Innovations in Health, Wellness, and Aging-in-Place

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Development of a Consumer-Centered Approach to Intelligent Home Services

**BY JOSEPH F. COUGHLIN
AND JAMES POPE**

The late Sarah Knaus, a centenarian from Pennsylvania, was asked on her 119th birthday if she enjoyed her extraordinary longevity. Her reply was simple: she enjoyed her years because she had her health and she could do things. In the face of unprecedented longevity, the challenge for society is to understand how best to enable older people to have their health and to do things. The convergence of an aging society with today's availability of advanced technology is an opportunity to innovate and to think differently about how we live throughout the lifespan, not just in older age. The home is the primary platform for much of life's activities influencing our health, wellness, independence, and safety as we age. Creatively exploiting technology to provide services that are both needed and desired, while employing effective delivery strategies into the home, will enhance the lives of older people and improve overall quality of life across the lifespan. This article presents the opportunity for intelligent technologies in the home, identifies today's apparent innovation gap indicated by the slow diffusion of existing smart technologies, and describes an integrated consumer-centric approach that may offer promise in translating inventions into innovations in people's lives across the lifespan.

Technology and the New Demands of an Older Society

All industrial and many developing economies are experiencing a demographic transition from predominantly younger populations to a much larger proportion of older people. Although the percentage of people 65 and older is dramatically increasing, it is the oldest old, the 85 plus, that is the fastest growing cohort. The oldest old are the most frail and experience the highest incidence of disease and comorbidity. As a result, the 85 plus also suffer a high rate of disability.

The combination of frailty, disease, and disability places a considerable burden on the capacity of individuals to live independently. Moreover, family members who provide informal care to support health and related activities of daily living to elderly loved ones are constantly seeking solutions to help and to be helped. Clearly, society has a stake in finding ways to improve the quality of life, to reduce health care costs, and to extend the independence of older people.

Researchers across academia, industry, and government have attempted to set national agendas enlisting technology to respond to the demands of an aging society [1]–[3]. Many nations are launching or are already executing initiatives to better understand how technology may be used to support an aging society as well as form the basis of new markets for export. Singapore has a government-sponsored Silver Committee to better understand the opportunities of technology. Codeworks, the Newcastle, United Kingdom, regional economic development authority, is looking to create both a research environment and new business incubator around old age and health. Countless universities in the United States, Italy, Japan, Israel, and elsewhere are developing robust research agendas to develop technology to respond to the needs of older adults as well as their caregivers. Likewise, many small businesses, as well as global giants, such as Intel, Microsoft, Matsushita, and General Electric, are investing in new products and services to meet the demands of a grayer marketplace.

Technology is being applied across many environments to help older adults. The simple, but ubiquitous, telephone has successfully been used to manage chronic disease across the age spectrum [4]. Improved warning systems have been developed to help older drivers with notoriously difficult left-hand turns. Assistive technologies are available to support everything from personal mobility to medication adherence as well as robotics and domotics to help with everyday activities in both long-term care and the home [3]. Sensors, video, and related algorithms are being engineered into the home to help caregivers monitor the well-being of an elder, prevent wandering, or detect health changes in a frail older adult and are now able to predict a catastrophic event.

Health at Home

No other domain has been a richer target of research and commercial interest than the intersection of health and the home. Many have observed that multiple health management and even treatment functions have moved from traditional clinical venues, such as the hospital, to the home [5]–[8]. Research and demonstration projects such as the Georgia Institute of Technology's Aware Home, University of Florida's Gator-Tech Smart House, Massachusetts Institute of Technology's House N/Place Lab, Intel's home health research, or

Procter & Gamble's model house of the future and many others all seek to apply information communications technology, robotics, and other novel applications to meet the health needs of older people. Although health may not be the exclusive interest of these projects, health in the home is a major and often primary focus.

Many look to technology to simply monitor health and disease state; however, as shown in Table 1, smart applications can be used to monitor, manage, and motivate health behaviors at home to ensure well-being; efficiently use provider resources; and encourage preventative behaviors [6]. Many, if not all of these systems, provide the foundation of today's telemedicine or telecare to the home to support the health, wellness, and disease management needs of older adults and caregivers.

Intelligent devices, Internet-enabled appliances, motion sensors, video systems, even sensors embedded in clothing, jewelry, and furniture combined with predictive modeling and related algorithms can be used to effectively monitor the health and daily activities of older people living in their own homes 24 h a day, 365 days a year [9], [10].

Other systems range from the cell phone to more elaborate smart home health systems that may include Internet-enabled scales, blood pressure cuffs, and a wide range of wireless devices, e.g., glucose monitors. Japan's manufacturers Toto and Panasonic have added intelligence to everyday devices to manage health. Smart toilets, connected to the Internet, are available to collect data and upload it to the relevant care provider or call center to manage multiple chronic diseases including diabetes, congestive heart failure, and other diseases that frequently affect the elderly. These systems enable home health providers, e.g., visiting nurses, disease managers, associated call centers, and others, to provide the right intervention at the right time, identify high-risk patients, and optimize clinical resources and assess patient progress [12], [13].

Selected technologies, such as glanceable devices, may use common objects such as a picture frame or an ambient orb to display variations of green, yellow, and red lighting to inform patients and caregivers of a change in condition. Pill bottle caps that change color to indicate that a medication should be taken are now equipped with the ambient technology. Smart medicine cabinets and pill bottles that work together to track movement of bottles in and out of the cabinets to ensure medication compliance are under development. More creative applications use cell phones, wearable technologies, and the ubiquitous television cable systems as portals to health services to motivate healthy behaviors with personalized information delivered at the point of decision, which include medication, diet, and exercise compliance [14], [15].

Translating Invention into Innovation

Although there is a growing awareness of the need for new ways to improve the well-being of older people at home as well as the availability of increasingly affordable technology and computational power, consumer and clinician adoption has been slow. For example, social alarms or personal emergency response systems (PERSs) enable a person to call for help in the event of an accident (e.g., fall) or other problem. Services like using a wireless pendant, bracelet, or call box connect the older person to a call center, which then notifies ambulance services and family members in the event of an emergency. The technology is more than 30 years old, simple, and perhaps one of the most affordable home technologies designed primarily for elderly living alone. Despite the affordability of these services, near or less than the price of basic cable television, adoption of these systems in nearly any country is far from robust despite their long-time presence on the market [16]. Estimates suggest that in the United States, there is only between 2 and 4% market penetration of likely users: older adults 65 or above managing two or more chronic diseases. Even in the United Kingdom, where a physician can routinely request a system for a patient at the full expense of the National Health Service, market penetration is less than 15% [16].

A wealth of inventions in support of older adult health at home may be found in laboratories around the world, but few have been widely translated into innovations in the living room. Some may argue that it is simply a matter of time—but how much time? Telemedicine is at least 40 years old, but it is still not widely used. Yet, technologies that are part of an overall smart home supporting comfort, communications, and entertainment, e.g., lighting and climate control, home computing, multimedia entertainment, gaming, are rapidly finding their way into people's kitchens, bedrooms, family rooms, and

Table 1. Technology use in home health care and disease management.			
	Function	**Selected Technologies**	**Innovation and Outcomes**
Monitor	24/7 monitoring of health and activities	Intelligent devices and appliances, robotics Internet-enabled services, predictive behavior models, etc.	Reduction of emergency events, rapid intervention to health changes, and/or decline
Manage	Identify and prioritize patients requiring remote or home-based intervention	Information technology and software with embedded risk models to triage, review, and assess patient progress	Efficient use of home health care human and financial resources
Motivate	Engage, educate, and empower patient and/ or family in their own health	Glanceable display technologies, two-way communications, integration of fun, and familiar entertainment systems to coach and connect patients, caregivers, families	Management of existing conditions and prevention of disease
Source: MIT AgeLab (6).			

even some bathrooms of their primary consumer market: the 50 plus. Why have innovations in technology-enabled services, particularly in health and wellness, been slow to diffuse into the homes of aging boomers and today's older adults? We suggest that the poor diffusion of these systems is due to how user needs and markets have been defined as well as how the services are currently delivered to the home. To fully realize the health and wellness benefits of these technologies in the homes of today's older adults as well as tomorrow's older baby boomers, researchers and providers must work to systematically

➤ *define* more broadly the potential adopters (and their unique user requirements) of home health and related systems to ensure wide market development and multiple revenue streams

➤ *develop* a comprehensive approach to health and wellness services in the home that goes well beyond today's single disease monitoring and device applications

➤ *deliver* home health technologies and services by a wide variety of sources from traditional health providers to commercial providers that may include utilities, affinity groups, banks, large pharmacy, food retailers, etc.

Defining New Markets for Intelligent Home Services

Although the oldest old present the greatest challenge and demand for invention, moving intelligent home services into their lives may require definition of multiple and complementary markets. These markets include family caregivers managing chronic disease, aging baby boomers managing health and wellness (often called the worried well), and older adults seeking to ensure their ability to age-in-place. Each of these consumer groups potentially offer discretionary out-of-pocket revenues beyond the current market dominated by private and public insurers. Moreover, these users may be instrumental in deciding to introduce technology-enabled services into the homes of today's elderly.

Caregivers and Employers

Family caregivers are the closest and most often the primary provider of support to the health and daily needs of frail elderly. One in four American homes is estimated to provide support to an older adult. Likewise in Europe, 25% of families provide at least 12–18 h of support to an older family member. In Japan and Taiwan, the changing role of women in the workplace is reducing the ability of those societies to rely on stay-at-home adult daughters to provide eldercare. Typically, a spouse or adult child caregivers are eager consumers of services to monitor a loved one's well-being, which includes safety, health and related tasks, medication compliance, diet and nutrition management, and monitoring of weight, blood pressure, glucose levels, etc.

Caregiving is more than a family problem. It is now an employee productivity challenge. Studies suggest that eldercare is now an equal or larger issue than childcare in the workplace. AARP and Met-Life have estimated that lost productivity due to eldercare demands on an employee's workday hours or inability to take a position away from their elderly parent may cost employers in the United States nearly US$32 billion per year. An increasing number of caregivers live several miles or several states from their parents, which makes care difficult or impossible. Employers may now be seen as a channel for service providers as well as a potential financial partner with employee or caregivers [17]. For example, Italy-based Generali Insurance is now providing home health services to older adults in France to fill in the emerging family caregiver gap as part of their strategy to reduce the home risks of their insureds.

Disease Management and Wellness

Disease management is today's largest consumer of intelligent home health services [18]–[21]. Most of these services, however, are reimbursed with government or health maintenance organization (HMO) funding limiting both the number of firms who may enter the market as well as funding available to develop new approaches to technology-enabled disease management. However, the worried well or predisease baby boomers may be a significant source of demand and discretionary income. The baby boomers, born between 1946 and 1964, are between ages 44 and 62. As Figure 1 indicates, health care costs begin to escalate dramatically at age 43, suggesting that the baby boomers are now in chronic disease prime time. Unlike their parents, the baby boomers of Europe, North America, or the Dankai of Japan have more experience with technology and are the largest consumers of wellness products and services. Intelligent home services that promote proactive vitality and wellness rather than manage disease alone are an emerging demand. Services that assist with diet decisions, exercise, and optimal physiological performance for those in predisease (e.g., prehypertension, prediabetic) states may drive introduction of technologies into the home as a lifestyle choice rather than a life stage need well before the users enter their seventh and eighth decades [21], [22].

Aging-in-Place

Considerable effort has gone into developing visions of the house of the future. Although some may downsize or move into a new home on retirement, most are likely to age-in-place, i.e., stay in the homes they currently live in for as long as possible. More than 80% of people 65 and older live independently
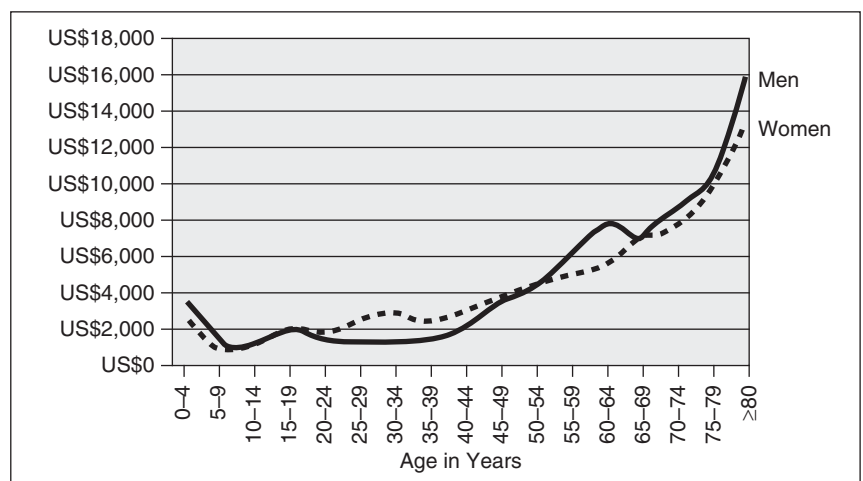

Fig. 1. Health care costs by age. Source: U.S. Centers for Disease Control.

today. The desire to maintain independence in one's own home is routinely identified as a passionate priority for people as they age. Intelligent home services may serve as a strategy to extend that independence, managing more than health and enabling home food delivery, remote monitoring of appliances [e.g., heating, ventilation, and air conditioning (HVAC), kitchen appliances] home maintenance needs, safety, and security, and other services that may stave off moving in with an adult child or anywhere else that results in leaving behind a home that houses a lifetime of memories. Services that address these needs are ageless and touch consumer values of convenience in youth and necessity in older age.

Developing an Integrated Architecture of Intelligent Home Services

Intelligent home health services should be envisioned as a complete technology architecture that fully leverages the convergence of consumer electronics, kitchen and bathroom appliances or fixtures, entertainment, computing, and specific applications in health and wellness to address the needs of the elderly. Rather than today's device and disease-driven service model that relies on government reimbursement or private health insurance alone, a variety of services should be offered to consumers to address a wide range of needs as well as wants. These consumer demands include health, wellness, safety, security, entertainment, education, convenience, connectivity, personalized advice, assistance with routine home maintenance, etc.

Figure 2 presents a proposed architecture to envision intelligent home health services for aging baby boomers and older adults. As illustrated in Figure 2, the home is evolving into a rich platform of sensors and connectivity touching nearly every aspect of living in the home. The home may now be characterized as a home health and services platform where a variety of sensors and devices, including smart appliances, wearable computing, and entertainment systems, provide multiple sources and parameters of data to monitor activities as well as information to enable personalized services.

The convergence of industry investments to improve the efficiencies of their supply chain along with the baby boomer's desire to remodel their homes will make this old house much smarter and age ready. Manufacturers such as Procter & Gamble and retail giants such as WalMart are investing in radio frequency identification tags (RFIDs) or so-called penny chips that contain data, including lot number, point of origin, expiration date, size, etc., to improve their supply chain efficiency. Although RFID may improve their operational effectiveness, it may also be a windfall for the consumer's management of critical health behaviors from diet to medication adherence. These chips will also be capable of containing and sharing information that is of interest to the consumer as well; e.g., number of servings, expiration date, ingredients and related nutrition facts, drug-drug interaction, and drug-food interaction. Combined with increasingly intelligent appliances from refrigerators and ovens to even a high-IQ breadbox, the combination of smart packaging and home technologies provides information to proactively monitor diet, to manage disease, or to simply ensure that there is food in the house [14], [23].

The aging baby boomers are the largest single market for home improvement products. As they choose to renovate their homes, the appliances they purchase are likely to contain options to connect to the Internet and to each other. In addition to smarter appliances, newly installed cabinets and countertops will be capable of exchanging data via the Internet on the foods, medications, and other products that pass across their tops or by their doors. The data might be used to generate a household shopping e-list enabling convenient shopping for owners or caregivers, facilitate automated home food delivery, or offer real-time dietary guidance to those preparing meals. A smart medicine cabinet may serve as an advanced medication compliance system to remind users that a pill should be taken. The same cabinet may also detect potential interaction hazards between medications sharing the shelf, when a prescription needs to be refilled, or when it is nearing its expiration date, automatically notifying the local pharmacy and enabling home delivery.

Video, motion detectors, and other systems that may be integrated in the home for safety and security will also provide data to predict changes in well-being. These aware systems can detect changes in activity to show either improvement, indicated by activity, or sense fatigue and illness, indicated by less movement in the home. Related context-aware systems and algorithms are being integrated into services that promise to predict a fall based on an observed change in gait rather than simply reporting an accident after it has happened. Even the toilet has become a data collection point. In Japan, smart toilets are collecting weight, glucose levels, and other information and then transmit these data to local hospitals and disease management call centers to better manage conditions ranging from congestive heart failure to diabetes.

Convergence of health and wellness with consumer entertainment electronics is already taking place in the home. Philips introduced Motiva, a system that connects patients, health devices, and care providers via television broadband. The system provides a home hub and private channel for users to connect to
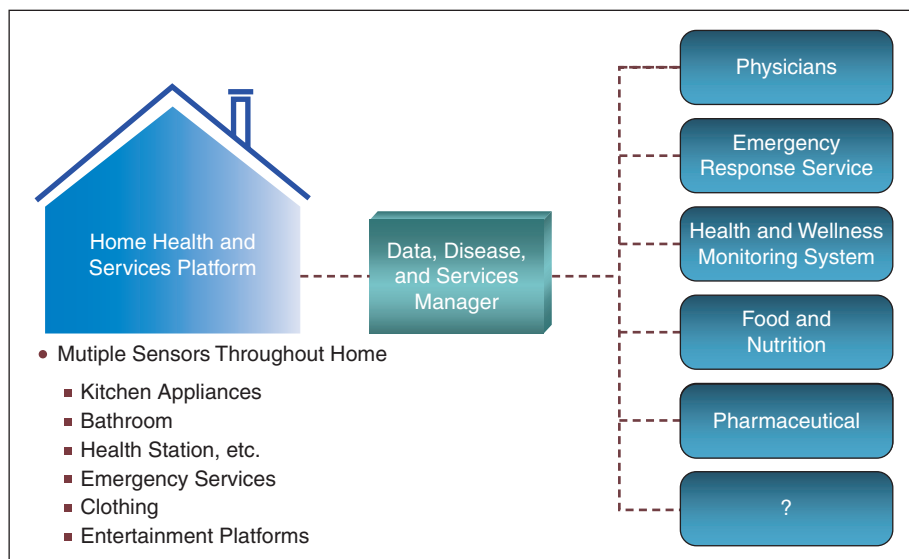

Fig. 2. An integrated approach to intelligent home health services.

> **T**echnology is being applied across many environments to help older adults.

formal and informal caregivers and receive information to motivate adherence to their prescribed health regimen.

Further developments that integrate home entertainment, kitchen, and bathroom appliances and health will be seen as the population ages. The consumer will demand this integration as a matter of improving usability and the desire to make health at home a signature of lifestyle, rather than as a stigma of age. Industry, through the Continua Health Alliance, is attempting to establish technology standards to improve the effectiveness and successful adoption of these promising telehealth systems. Consumer pull and technology push will reshape today's collection of otherwise disparate devices from blood pressure cuffs to smart scales, glucose meters, etc., into a home health station. The health station will integrate functionality and instant connectivity to care and disease mangers as well as serve as a portal to multiple service providers. Similar to the washers and dryers, television, or, more recently, the personal computer, the elegant integration of these systems into our homes will create a new permanent place in the home to access wellness services across the lifespan, from children with ear infections to older adults managing multiple chronic conditions [15].

As Figure 2 illustrates, these various home systems will connect to a data, disease, and services manager that could serve as a trusted virtual home concierge to integrate these data to manage the delivery of services. A wellness and disease management company in partnership with a major information technology firm or utility company could provide these services. In France and Japan, selected utility companies are offering adult children a service that reports gas or electric utilization rates by an elderly parent. If there is a predictable spike in the morning, it can be assumed that the morning coffee or tea is being made. If not or the appliance appears to have been left on, a text message is immediately sent to the adult child. Similarly, Tokyo Power & Electric works with a major Tokyo hospital to provide a conduit for data collected from patients using health devices to manage congestive heart failure.

An integrated approach to intelligent home services generates consumer value by offering easy access to multiple services that could be selected one at a time or bundled the way cable, telephone and Internet access is sold today. As shown in Figure 2, a variety of services could be chosen from telemedicine, pharmacy, food and nutrition, emergency services, etc. Trusted organizations and companies would deliver each of these services as part of an overall service package. For example, a local utility could monitor the function and maintenance of a hot water tank or heating system and notify the resident or caregiver of an impending problem. Rather than creating an older person's home, the intelligent home organizes needs, wants, and services for an active boomer, older person, or caregiver into a coherent lifestyle and envelope of care, one that would change with the evolving needs of the user across the lifespan.

New Delivery Channels

New markets and creative application of technology alone will not ensure the movement of intelligent home services into the lives of older people. Where and how the services are offered and sold is equally important. Despite clear need and potential demand, many products and services designed specifically for the elderly do not succeed in the marketplace. Moreover, distributions through traditional channels that frame products as an old man's purchase are likely to stymie market success with younger and older consumers.

Distribution may be most successful through traditional retail channels. Smart technologies that combine fun and functionality, e.g., home entertainment systems that also serve as a platform for health monitoring, could be offered through consumer electronics stores adept at offering services to complement their product sales. For instance, Best Buy, the Minnesota-based consumer electronics retailer, is experimenting with a new store concept, EQ Life, that exclusively sells wellness products and services. Other providers may include large retail pharmacy chains that have entered the services business, e.g., Walgreens Health Initiatives or CVS's recent purchase of Minute Clinic. Grocery stores that sell wellness as a lifestyle as much they sell food, e.g., Whole Foods, may also be seen a powerful distribution channel in the United States while global grocer Tesco may be another trusted provider of services to the home.

Wireless, phone, cable providers, and other communications companies should be seen as both providing access to the home as well as a potential means to organize and bill for services. Social alarms, health monitoring, or other distance caregiving services may be ideal solutions for adult children looking for solutions through trusted ubiquitous providers, such as home improvement stores, retail banks, or even through employers who have a corresponding interest in the productivity of their adult child employees. Likewise, long-term care, life and health insurers, affinity groups, and others could provide unique distribution offering special services or discount programs for their clients and members to use these services while banks may provide an integral role in trusted transactions from simple information sharing to billing.

In addition to novel approaches to distribution, device manufacturers may have to adopt a new business model that is similar to the cell phone industry. Instead of selling hardware, services, particularly health support, will evolve as the primary value proposition: recognizing that the technology is a commodity that will be replaced as needs, technology, or services change.

Discussion

The home has been the topic of countless research projects and pilots demonstrating the potential of intelligent systems to

manage health or monitor the status of older adults. Thus far, the focus has been on invention rather than innovation—emphasizing individual sensors, telemedicine applications, or related devices that address specific health and safety needs of the most frail. Despite their potential, and in many cases demonstrated effectiveness, the adoption of these systems has been remarkably slow. Some have argued that privacy and price concerns have limited adoption. While that may be true, it is probably an incomplete explanation. In other domains, privacy has been overcome when the value proposition to the user is great; e.g., privacy and connectivity, convenience as provided by cell phones, and credit cards. A comprehensive and compelling consumer-centric vision of how the home can support our health and well-being throughout the lifespan has yet to be introduced to the marketplace—one that is as attentive to user demands as much as it is to technology potential.

In the short term, the successful commercialization of home health services is most likely to be built around familiar technology already in the home today. The Trojan horse for health in the home may actually be fun and entertainment rather than through the every growing list of disparate clinical devices. Through the TV, or even video games, behaviors could be shaped and health data collected, visualized, and serve as a portal to an ongoing dialogue with formal and family caregivers. Developers and manufacturers of smart home health devices, along with their respective service providers, would be wise to strike strategic alliances with consumer electronics companies and retailers to attain placement in the home and minds of the baby boomer consumer.

Over the longer term, newer homes will contain integrated health systems that are part of an emerging technology-enabled lifestyle: a smart nutrition advisor system in the kitchen provided by the local grocery store in collaboration with an interested insurer to facilitate home delivery and advise on food choices or a home health station in the bath or bedroom connecting to a wellness call center.

The architecture presented here is an attempt to integrate consumer demands and technology with a new look at how services might be delivered to envision a home designed for living across the lifespan serving as a platform for promoting vitality, managing disease, and enabling convenient living for today's busy boomer and support for tomorrow's elderly boomer aging-in-place.

Joseph F. Coughlin is the founder and director of the Massachusetts Institute of Technology (MIT) AgeLab. His research examines the disruptive demographics of an aging society as a driver of technical, policy, and market innovations. A frequent speaker, and consultant to both business and governments around the world, he teaches courses on policy and strategic change offered at both MIT and Harvard Medical School.

James Pope is the executive vice president, and chief operating officer of Healthways, overseeing product development, delivery, and support for all U.S. business. In 2003, after 26 years of private practice in Tampa, Florida, he joined Healthways as chief medical officer. In that role, he was responsible for all medical quality initiatives. He serves on the Board of Directors for the Disease Management Association of America (DMAA). He has co-authored numerous journal articles, and held a number of executive positions, including president of the HeartCare Institute of Tampa and president and medical director of Florida Cardiac Network, Inc. He also served on the faculty at Wake Forest's Bowman Gray School of Medicine.

Address for Correspondence: Joseph F. Coughlin, Ph.D., Director, MIT AgeLab, One Amherst Street, Cambridge, MA 02142. E-mail: coughlin@mit.edu.

References

[1] J. F. Coughlin, "Technology needs of aging boomers," *Issues Sci. Tech.*, Fall 1999.
[2] E. Dishman, "Healthcare revolution: Technologies enable seniors to age gracefully at home," *Technology@Intel Mag.*, pp. 1–11, Dec. 2004.
[3] R. W. Pew and S. B. Van Hemel, Eds., *Technology for Adaptive Aging.* Washington, DC: Steering Committee for the Workshop on Technology for Adaptive Aging, National Research Council, 2004.
[4] P. M. Orr, B. Hamar, D. Carr, et al., "The impact of telephonic intervention on compliance with LDL and A1c testing in a disease management program," *Circulation*, vol. 113, no. 6, pp. 788–834, 2006.
[5] I. Korhonen, J. Parkka, and M. Van Gils, "Health monitoring in the home of the future," *IEEE Eng. Med. Biol. Mag.*, vol. 23, no. 3, pp. 66–73, May/June 2003.
[6] J. F. Coughlin, J. E. Pope, and B. R. Leedle, Jr., "Old age, new technology, and future innovations in disease management and home health care," *Home Health Care Manag. Pract.*, vol. 18, no. 3, pp. 196–207, 2006.
[7] A. J. Sixsmith, "An evaluation of an intelligent home monitoring systems," *J. Telemed. Telecare*, vol. 6, no. 2, pp. 63–72, 2000.
[8] T. Tamura, T. Togawa, M. Ogawa, and M. Yoda, "Fully automated health monitoring system in the home," *Med. Eng. Phys.*, vol. 20, no. 8, pp. 573–579, 1998.
[9] S. Rhee, B.-H. Yang, and H. Asada, "The ring sensor: A new ambulatory wearable sensor for twenty-four hour patient monitoring," in *Proc. 20th Annu. IEEE EMBS Int. Conf.*, 1998, pp. 1906–1909.
[10] J. Parkkas, M. van Gils, T. Tuomisto, R. Lappalainen, and I. Korhonen, "A wireless wellness monitor for personal weight management," in *Proc. 2000 IEEE EMBS Int. Conf. Information Technology Applications in Biomedicine, ITAB-ITIS*, 2000, pp. 83–88.
[11] D. L. Hudson and M. E. Cohen, "The role of information technology in disease management," in *Proc. 4th Annu. IEEE Conf. Information Technology Applications in Biomedicine*, 2003, pp. 169–172.
[12] P. M. Orr, M. A. McGinnis, L. R. Hudson, S. S. Coberley, A. Crawford, J. L. Clarke, and N. I. Goldfarb, "A focused telephonic nursing intervention delivers improved adherence to A1c testing," *Dis. Manag.*, vol. 9, no. 5, pp. 277–283, 2006.
[13] S. S. Intille, "A new research challenge: Persuasive technology to motivate healthy aging," *IEEE Trans. Inform. Technol. Biomed.*, vol. 8, no. 3, pp. 235–237, 2004.
[14] J. F. Coughlin, "Disruptive demographics, design and the future of everyday environments," *Des. Manag. Rev.*, vol. 18, no. 2, p. 53, 2007.
[15] J. Lau, "Diffusion of innovation and technology policy for an aging society," S.M. thesis, Technology and Public Policy Program, MIT, 2006.
[16] J. F. Coughlin, "Aging & family caregiving: Why should financial services care?" *AgeLab 06-02*, MIT, 2006.
[17] Disease Management Association of America. (n.d.). *Definition of disease management* [Online]. Available: www.dmaa.org/definition.html
[18] "Disease management programs: Improving health while reducing costs?" *Center on an Aging Society*, Georgetown University, no. 4, Jan. 2004.
[19] S. Forman and M. Kelliher, *StatusOne: Breakthroughs in High-Risk Population Health Management.* San Francisco, CA: Jossey-Bass, 1999.
[20] P. M. Orr, A. Hobgood, S. S. Coberley, P. Roberts, G. Stegall, C. Coberly, and J. Pope, "Improvement of LDL-C laboratory values achieved by participation in a cardiac or diabetes disease management program," *Dis. Manag.*, vol. 9, no. 6, pp. 360–370, 2006.
[21] L. R. Hudson, G. Brent Hamar, P. M. Orr, J. H. Johnson, A. Neftzger, R. S. Chung, M. L. Williams, W. M. Gandy, A. Crawford, J. L. Clarke, and N. I. Goldfarb, "Remote physiological monitoring: Clinical, financial, and behavioral outcomes in a heart failure population," *Dis. Manag.*, vol. 8, no. 6, pp. 372–381, 2005.
[22] J. Sidorov, R. Shull, J. Tomcavage, S. Girolami, N. Lawton, and R. Harris, "Does diabetes disease management save money and improve outcomes?" *Diabetes Care*, vol. 25, no. 4, pp. 684–689, 2002.
[23] J. Kaye. (1999, June). *Counter intelligence, White Paper-Prospectus* [Online]. MIT Media Lab. Available: http://www.media.mit.edu/ci/papers/whitepaper/ci13.htm