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The ADOPT Model: Accelerating Diffusion of Proven Technologies for Older Adults

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Abstract The growing older adult population faces unprecedented health challenges. Home and community-based technologies have proven to be an effective way of helping older adults improve health outcomes and maintain independence. However, such technologies are currently not widely used by older adults for health purposes. Nor have they been widely adopted by the providers serving older adults; to date, successful health technology diffusion has occurred mainly within capitated and integrated health systems, such as the Veterans Health Administration (VHA) and Kaiser Permanente (KP). This article presents a conceptual model of technology diffusion, ADOPT (Accelerating Diffusion of Proven Technologies), which discusses important considerations for diffusing health technologies in home and community-based settings for older adults. At the center of the ADOPT model is a framework that highlights factors that affect technology adoption and use relevant to older adults, their collaborators, and their context. The model then overlays seven important "diffusion strategies" that older adults' collaborators (including technology companies, aging services organizations, formal/informal caregivers, family members, medical providers, insurance companies, and others) can undertake to help facilitate technology diffusion. The goal of this article is to introduce the ADOPT model to guide older adults' collaborators in achieving greater technology diffusion, in order to create widespread health outcome improvements and promote independent living for this population.

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Introduction and the Need for the ADOPT Model

Older adults currently face considerable health challenges, including a rapidly growing population (US Census Bureau 2008), an increasing prevalence of costly chronic diseases (DeVol et al. 2007), and a projected shortage of caregivers (Fleming et al. 2003). The use of home and community-based technologies has demonstrated strong potential to improve the health of older adults, particularly in maintaining independence and avoiding expensive hospital-based care. To date, much of the progress from using technology to improve health has been the result of small pilot projects, or within capitated and integrated systems such as the VHA and KP (Spyglass Consulting Group 2009). One such example of successful health technology use for older adults is the VHA's deployment of its Care Coordination/ Home Telehealth program, which has resulted in a 19% reduction in hospitalizations and 25% reduction in bed days of care for patients using the system, in addition to lower costs and high patient satisfaction (Darkins et al. 2008). Other technologies that have also demonstrated successful health outcomes for older adults include electronic health records (EHRs) (Chen et al. 2009), medication optimization technologies (Schnipper et al. 2009), and Internet-based applications (Bond et al. 2007). However, the Institute of Medicine (2001) found that it takes an average of 17 years for new evidence to be incorporated into practice in health care delivery. Successful technology diffusion remains the critical link between the development of innovative technological approaches and widespread health benefits for the older adult population at large. This article aims to promote successful health technology diffusion for older adults by addressing the relevant factors and strategies through a conceptual model, ADOPT: Accelerating Diffusion of Proven Technologies.

Adoption, the selection of an idea or technology for use by an individual/ organization, is generally seen as the first step to diffusion, which refers to how, why, and how quickly these new ideas and technologies proliferate. Adoption and diffusion have been examined from various perspectives, including both user (Burkman 1987; Rogers 1995) and organizational/environmental (Tessmer 1990). Rogers (1962) formed one of the best-known diffusion models in *Diffusion of Innovations*, which was based on research from more than 500 diffusion studies in various fields; Rogers defines diffusion as "the process by which an innovation is communicated through certain channels over time among the members of a social system" (pp. 5, Rogers 2003). In his model, Rogers (1995) highlights five stages of the diffusion process from the adopter standpoint (knowledge, persuasion, decision, implementation, and confirmation), as well as five adopter categories following a bell-shaped curve (innovators, early adopters, early majority, later majority, and laggards). In Rogers' model, the market share of an innovation follows an S-shaped curve, eventually reaching saturation with adoption by the "laggard" category. Rogers (1995) also theorized that diffusion takes place over time, with a slow, gradual growth period, followed by rapid growth, and then eventual stabilization and

decline. Diffusion models have also explored the importance of innovation champions and opinion leaders in the diffusion process (Rogers 1995; Cain and Mittman 2002). In addition, the technology acceptance model (Davis 1989) describes the importance of perceived usefulness and ease of use in technology adoption. Cain and Mittman (2002) examined 10 critical factors affecting health diffusion, including relative advantage; trialability; observability; communications channels; homophilous groups; pace of innovation/reinvention; norms, roles, and social networks; opinion leaders; compatibility; and infrastructure.

The ADOPT model aims to narrow the focus from these general diffusion theories to provide a framework for technology diffusion within older adult health services. The ADOPT model is prescriptive in nature, in exploring how diffusion strategies interact with critical success factors (relevant to the older adult, his or her collaborators, and the overall context), in order to support the ultimate goal of improved health outcomes. The primary targets of the ADOPT model are technology developers, aging services organizations, medical providers, health plans, formal/informal caregivers, family members, and others who work with older adults in promoting diffusion of home and community-based health technologies. Examples of aging services organizations include nursing homes, home care agencies, community centers, and residential facilities.

The ADOPT model is focused on home and community-based technologies, including, but not limited to, remote patient monitoring, medication optimization, and mobile and Web-based technologies (including electronic and personal health records). Technology diffusion for older adults requires a number of unique considerations due to characteristics of this population, including the following: an overall lower level of familiarity/use of technology than younger populations (Czaja et al. 2006), higher rates of cognitive and mobility limitations (Kraus et al. 1996), a higher burden of chronic conditions (DeVol et al. 2007) and a resulting increased number of medical providers, and different channels for technology diffusion (including an emphasis on aging services providers, health providers, and formal/informal caregivers, rather than workplaces and schools). Additionally, caregivers and other collaborators may in some instances need to use technology on behalf of, or alongside, older adults. Successful technology design, adoption, and diffusion for older adults require that these considerations be taken into account.

The goal of this article is to introduce the ADOPT model to organizations and individuals who work with older adults, in order to improve understanding of the factors and strategies involved in successful technology diffusion. Such an understanding will aid these collaborators in successfully implementing technology, leading to more widespread technology use to create a healthier and more independent older adult population.

Conceptual Model: ADOPT (Accelerating Diffusion of Proven Technologies) for Older Adults

To illustrate a prescriptive process of successful technology diffusion, the Center for Technology and Aging has created the ADOPT model (see Fig. 1). Though the

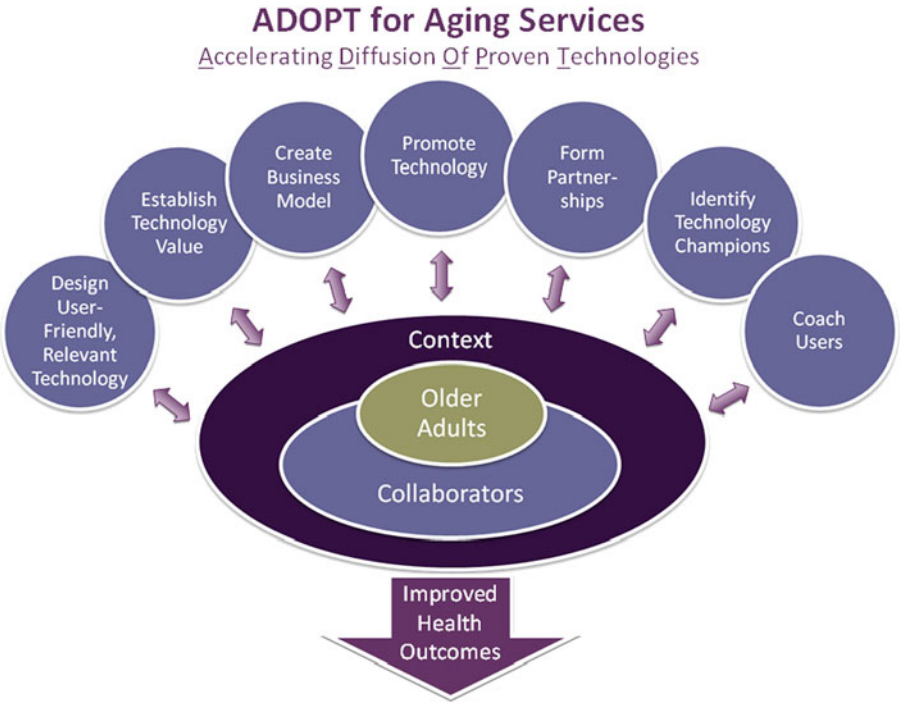

Fig. 1 The ADOPT (Accelerating Diffusion of Proven Technologies) model

model is geared towards older adults and home/community-based health technologies, the core elements of the model and its implications can be applied to other populations and settings as well. The ADOPT model illustrates the factors that affect successful technology adoption and use by older adults, the strategies their collaborators can take to facilitate technology diffusion, and the improved health outcomes that such diffusion can create for older adults. Specifically, collaborators who can help promote diffusion of these technologies include, but are not limited to, technology developers, aging services organizations, formal/informal caregivers, family members, medical providers, and health plans. The ultimate goal of the ADOPT model is to use technology diffusion as a mechanism to improve the health of older adults. In this context, it is important to note that the ADOPT model should be used to accelerate diffusion of technologies that have demonstrated *proven* successes in this area.

The three environments in the center of the model (Older Adults, Collaborators, and Context) focus on the important factors that affect technology use, adoption, and diffusion within each of these environments. The seven diffusion strategies around the center describe important actions that collaborators (including technology developers, and organizations and individuals who work directly with older adults) can take to facilitate technology diffusion. When these two aspects of the model interact successfully, with the factors and diffusion strategies aligned, the result is successful technology diffusion leading to improved health outcomes for older adults.

Section I. Older Adults, Collaborators, and Context: Framework of Important Factors Affecting Technology Adoption and Diffusion

At the center of the ADOPT model is a framework that includes the older adults themselves, as well as the external collaborators and context factors that affect older adults most closely (see Fig. 1: The ADOPT Model). Collaborators are essential for taking actions to facilitate technology adoption and use for older adults, while the overall context includes factors that impact technology diffusion more broadly. These three environments (older adults, collaborators, and context) encompass many important factors that affect technology adoption, use, and diffusion.

Older Adults

A number of issues directly relating to the older adult must first be considered in terms of his or her ability to use technology. In his adoption model, Rogers (1962) recognizes the difference between age groups, stating that innovators and early adopters are more likely to be younger, while laggards are more likely to be advanced in age. Relevant issues to consider for older adults and technology use include cognitive and physical limitations (Kraus et al. 1996), health status and disease conditions, multiple medical providers, technology literacy and familiarity, and motivation to use technology for health and other purposes (Selwyn 2004; Czaja et al. 2006). Certain older adults may be unwilling or unable to use technology due to one or more of these factors, and an assessment of these dimensions is important in determining the feasibility of successful technology use for a given older adult. In addition, technology use is a spectrum that can change over time; an older adult may be willing and able to use one type of technology, but not another more complex or unfamiliar one. It is important to understand a given older adult's location on this spectrum of technology familiarity, acceptance, and ability.

Perceived usefulness is another key factor in technology adoption (Davis 1989); patients who do not have a health need that would benefit from technology use, or who do not see managing illness as their own responsibility, are much less likely to use health technologies. In contrast, older adults are more likely to use technology when the technology's benefits are apparent and can enable them to accomplish their goals (The SCAN Foundation 2010). Despite public perception that older adults lag in their technology use, this population has demonstrated numerous instances of successful use of technology for health. For example, older adults exhibit high rates of using the Internet for health information (Pew Internet & American Life Project 2009). Additional examples of successful health technology use by older adults are discussed in the Improved Health Outcomes: Result of Successful Technology Diffusion.

Collaborators

Collaborators are key facilitators of older adults' ability to use technology. Collaborators include, but are not limited to, formal/informal caregivers, family members, aging services providers, technology developers, medical providers, and health plans. The presence of collaborators is especially important for older adults

(compared to other populations) due to unique considerations of older adults that affect their use of technology: a lower level of familiarity/awareness of technology (Czaja et al. 2006), cognitive or physical limitations that make it difficult to use technology (Kraus et al. 1996), and resource and other limitations that make accessing technologies difficult. Kaufman et al. (2003) discuss many of these barriers in a study on the implementation of a diabetes home-telemedicine program for older adults. One example of a resource constraint is that older adults are less likely to use a computer or have a computer in their home compared to younger age groups (Pew Internet & American Life Project 2004), which points to a need for collaborators to help them access and use these technologies. Access and user education can be difficult if not impossible to obtain in the absence of these collaborators. Rogers (1962) also highlights the importance of social contact and connectedness in diffusion and describes how certain individuals (termed "opinion leaders") can influence the overall diffusion process. Technology developers are another group of collaborators who also have very important roles in technology diffusion by designing easy-to-use and relevant technologies, and taking actions to facilitate the spread of these technologies. Diffusion Strategies: Important Actions for Collaborators to Facilitate Technology Diffusion describes specific strategies that older adults' collaborators can take to help facilitate successful technology diffusion.

Context

The wider context in which older adults live also contains important factors that impact their ability to use technology. Two key context factors are policy (including reimbursement, interoperability, and privacy considerations) and resources/access relating to technology. Policy and reimbursement have the ability to create widespread changes and to dictate health care structure. For example, in February 2009, $19 billion in the America Recovery and Reinvestment Act was earmarked to reimburse providers for some of the cost of electronic medical record (EMR) implementation, with the expectation that this will increase the lagging EMR adoption rate in the United States (American Recovery and Reinvestment Act 2009). One example of how reimbursement policy affects existing health care structure is that fee-for-service reimbursement has driven fragmented care in the current system (Baron and Cassel 2008). Pilots are currently being undertaken to use accountable care organizations to change system incentives to focus on quality and outcomes (McClellan et al. 2010). Reimbursement and policies that either reimburse technologies directly or incentivize health outcomes would likely increase diffusion of beneficial technologies (Middleton 2005; Rosenfeld et al. 2005), as reimbursement, sustainable business models, and aligned incentives are key barriers to technology diffusion (Poon et al. 2006). Privacy policies and safeguards can also affect many older adults' willingness to adopt technology, as this population has a lower level of familiarity and trust relating to technology (The SCAN Foundation 2010). Increased interoperability between technology platforms and devices can also help drive their increased use, through streamlining and increasing the robustness of the technology's capabilities. In addition, other regulatory issues such as licensing can affect health technology diffusion (Hwang and Christensen 2008), particularly for technologies that overlap with the clinical setting.

Table 1 Key factors affecting technology adoption and use

Older adults	Collaborators	Context
• Cognitive and physical limitations	• Presence of collaborators (including aging services providers, technology developers, medical providers, insurance companies, formal/informal caregivers including family members, and others)	• Policy relating to technology (including reimbursement, interoperability, and privacy considerations)
• Health status and disease conditions		• Economic and other resources
• Technology literacy/ familiarity	• Access to technology	
• Perceived usefulness of technology	• Cultural and societal factors	

The second context issue of resources/access (perceived or actual) is also an important determination of older adults' ability to use technology. Porter and Donthu (2006) discuss how older, less educated, minority, and lower-income Americans have lower Internet usage rates than their counterparts with higher resource levels. Lack of broadband access has been correlated with lower income and education levels, as well as higher age (Horrigan 2010). An older adult can have tremendous motivation and need for technology, but if he or she lacks resources to access the technology (due to either economic or other logistical barriers), he or she will be unable to use the technology and realize its benefits. In addition, broader cultural or societal factors may also impact technology adoption, learning, and diffusion (McLoughlin 1999).

Older adults, the presence of collaborators, and their context encompass many determinants of an older adult's capability and likelihood to use technology (see Table 1 above). The next section discusses the seven "diffusion strategies" in the ADOPT model, which describe actions that older adults' collaborators can take to facilitate technology adoption and diffusion.

Section II. Diffusion Strategies: Important Actions for Collaborators to Facilitate Technology Diffusion

While Older Adults, Collaborators, and Context: Framework of Important Factors Affecting Technology Adoption and Diffusion discusses the importance of collaborators in general (in addition to factors relevant to older adults and their context) in affecting technology adoption and diffusion, Diffusion Strategies: Important Actions for Collaborators to Facilitate Technology Diffusion focuses exclusively on the collaborators' roles in the technology diffusion process. The ADOPT model presents seven diffusion strategies that are important actions for collaborators to consider in designing and promoting use of appropriate technologies for older adults.

These diffusion strategies are arranged in the ADOPT model in approximate sequential order around the older adults, collaborators, and context environments (see Fig. 1: The ADOPT Model). The first four diffusion strategies are most relevant to technology developers and companies, while the last three strategies also have significant relevance to aging services and medical providers, formal/informal caregivers, and other collaborators who work directly with older adults. Though the seven diffusion strategies are presented/numbered in approximate sequential order, these strategies have relevance for all stages of the diffusion process and are continuous. For example, the design of user-friendly technology is still important long after the technology has been launched and adopted, as some aspects of the technology may require re-design in the next iteration of the product. Similarly, partnerships between technology companies and organizations that work directly with older adults can be formed at all stages throughout the technology diffusion process.

Diffusion Strategies Geared Towards Technology Developers/Companies

1. *Design user-friendly, relevant technology:* Technology should be designed as a solution to existing needs of the user; therefore, identifying a need is the first step in technology development. In particular, older adults tend to use technology to reach a goal or realize a benefit, rather than for the sake of using technology (The SCAN Foundation 2010). Both perceived usefulness and ease of use, while always important considerations in technology design, are of particular importance for older adults (McCloskey 2006). The technology acceptance model (Davis 1989) discusses the importance of these two characteristics in general technology adoption. In addition, older adults have lower overall levels of familiarity with technology compared to other age groups (Czaja et al. 2006) and may also face physical or cognitive barriers (Kraus et al. 1996), making ease of use in many cases a necessary characteristic for a technology to become adopted and eventually diffused. Rogers (1962) cites lack of complexity as an important characteristic in the adoption of technologies. Numerous examples illustrate the importance of this principle, from scaled-down technologies such as the Jitterbug phone to the simple interface of the Health Buddy remote patient monitoring system. For example, the iPad, although not exclusively used for health, has been increasing rapidly in popularity among older adults (Kim 2010) as an easy-to-use device that runs one application at a time in its current iteration. Designing technologies that are both easy to use and meet older adults' needs is a critical first step towards adoption and diffusion. Obtaining direct feedback from older adults on these criteria before and during the development process may be helpful in designing suitable technology applications for this population. Technology developers and companies should also work to refine existing products to increase their relevance and ease of use. Additionally, technology developers and companies should take into account interoperability and privacy concerns in designing their products, in order to maximize their functionality and usefulness for older adults.
2. *Establish technology value:* Reimbursement for technology, either explicit or implicit, is a critical part of driving wider technology diffusion (see Context

section; Cain and Mittman 2002). Currently, reimbursement for health technology from payers is limited (Rosenfeld et al. 2005); however, technology developers can work towards changing this policy by developing a more robust evidence base for the outcomes their technologies can create. Through randomized control trials, ROI calculations, and other outcome and care coordination support evidence, technology developers can make a stronger case for why their technologies should be reimbursed (either directly or indirectly) and widely used. Currently, closed/integrated systems and accountable care organizations have the largest financial incentives to use health technologies to promote healthier behaviors, disease management methods, and care coordination; Coye et al. (2009) discuss how integrated systems such as the VHA and KP (among others) have business models that promote the use of the remote patient monitoring technologies for integrated chronic disease management. If technology developers were able to develop a more robust evidence base for their technology's ability to improve quality of care while lowering costs, payers and government mandates would be more likely to promote policies and reimbursement that support the spread of these technologies, even in organizations that do not currently have aligned financial incentives. An evidence base is a first step towards such policies; Taylor et al. (2005) discuss the importance of policy initiatives around incentives and subsidies to promote broader health information technology (HIT) adoption.

3. *Create business model:* Technology companies can fail despite having a superb product if a sustainable business model is not in place; Tang et al. (2006) discuss the fact that the lack of a proven business case is a significant obstacle to personal health record (PHR) diffusion, despite the benefits of the technology. Technology diffusion can take a significant amount of time (Rogers 1995); therefore, developing a strong business model as early as possible is necessary for successful and sustainable technology diffusion. This includes finding the proper mechanisms to support the company (through payments, grants, partnerships, reimbursement, or other sources), as well as making technology affordable for its customers. Financial concerns are among the largest barriers to HIT adoption (Poon et al. 2006), as many health systems, hospitals, aging services organizations, and individual end-users have significant budget constraints. Affordability for the customer may result from several factors, including low cost of the product, reimbursements, grants to sponsor use of the product, and/or savings from outcome improvements (if financial incentives are properly aligned). The technology must be able to deliver financial or other benefits for whoever is paying for the technology, whether that is the patient or another party such as a health care provider. Hwang and Christensen (2008) discuss the important elements of developing a profitable business model to promote disruptive innovations in health care delivery, starting with establishing and delivering the product's value proposition. One of the goals of broader HIT use in general is to make U.S. health care more affordable and sustainable (Taylor et al. 2005), and developing a strong business model is a logical place for a health technology company to start.
4. *Promote technology:* Lack of awareness and other knowledge barriers are common obstacles to technology use on the part of organizations as well as

individuals. Tanriverdi and Iacono (1999) discuss how knowledge barriers have impeded telemedicine adoption at Boston medical centers. In addition, a 2009 survey of health providers, patients, payers and technology leaders had 40% of respondents indicate that they were unaware of connected health solutions or examples (Monegain 2009). It is therefore incumbent upon technology developers to not only develop a user-friendly technology and establish its value, but also to market their technology effectively. This includes developing methods and materials to communicate the benefits of a technology, promoting through the appropriate channels, and creating a clear and compelling story for its use to the target audience (which likely contains individuals, aging services organizations, and/or health providers).

Diffusion Strategies Geared Towards Aging Services/Medical Providers and Other Collaborators Who Work Directly with Older Adults (in addition to Technology Developers/Companies)

5. *Form partnerships:* Following the launch of a technology, spreading its impact is often most effective through creating the right partnerships that will allow for scale in the diffusion process. Partners for spreading technology may include large health care systems, a network of aging services organizations, or a community-based organization. For example, two of the most successful examples of large scale health technology diffusion have occurred through large integrated systems, KP (My Health Manager EHR) (Chen et al. 2009) and VHA (remote patient monitoring and Vista EHR) (Byrne et al. 2010). These large systems have the financial and human resources (Simon et al. 2005), as well as the aligned financial incentives, to overcome challenges in the diffusion process. For some technologies, such as EHRs and remote patient monitoring, partnering with a provider is often necessary for the patient to be able to use the technology. The impact of successful technology diffusion through these systems also reaches a large number of people; as of 2009, more than 3 million patients use KP's My Health Manager (Kaiser Permanente 2009), while in 2007 more than 30,000 patients were enrolled in the VHA's Care Coordination/Home Telehealth program (Darkins et al. 2008). In contrast, trying to diffuse technologies through solo providers and individuals can be extremely challenging from both a time and monetary perspective, especially when considering that the technology company has limited resources to spend on technology diffusion. Direct-to-consumer technologies, such as a health-related website or mobile application, can also be diffused with the aid of community-based aging services or health organizations. Forming the right partnerships, depending on the scale of the diffusion project, is a step that organizations and technology companies should explore as early as possible in the process to enable successful diffusion.
6. *Identify technology champions:* Technology champions are a critical but often overlooked element of successful technology diffusion (Rogers 1995; Beath 1991). Once a technology has been launched within an organization, community, or individual end-user, in many cases it is necessary to find someone to champion

the technology rather than trust that it will naturally diffuse. A physician from KP described the presence of a knowledgeable and motivated champion as the most important factor in the organization's EMR implementation (Jackson 2010). The technology champion(s) may be an employee in an aging services organization, a community member, or an older adult's caregiver or family member, among other examples. Financial issues aside, technology adoption can also be challenging from a workflow standpoint (Simon et al. 2007; Poon et al. 2006), particularly for older adults and/or organizations who are unaccustomed to frequent technology use. Therefore, it is necessary to have a champion who believes in the technology, is committed to its implementation, and has the resources to help overcome inevitable barriers and failures in the adoption process. Technology champions are often most visible on a system-wide or national level, such as a Chief Information Officer of a health care system, or the Office of the National Coordinator (ONC). However, there is a similar need for local technology champions, who can also have a profound positive effect on smaller-scale diffusion.

7. *Coach users:* Coaching the user is a vital part of the technology adoption/diffusion process (Moore 1999). The user includes both the older adult, as well as others who must overcome workflow challenges to work with the older adult or use technology on his or her behalf (e.g., caregivers or employees of an aging services organization). Workflow challenges are among the largest barriers to technology adoption and use (Poon et al. 2006; Chin 2004); therefore, coaching users on how to make technology fit into the flow of their work or life is critical. The older adult, or the party who acts on behalf of the older adult, must receive the proper coaching to learn how to use the technology and what benefits it provides. Coaching should be an interactive process focused on empowering and activating the older adult, and helping older adults develop the skills for sustained self-management and technology use. User coaching can be very simple for some technologies (such as a medication-reminder device, or a health-related website) or very complex for others (such as an interactive, remote patient monitoring system or complex care coordination record). Depending on the situation, the optimal coach could be the older adult's health provider, family member, informal/formal caregiver, or an organization's technology champion (or a combination of these). User coaching may be formal or informal. In addition, peer modeling (the use of older adults who are already familiar with a technology to demonstrate its benefits) can also be a highly effective coaching method, by making technology use seem less intimidating and more feasible (The SCAN Foundation 2010). The ADOPT model's diffusion strategies begin and end with actions centered around the user's needs, from creating relevant and user-friendly technology, to coaching the user on how to use the technology.

Section III. Improved Health Outcomes: Result of Successful Technology Diffusion

The successful interplay between the seven diffusion strategies and the factors relevant to older adults, their collaborators, and their context, leads to the ultimate

goal of health technology diffusion: improved health outcomes and its associated benefits (including economic benefits, improved quality of life and productivity, and decreased caregiver burden). These health outcomes are created by a patient who is empowered and activated through technology, receiving care that is personalized and appropriate to his or her situation. Examples of successful health outcomes include reduced hospitalizations and health care utilization, prolonged independent living, reduced disease burden, and behavior modifications. For example, the implementation of KP's My Health Manager has led to a 21.5–26.2% reduction in specialty, primary, and total office visit rates in its Hawaii region (Chen et al. 2009). The VHA's Care Coordination/Home Telehealth program has resulted in a reduction in both health care utilization and costs, as well as high patient satisfaction (Darkins et al. 2008). In addition, the VHA measured higher than a national sample in overall quality of care, preventive care, and chronic disease care, which is likely due in part to its EHR (Asch et al. 2004). The Center for Connected Health has indicated that the use of telehealth, remote patient monitoring, and disease management approaches can promote patient adherence, engagement, and improved clinical outcomes (Monegain 2009). Another study found that a telehealth intervention was able to increase older adults' physical functioning following coronary artery bypass surgery, an important aspect of preventing further mortality and morbidity (Barnason et al. 2009). Researchers have also found success using online programs for older adults, such as a six-month Internet-based program for diabetic adults ages 60 and older that resulted in significant reductions in HbA1c, weight, and cholesterol levels and HDL improvement compared to a control group (Bond et al. 2007).

Many such examples of technology to improve health outcomes for older adults can be provided. However, these success stories are unfortunately not yet the standard for the entire older adult population. The VHA's Care Coordination/Home Telehealth program, with more than 30,000 enrollees in 2007 (Darkins et al. 2008), is currently one of the largest integrated home-telehealth programs in the United States. Meanwhile, the U.S. population contained more than 50 million people over age 60 in 2007 (US Census Bureau 2007). Despite EHRs' ability to improve patient safety and disease management for older adults as well as other populations, their ambulatory usage was estimated to be less than 30% in the United States in a 2006 survey of primary care physicians, which is relatively low compared to leading countries (Davis et al. 2009). It is also estimated that remote patient monitoring could save the United States more than $200 billion in the next 25 years, if the technology were used more widely by patients with chronic diseases (Litan 2008). Medication adherence is also a significant issue for older adults (approximately 90% take one or more medications per week) that can be addressed through technologies such as talking pill bottles, medication dispensers, and medication reminders (Center for Technology and Aging 2009). It is estimated that $290 billion of health care savings could be realized if medication adherence were improved (New England Healthcare Institute 2009).

Social networking and other consumer-oriented technologies that do not exclusively focus on health, though not extensively addressed in this article, also have potential to improve the health of older adults. However, while older adults have shown an interest in using the Internet for health (Pew Internet & American Life Project 2004), there is currently a lack of rigorous outcomes research and

relevant/widely used health applications for these consumer-facing platforms. As of January 2010, Facebook had almost 10 U.S. million users who were ages 55 and older, which was by far the fastest-growing age group from 2009 to 2010 (Corbett 2010); studies have shown that networks can play a role in improving physical and emotional health for older adults (Green et al. 2001; Lubben 1988). However, despite their wide reach, social networks are not currently widely used to support health-related applications. WebMD.com, one of the most heavily trafficked health websites, on average reaches less than 20 million unique U.S. visitors per month (as of 2010), with only a fraction of those being older adults; most health-related websites receive far fewer visits (Venture Beat 2010). Mobile platforms also have high penetration levels in the United States at around 90% (CTIA 2009), but currently mobile health solutions are fragmented and have limited usage rates and evidence bases. Though these Internet/consumer technologies have wider reach and lower cost barriers than more clinically-oriented technologies (such as remote patient monitoring or EHRs), their specific health-related applications and usage could greatly benefit from increased design and development, evidence collection, and diffusion.

This ability of technology to enhance older adults' health, coupled with its limited reach thus far, highlights the opportunity for technology diffusion to help create health outcome improvements for the population as a whole. The factors and strategies outlined in the ADOPT model are critical elements of driving this much-needed technology diffusion to improve older adults' health.

Conclusion

Technology diffusion is a complex process that requires alignment of many different factors and stakeholders. The ADOPT model was created to highlight some of the most important factors and strategies in this process, particularly in the case of older adults who face unique challenges in using technology. Given the rise of chronic conditions (DeVol et al. 2007) and projected shortage of caregivers (Fleming et al. 2003), the growing older adult population faces unprecedented health challenges. This article presents numerous examples of technologies that have shown an ability to improve health outcomes for older adults; however, the current reach of such technologies is limited. Widespread technology diffusion has the potential to help create a sustainable, healthy future for older adults.

In the future, changing reimbursement mechanisms may help drive technology diffusion, either directly (through reimbursing technology use) or indirectly (through reimbursing for improved outcomes or care coordination). However, technology developers, aging services organizations, caregivers, health providers, insurance companies, and others who work with older adults should not rely on policy changes and overlook the important roles they can play in technology diffusion. The ADOPT model raises important factors that affect technology adoption and use (relating to older adults, and their collaborators and context), as well as strategies for these collaborators to consider for promoting technology diffusion: 1) design relevant, user-friendly technology, 2) establish technology value, 3) create business model, 4) promote technology, 5) from partnerships, 6) identify technology champions, and 7) coach users.

Though their technology usage rates may lag other age cohorts, older adults' use of technology is nonetheless on the rise (Pew Internet & American Life Project 2009). This population has demonstrated success with using technologies ranging from remote patient monitoring devices (Darkins et al. 2008) to social media technologies (Koppen 2010). The next step will be for technology developers, aging services organizations, health providers and plans, caregivers, and other collaborators to undertake strategies to promote the spread of technology, in order to transform these small-scale successes into widespread health benefits through technology diffusion. In the context of these efforts, the continued sharing of best practices and success stories among collaborators working to increase technology diffusion for older adults is highly important. The ADOPT model provides a roadmap to help older adults reach the goal of living healthier, higher-quality, and more independent lives through the wider use and implementation of proven technologies.

Limitations of the Model

The ADOPT model is primarily focused on the diffusion of home and community-based health technologies to improve outcomes for older adults. The ADOPT model is not meant to be entirely generalized to other types of technology settings and populations/age cohorts; however, literature from health systems and hospitals are cited in this article due to the relevance of technologies that overlap with the clinical setting, such as EHRs and remote patient monitoring technologies. Additionally, many of the concepts presented in the ADOPT model have relevance to technology diffusion in general, as well as other populations who face some of the same constraints as older adults in using technology (including children and the developmentally disabled).

Notes The ADOPT model was developed through literature research, The Center for Technology and Aging's research and technology diffusion grant initiatives, and The Center for Innovation and Technology in Public Health's research projects. Both the Center for Technology and Aging and the Center for Innovation and Technology in Public Health are affiliated with the Public Health Institute. The Center for Technology and Aging was established through a grant from The SCAN Foundation.

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