):i50–8.
65. Holden RJ, Scott AMM, Hoonakker PL, Hundt AS, Carayon P. Data collection challenges in community settings: insights from two field studies of patients with chronic disease. *Qual Life Res* 2015;24:1043–55.
66. Valdez RS, Holden RJ. Health care human factors/ergonomics fieldwork in home and community settings. *Ergon Des* 2016;24:4–9.
67. Karsh BT, Holden RJ, Alper SJ, Or CKL. A human factors engineering paradigm for patient safety: designing to support the performance of the healthcare professional. *Qual Saf Health Care* 2006;15(Suppl 1):i59–65.
68. Nikou S. Mobile technology and forgotten consumers: the young−elderly. *Int J Consumer Stud* 2015;39:294–304.
69. Schnall R, Rojas M, Bakken S, et al. A user-centered model for designing consumer mobile health (mHealth) applications (apps). *J Biomed Inform* 2016;60:243–51.
70. Zapata BC, Fernández-Alemán JL, Idri A, Toval A. Empirical studies on usability of mHealth apps: a systematic literature review. *J Med Syst* 2015;39:1.
71. Henriquez-Camacho C, Losa J, Miranda JJ, Cheyne NE. Addressing healthy aging populations in developing countries: unlocking the opportunity of eHealth and mHealth. *Emerg Themes Epidemiol* 2014;11:136.
72. Papautsky EL, Dominguez C, Strouse R, Moon B. Integration of cognitive task analysis and design thinking for autonomous helicopter displays. *J Cogn Eng Decis Making* 2015;9:283–94.
73. Papautsky EL, Crandall B, Grome A, Greenberg JM. A case study of source triangulation: using artifacts as knowledge elicitation tools in healthcare space design. *J Cogn Eng Decis Making* 2015;9:347–58.

74. Bisantz AM, Burns CM, Fairbanks RJ, eds. Cognitive Systems Engineering in Health Care, CRC Press; 2014.
75. Barry MJ, Edgman-Levitan S. Shared decision making—the pinnacle of patient-centered care. *New Engl J Med* 2012;366:780–1.
76. Miller WR, Rollnick S. Motivational Interviewing: Helping People Change. 3rd ed New York: Guilford Press; 2013.
77. Roque NA, Boot WR. A new tool for assessing mobile device proficiency in older adults: the mobile device proficiency questionnaire. *J Appl Gerontol* 2016;37:131–56.
78. Czaja SJ, Charness N, Fisk AD, et al. Factors predicting the use of technology: findings from the Center for Research and Education on Aging and Technology Enhancement (CREATE). *Psychol Aging* 2006;21:333–52.
79. Whiteman KL, Lohman MC, Gill LE, Bruce ML, Bartels SJ. Adapting a Psychosocial Intervention for Smartphone Delivery to Middle-Aged and Older Adults with Serious Mental Illness. *Am J Geriatr Psychiatry* 2017;25:819–28.
80. Quinn CC, Shardell MD, Terrin ML, et al. Mobile diabetes intervention for glycemic control in 45- to 64-Year-old persons with type 2 diabetes. *J Appl Gerontol* 2014;35:131–49.
81. Rush B, McPherson-Doe C, Behrooz RC, Cudmore A. Exploring core competencies for mental health and addictions work within a Family Health Team setting. *Mental Health Family Med* 2013;10:89–100.
82. Hassan T, Chatterjee S. A sensor based mobile context-aware system for healthy lifestyle management. *Persuasive* 2008: 4–6.
83. OpenNotes. Our History. Available at: https://www.opennotes.org/about/history/; 2017.
84. Deloitte Center for Health Solutions. Next-generation "smart" MedTech devices: preparing for an increasingly intelligent future. Available at: http://www2.deloitte.com/content/dam/Deloitte/us/Documents/life-sciences-health-care/us-dchs-smart-medtech.pdf; 2017.
85. Hosseini M, Jones J, Faiola A, Wu H, Vreeman D, Dixon B E. Reconciling disparate information in continuity of care documents: piloting a system to consolidate structured clinical documents. *J Biomed Inform* 2017;74:123–9.
86. Robert Wood Johnson Foundation. Health information technology in the United States, 2015: Transition to a Post-HITECH World. Available at: http://www.rwjf.org/content/dam/farm/reports/reports/2015/rwjf423440; 2017.
87. Hodson R. Precision Medicine. *Nature,* 537. Available at: https://www.nature.com/articles/537S49a; 2017.
88. U.S. National Library of Medicine. Precision medicine. *NIH Genet Home Ref* Retrieved August 13 https://ghr.nlm.nih.gov/primer/precisionmedicine/definition; 2018.
89. WHO-World Health Organization. Connecting for health: global vision, local insight. Available at: http://www.who.int/ehealth/publications/WSISReport_Connecting_for_Health.pdf?ua=1; 2017.
90. Athena Health. Going mobile: integrating mobile to enhance patient are and practice efficiency. Available at: http://landing.athenahealth.com/Global/FileLib/Whitepapers/Mobile_Devices_Whitepaper.pdf; 2017.

91. Segar M. No Sweat: How the Simple Science of Motivation can Bring You a Lifetime of Fitness. AMACOM: A Division of American Management Association; 2015.
92. Arena R, Lavie CJ, Cahalin LP, et al. Transforming cardiac rehabilitation into broad-based healthy lifestyle programs to combat noncommunicable disease. *Expert Rev Cardiovasc Ther* 2016;14:23–36.
93. Garrett P, Seidman J. EMR vs EHR—what is the difference. *HealthITBuzz*. January 4, 2011.
94. Gillon S. Boomer Nation: *The Largest and Richest Generation Ever, and How I*. Simon and Schuster; 2004.
95. Kruse CS, Mileski M, Moreno J. Mobile health solutions for the aging population: a systematic narrative analysis. *J Telemed Telecare* 2016;23:439–51.
96. Lippa KD, Klein HA, Shalin VL. Everyday expertise: cognitive demands in diabetes self-management. *Human Factors* 2008;50:112–20.
97. Novak LL, Unertl KM, Holden RJ. Realizing the potential of patient engagement: designing IT to support health in everyday life. *Stud Health Technol Inf* 2016;222:237–47.
98. Pray JE, Woollen J, Wilcox L, et al. Patient engagement in the inpatient setting: a systematic review. *J Am Med Inform Assoc* 2014;21:742–50.
99. Research2Guidance. mHealth app developer economics: state of the Art of mHealth App Publishing. Available at: https://research2guidance.com/product-category/mhealth/; 2017.
100. Stonerock GL, Blumenthal JA. Role of counseling to promote adherence in healthy lifestyle medicine: strategies to improve exercise adherence and enhance physical activity. *Progr Cardiovasc Dis* 2017;59:455–62.
101. Tang PC, Ash JS, Bates DW, Overhage JM, Sands DZ. Personal health records: definitions, benefits, and strategies for overcoming barriers to adoption. *J Am Med Inform Assoc* 2006;13:121–6.
102. Engage. Retrieved from https://www.merriam-webster.com/dictionary/engage. Accessed July 28, 2018.

The importance of a healthy lifestyle for managing chronic diseases has been emphasize more and more in the environment of today. This approach empowers patients to adopt and sustain healthy lifestyle choices utilizing innovative technologies, such as, beneficial ways of delivering health literacy, self-monitoring and patient-provider collaboration Several perspectives can be drawn from this interesting manuscript

First, the utilization of mHealth can support the patient, provider and collaborative work necessary to sustain the healthy behaviors of the baby-boomer generation. Second, it is important to point out that more research is needed to understand how to tailor mobile technologies by the baby boomer generation that could be used to sustain healthy lifestyle practices.

Third, although it is possible that some mobile technologies may be rejected by baby boomer generation, however, providers, care teams and health coaches should educate and promote such tools. mHealth tools, can use new mHealthy Lifestyle Management models that can be relevant to the baby boomer generation needs, roles, and contexts of normal daily use.

Finally, for patient-centered work in the public health sectors to progress, strategic planning must include collaborative efforts that contribute to sustained patient health. To achieve sustained patient health, providers should move not only informing, but also to mHealthy Lifestyle Management coaching that provides the benefits of mobile technology or other eHealth systems. The mHealthy Lifestyle Management model proposed by the authors, will provide a roadmap to assist providers and healthcare teams to become more successful in empowering patients to achieve a long and healthy lifestyle.

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