Chapter 5
Expanding the Technology Safety Envelope for Older Adults to Include Disaster Resilience

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5.1 Introduction

The concept of resilience is central to understanding how technology might have a role to play in reducing the disproportionate vulnerability of older adults in natural and human-made disasters. Resilience has been defined in various ways by different theorists and researchers, but the common thread is the idea of adaptive capacity

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and the ability to recover from adversity (Norris, Stevens, Pfefferbaum, Wyche, & Pfefferbaum, 2008). Resilience is not simply a personality style or a characteristic of individuals but a product of the interplay among various determinants of population health: income and social status, social support, education, employment, social and physical environments, health practices and coping skills, developmental factors, biological and genetic endowment, health services, gender, and culture (Public Health Agency of Canada [PHAC], 2003). Disasters are large-scale disturbances or sources of adversity that tax the resilience not only of individuals but of whole communities and broader societies. All members of a population can be at risk depending on the nature of the crisis. As would be expected given the multiple interacting determinants that come into play, the pathways from risk vulnerability to disaster resilience are complex (International Federation of Red Cross and Red Crescent Societies [IFRC], 2004). Similar to other population health challenges, the availability of appropriate resources, effectively implemented, is likely to contribute to more desirable outcomes for individuals and groups who are responding to and attempting to recover from disasters (Lindsay, 2003). Disaster resilience is increasingly in the public eye as the number of catastrophic natural and human-made events continues to rise. This chapter examines the potential for technology to promote disaster resilience among older adults. They are a population subgroup with increased vulnerability in emergencies not because of age per se, but because they are more likely to live with a constellation of risk factors for increased vulnerability, including health problems, dependence on healthcare and social services, lower socioeconomic status, and restricted social networks. In addition, with increasing age, higher proportions of older adults are women, a population subgroup with heightened vulnerability across the life course (Powell, 2009).

Research shows that older adults are given low priority and little attention before, during, and after disasters (HelpAge International, 2000), despite experiencing disproportionate risk for morbidity and mortality. The neglect of older adults' unique concerns is thought to be systematic and discriminatory (IFRC, 2007). The consensus from two international workshops on seniors and emergency preparedness convened by the Public Health Agency of Canada was that there was a critical need to ensure older adults are included in all aspects of emergency management (PHAC, 2008a, 2008b). Similar conclusions have been expressed in publications by AARP (Gibson & Hayunga, 2006), the World Health Organization (WHO) (Hutton, 2008; WHO, 2008), and the IASC (2008). The gaps identified in this literature are far reaching and include lack of consideration of older adults' vulnerabilities such as their ease of access to healthcare and social services, economic subsidies and incentives, and transportation. We argue that there is a role for technology in bridging some of the gaps.

At the same time, it should be noted that there is also insufficient attention given to the contributions that older adults can make to their families and communities in disaster situations. For example, in *Older People in Disasters and Humanitarian Crises: Guidelines for Best Practice*, HelpAge International (2000) notes that "Older people play valuable roles as carers and resource managers, while the knowledge they hold—of traditional survival systems, appropriate technologies, and alternative medicines—can be central to the development of community coping strategies in and after crises" (p. 12). Older adults' experience and their willingness to participate in emergency response and recovery activities represent largely untapped resources in both traditional and more industrialized societies. In industrialized societies in particular, there is potential for the increasingly tech-savvy older generation to contribute to disaster resilience through participation in research and knowledge translation that focuses on the applications of technology to emergency management challenges.

To set the stage for discussion of the role of technology in building and facilitating disaster resilience among older adults, we begin by describing the four phases of the emergency management cycle and the risk factors that contribute to increased vulnerability for older adults. Our analysis is framed within the emergency management cycle to highlight the potential for technological solutions to contribute to the resolution of practical problems that disproportionately impact older members of the population, and thereby to increase the likelihood that they will survive a disaster and recover in its aftermath.

The technologies we consider include tracking and mapping systems, intelligent building systems, medical and assistive devices, communication and notification systems, needs assessment strategies, medical support strategies, security strategies, and reconstruction strategies. The chapter closes with a discussion of factors that may influence the acceptance, uptake, and application of technology in building disaster resilience in aging individuals and the systems that they rely on for support and protection.

5.2 The Emergency Management Cycle

The four phases of the emergency management cycle are prevention/mitigation, preparedness, response, and recovery (WHO, 2008). *Prevention and mitigation* entail proactive measures taken before an emergency situation occurs in the interests of eliminating or reducing the potential impacts and risks. *Preparedness* refers to actions taken to become ready to respond to an emergency situation if and when one occurs. Prevention, mitigation, and preparedness activities target risk reduction (WHO, 2007). *Response* refers to the actions that are taken during and immediately after an emergency situation in order to manage the consequences, and in particular to limit harm and loss, including loss of life. *Recovery* involves efforts to repair or restore conditions to an acceptable level through measures taken after a disaster.

Although it is useful to conceptualize emergency management within these four phases for planning purposes, in actual crises, there is significant overlap. For example, in a large-scale flood, different communities, discrete households within communities, and individuals within those households may be at very different stages of action. Some communities, households, and individuals will be well prepared, have ample resources and strong social supports, and be able to move relatively quickly from response to recovery, while others may be scrambling to prepare as the flood waters rise and/or be lost in bureaucracy when the window of opportunity for restoration support is open. Gaps in emergency management can contribute to a hazardous situation becoming a disaster involving widespread injury, property damage, and death.

5.3 Vulnerability Risk Factors for Older Adults

Internationally, there is mounting evidence that older adults are at increased risk for morbidity and mortality in emergency situations (Barney & Roush, 2009). For example, the WHO (2008) reports that the highest age-specific death rates in Aceh, Indonesia, that resulted from the 2004 Indian Ocean tsunami were among persons aged 60–69 (22.6 %) and 70 and over (28.1 %). The European heat wave of 2003 caused 14,800 deaths in France alone, and it was older adults who had the highest mortality (Kosatsky, 2005). Almost three quarters of the deaths from Hurricane Katrina in the United States in 2005 were in those aged 60 and older (Gibson & Hayunga, 2006). Physical and medical issues that increase the vulnerability of older adults include mobility limitations, changes in thermoregulation ability, and chronic disease. Impaired mobility reduces physical capacity to take evasive and defensive action, such as evacuating a high-rise building using stairs (Shields, Boyce, & McConnell, 2009). Age-related changes in thermoregulation place the older adult at risk of either hyperthermia or hypothermia, although few die from these causes (Goodwin, 2007). In fact, the major causes of death during cold weather are respiratory (e.g., chronic obstructive pulmonary disease, bronchitis) and thrombotic illnesses (e.g., myocardial infarction, stroke). Relatively minor exposure to cold in daily life increases hypertension and hemoconcentration (Donaldson, Robinson, & Allaway, 1997). This may explain why deaths from arterial disease are more prevalent in the northern hemisphere in winter. Impaired cardiovascular reflexes are also implicated in hot weather-related mortality. The risk here however is lowered blood pressure.

Many older adults have chronic diseases such as pulmonary and cardiovascular disease that require ongoing treatment. In 2009, nearly a quarter of Canadian seniors (23 %) indicated that they had some form of heart disease (PHAC, 2010). Coronary artery disease leads to angina and myocardial ischemia, causing decreased physical endurance. Hypertension, cardiac arrhythmias, and congestive heart failure are also common, causing reduced physical activity and fatigue. Cerebrovascular disease can lead to stroke, resulting in residual deficits and weaknesses that may require the use of mobility aids such as canes, walkers, and wheelchairs and/or the assistance of others to maintain independence.

Osteoarthritis, affecting an estimated 85 % of persons aged 75 and older (PHAC, 2010), causes pain, limits mobility, and is a risk factor for falls. Osteoporosis, which leads to loss of bone mass and an increased risk of fractures, is also common in the older population, affecting an estimated 65 % of women and 6 % of men aged 65 and over. Many older adults also have vision and hearing impairments that can compromise their ability to respond to danger.

Dementia and frailty are specific risk factors for heightened vulnerability. Dementia is the name given to a group of progressive neurological diseases that slowly destroy memory and reasoning, erode independence, and eventually take life. Alzheimer's disease is the most well-known and common form of dementia (Alzheimer Society of Canada, 2010). Impaired cognition resulting from dementia reduces decision-making and follow-through capacity in a disaster situation. Frailty is a clinical syndrome separate from the normal aging process in which impairments such as sarcopenia, functional decline, neuroendocrine dysregulation, and immune impairments occur in combination (Abellan Van Kan et al., 2008). The comorbid aspects of dementia and frailty exacerbate each condition, making the provision of both physical and mental health care even more problematic in disaster situations.

Risk factors related to health intersect with situational and socioeconomic factors to increase vulnerability for older adults in emergencies and disasters. Social isolation is one of the most important of the latter (Gibson & Hayunga, 2006; HelpAge International, 2000). Older adults who live alone who have physical, cognitive, or mental health conditions that limit their functional abilities may face insurmountable barriers in meeting practical challenges such as obtaining heat, electricity, potable water, food, and medical supplies and providing pet care in emergency situations. They may be reliant on healthcare and social services that are disrupted by the event. Older immigrants may be at particular risk for experiencing cultural, linguistic, and/or literacy barriers that reduce their access to information and resources. Generally, older adults have fewer financial and social resources to draw on. Moreover, lack of awareness, ageism, and systemic discrimination contribute to the neglect of vulnerable older adults in emergency preparedness initiatives and in community recovery and rehabilitation activities post-disaster (Hutton, 2008).

Older adults who live in long-term care facilities also face distinct challenges during and after disasters. Residents of these facilities have serious physical and/or cognitive impairments, rely on others for assistance with activities of daily living, and require 24 h skilled nursing supervision. One in five Canadians aged 85 years and older currently reside in long-term care facilities (Statistics Canada, 2010). However, it is estimated that by 2041, 120,000 beds will be needed in addition to the current 200,000 long-term care beds across the country. The frailty and medical complexity of facility-based residents are very different from what they were a decade or two ago. Residents are admitted when they are closer to the end of life. They are more functionally dependent and require greater assistance with activities of daily living (Frohlich, De Coster, & Dik, 2002; McGregor et al., 2010; Smith, Tremethick, Johnson, & Gorski, 2009). Many have a diagnosis of dementia.

The effects of Hurricane Katrina demonstrated the vulnerability of long-term care facility residents during and after disasters. Common problems in these facilities included inability to track and monitor all residents; loss of electricity for brief or sustained periods of time; lack of sufficient and appropriate transportation for evacuation of residents; disruption of communication systems with breakdowns in telephone and cellular services; lack of food, water, medications, oxygen equipment, and other medical and general supplies; lack of sufficient numbers of staff; and lack of adequately prepared staff (Deeg, Huizink, Comijs, & Smid, 2005; Dosa, Grossman, Wetle, & Mor, 2007; Laditka, Laditka, Cornman, Davis, & Richter, 2009; Saliba, Buchanan, & Kingston, 2004). Evidence suggests that in the case of Hurricane Katrina and other disasters, long-term care facilities receive less support than needed from emergency response agencies (Brown, Hyer, & Polivka-West, 2007; Dosa et al., 2007; Hyer, Brown, Berman, & Polivka-West, 2006; Laditka et al., 2009).

5.4 Gerontechnology and Emergency Management

Gerontechnology is an interdisciplinary field of research and application involving gerontology-the scientific study of aging, and the development and distribution of technology-based products, environments and services (Fozard, Rietsema, Bouma, & Graafmans, 2000). In general, much of the work on human interaction with machines, devices, and information systems can be usefully conceptualized as an attempt to maximize the degree of fit between the hardware, software, and instructional components of technological systems and the user's sensory, perceptual, cognitive, and psychomotor abilities (Czaja, Sharit, Charness, Fisk, & Rogers, 2001). As a discipline, gerontechnology has acquired depth and breadth over the past two decades (Charness & Jastrzembski, 2009). In its essence, however, it continues to primarily involve the integration of two broad fields—engineering and gerontology—to achieve practical goals such as providing solutions to compensate for deficits in motor functioning, sensory acuity, decision-making, social connectedness, and the like that become more prevalent with age (Fozard et al., 2000). Results from research on aging are used to inform the technical aspects of product design, housing, mobility, information and communications, safety and security systems, training and education, health and home care, and medical technology (Graafmans & Taipale, 1998).

The functions of gerontechnology include *preventing* problems from occurring, *enhancing* personal ability to overcome problems, *compensating* for losses that cannot be overcome by enhancement, assisting with *care* provision where care is needed, and promoting *research* on problems without current solutions (Fozard, Graafmans, Rietsema, Bouma, & van Berlo, 1996). It would seem that gerontechnology could play a central role in reducing the disproportionate vulnerability of older adults in emergencies and disasters and building disaster resilience. The core functions of gerontechnology (prevention, enhancement, compensation, care, and research) have relevance for meeting the needs of older adults within each phase of the emergency management cycle. Gerontechnology methodologies of inquiry have a critical contribution to make to the development of resources to enhance disaster resilience and reduce risk for older adults. This potential is explored in the following sections.

5.5 Prevention/Mitigation

In emergency management, there is increasing recognition of the value of taking actions in the present to preventing foreseeable problems from occurring in the future (WHO, 2007). For example, Hwacha (2005) describes a consultation process with provinces, territories, and stakeholders in Canada aimed at developing a national disaster mitigation strategy, and Henstra and McBean (2005) highlight the human and economic losses that are motivating this paradigm shift. Mitigation and prevention have traditionally involved technology and engineering, generally at the infrastructure level. For example, floodways are built to reduce the risk of flooding, buildings are engineered to withstand earthquakes, and cyclone shelters are built in strategic locations.

In the field of gerontechnology, there has been a conceptually similar prevention and mitigation focus on developing technologies that enable older people to remain in conventional housing in the community (i.e., in single family detached and semi-detached houses, row housing, low- and high-rise apartment blocks) for much longer than might be expected based on their medical conditions. These technologies include walkers, wheelchairs, and electric scooters for those with mobility limitations, portable oxygen systems for persons with pulmonary disease, home dialysis systems, and various types of personal emergency response systems (PERS). This trend has implications for emergency management. Haq, Whitelegg, and Kohler (2008) draw attention to weather-related disasters, expressing concern that the hazards of climate change could negate the value of these technologies without careful planning. In the next section, we highlight some infrastructure-enhancing technologies that have the potential to increase disaster resilience for older adults by mitigating foreseeable risks.

5.5.1 Tracking and Mapping Systems

The two major technologies for tracking and mapping that have been applied to emergency management are global positioning systems (GPS) and geographic information systems (GIS). GPS are satellite-based navigation systems that provide reliable location and time information. GPS technology has become ubiquitous, readily available in vehicles and cell phones. GPS are one of the primary components of computer-facilitated dispatch/response systems. In the event of a disaster, the nearest response units can be selected, routed, and dispatched once the location is known. GIS are database systems that use software to analyze data that can create maps and tables for planning and decision-making (Federal Emergency Management Agency [FEMA], 2011). Use of GIS allows for information sharing of spatial databases (e.g., hydro lines, streets, population distributions) on computer-generated maps. In the United States, GIS are used in emergency management at the federal level by agencies such as FEMA and at the state and local level by police, fire, and other emergency services. The use of Web-based GIS mapping has grown at the organizational level and is also beginning to expand to the personal level (FEMA, 2011). This expansion means people may one day be able to link into an emergency management system via their personal computer to learn how, for example, to evacuate from their town using the best route based on the trajectory of an imminent tornado. Following the 9/11 terrorist attack in the United States, there was a spike in the proposal and development of advanced GIS for emergency management. One example was a proposed GIS-based intelligent emergency response system (GIERS) that would use real-time three-dimensional (3D) GIS (Kwan & Lee, 2005). A 3D system would allow identification of details such as occupancy of a single room in a building that would increase evacuation speed.

GPS and GIS can be used together for a variety of purposes. For example, one California healthcare organization has used the two together to dispatch helicopters and ambulances, to identify the fastest routes for response vehicles, and to interface with police and fire departments and emergency medical services (Hildreth, 2007). Significant efforts are underway to apply these technologies to humanitarian emergencies (Johnson, 2000; Kaiser, Spiegel, Henderson, & Gerber, 2003). It is critical that the distinct needs of frail older adults in community settings and in long-term care facilities are represented in the evolution of these systems as emergency management resources. Applying this technology to emergency management in large-scale disasters, GIS and GPS technology could be used together to improve evacuation of older adults to temporary shelters. Where disaster zones are known to encompass neighborhoods with high concentrations of older adults who are likely to need assistance evacuating from their homes, use of these systems can assist emergency responders to effectively deploy scarce resources. If long-term care facilities are included in the system, both sending and receiving facilities would benefit from increased ability to place older adults appropriately, considering both bed availability and care needs. The combined systems could be used to track persons with dementia and others whose medical conditions impair their ability to self-report their location before, during, and after an evacuation. Systems that include the capacity for advanced vehicle locating (tracking the location of transportation vehicles in real time) would permit response to any untoward situation that might arise during the transportation of vulnerable older adults from one setting to another. If the integrated systems are advanced enough, medical records could also be incorporated within them. This would be of particular value to older adults, who are likely to experience disruptions in medical care for preexisting conditions during disaster situations. Maintaining treatment for common conditions such as arthritis, cardiovascular disease, diabetes, and cancer is often dependent upon timely access to healthcare records that document medical treatment routines. Information sharing between agencies can be difficult due in large part to a strong reliance on paper-based systems or on a computer system where data are not accessible outside the facility. Past disasters in the United States have demonstrated that the lack of an electronic medical record system delays the provision of health services for frail older persons (Hyer et al., 2006), while the availability of such a system can expedite resumption of services (United States Department of Veterans Affairs, 2005).

Technological challenges for the use of GIS and GPS in emergency management can include dropped signals, imprecise mapping, and difficulty linking systems and matching coordinates. Cost-effective and widely accessible monitoring technologies that will allow superior communication and integrated response are needed (Anderson & Gow, 2003). Overarching requirements for the success of this technology as a resource for disaster prevention and mitigation include refining interconnectivity between different systems to guarantee completeness and continuity of information flow between organizations, facilities, transfer locations, and care documentation systems. Laws may need to be revised to permit electronic access and sharing of information between tracking and mapping technologies. However, the potential for these systems to reduce vulnerability for older adults in emergencies and disasters is significant (Kiefer, Mancini, Morrow, Gladwin, & Stewart, 2008; Smith et al., 2009).

5.5.2 "Intelligent Building" Systems

A promising development in gerontechnology is the use of *intelligent building* systems in residential settings such as long-term care facilities, assisted living facilities, senior housing, and retirement communities. Although the definition of an intelligent building has been debated over the years, in general, they use a combination of communication, mechanical, electrical, and safety systems that are integrated to create a space that can improve workplace productivity, promote building energy efficiency, allow for remote operations, and ensure safety (Continental Automated Buildings Association [CABA], 2002; Wong, Li, & Wang, 2005). In theory, emergency management organizations can be linked to the safety system of an intelligent building so that timely information is transmitted in emergency situations to appropriate emergency responders (police, fire department, paramedics). The *intelligent Building Response* (iBR) project at the National Institute of Standards and Technology Building and Fire Research Laboratory in the United States is working on the creation of a standard for real-time transfer of information such as location of building occupants and hazards (e.g., fire) from the intelligent building system to emergency response organizations (National Institute of Standards and Technology, 2005). Currently, most of the information collected by intelligent building systems remains within the building which does not allow emergency responders to fully assess the situation until they arrive on the scene.

Smart houses, comprised of dwellings with automated systems that control temperature, lights, sound systems, surveillance cameras, and so forth, are another example of intelligent buildings that could be linked to emergency management organizations (Tiresias, 2009). While currently the cost of owning and managing a smart home is beyond the reach of many seniors, the potential benefits of this technology for building disaster resilience as well as for other purposes may become accessible to larger segments of the aging population in the future.

5.6 Emergency Preparedness

Mitigation and prevention activities can reduce or eliminate the threat posed by hazardous events; however, not all emergencies can be prevented. Still, earthquakes, tsunamis, ice storms, hurricanes, and other such events are predictable in their likelihood, if not their timing, and large-scale industrial accidents, pandemics, terrorist activities, and other hazards of modern life are likely to continue to occur. Emergency preparedness means being ready, willing, and able to respond to these events. The critical questions for individuals are the following: What are the risks to my safety where I live? What information do I need to have to minimize my risks? Where can I obtain this information? In addition to self-reliance, however, there is a collective responsibility for policies, strategies, and programs aimed at emergency preparedness at the level of organizations, communities, and governments. This multidimensional model for preparedness reflects the population health approach to understanding disaster vulnerability and resilience (Berry & Hutton, 2009). In this section, we consider applications of technology in aid of emergency preparedness for both individuals and communities.

5.6.1 Individual Preparedness: Medical and Assistive Devices

Lack of a steady supply of electricity to ensure medications can be maintained at required temperatures for viability and to power medical equipment such as respiratory and dialysis machines can quickly aggravate chronic diseases common to older age (IASC, 2008). The 2003 blackout in the eastern seaboard of Canada and the United States dramatically illustrated this challenge. A study of New York's healthcare system revealed a surge of hospital emergency room visits secondary to respiratory device failure (mechanical ventilators, positive pressure breathing assist devices, nebulizers, and oxygen compressors) (Prezant et al., 2005). It is essential that personal preparedness plans for older adults include information on how to meet the need for temporary backup electricity if this is required to support lifesaving equipment or medications (Gibson & Hayunga, 2006). The same is true for electric wheelchairs and scooters and other electronic assistive devices. How temporary backup strategies function, how affordable they are for older adults, and how easily and safely they may be used are all questions for the field of gerontechnology.

Everyday assistive devices such as eyeglasses and hearing aids are another essential component in emergency preparedness planning for older adults. Hearing loss, due to presbycusis, is very common in older adults. Close to half of men aged 65 and over and nearly a third of older women in the United States reported hearing difficulties in a 2002 study (Federal Interagency Forum on Aging Related Statistics, 2004). With aging, visual acuity is reduced due to presbyopia, and many seniors need glasses to read. Vision may also be limited by cataracts or macular degeneration, placing the senior at risk for adverse events such as falls. Older adults with severe hearing loss and/or without their hearing aids or batteries may not respond to alarms in emergency situations and, if evacuated, are at risk for communication difficulties. Similarly, evacuees will experience difficulties if eyeglasses are lost or forgotten. Alternate communication strategies and access to temporary assistive devices should be part of the personal emergency preparedness plan put in place by an older adult with sensory impairments. Cost and availability of innovative solutions are challenges for gerontechnologists to consider.

5.6.2 Community Preparedness: Communication and Notification Systems

Increasingly, there are examples of social media playing a role in emergency preparedness (Merchant, Elmer, & Lurie, 2011). For example, aid officials in the Philippines credited social media communications with persuading people to take precautions in advance of an October 2010 typhoon (IRIN, 2010). The increasing numbers of people, including older adults, who use the Internet attests to its potential as a communication tool for notification of emergencies and disasters (Czaja & Lee, 2003). However, it is important not to lose sight of the digital divide. A recent national survey indicated that only 54 % of Americans living with a disability use the Internet, compared with 81 % of adults without a disability. Disability was associated with being older, less educated, and living in a lower-income household (Fox, 2011). At the same time, recent research indicates that social networking sites such as Facebook and LinkedIn are attractive to older adults because they are more likely to be living with a chronic disease and reach out for support online (Madden, 2010). The evolution of this trend as a resilience-building component within emergency preparedness warrants close attention.

It is important to avoid overreliance on one technology for communication and notification, however. Public emergency notifications should be made available through a variety of modes and mediums. Older people need to receive emergency notifications that are appropriate to their needs and in accessible formats (WHO, 2008). In the United States, television, radio, community technology centers, sirens/loudspeakers and, when available, telephones with systems such as a 311 information system or reverse 911 are all types of technology that have been used. These systems are potentially the best source of technology to reach vulnerable populations (Kiefer et al., 2008). Reverse 911 automated systems can call large numbers of homes in a designated area quickly as an aid to emergency notification (Gibson & Hayunga, 2006). Contacting staff and family members during a disaster is a challenge for healthcare facilities, including long-term care homes, due to the limited number of phone lines or cell phones. Families are often concerned about the well-being of their older member and resort to phone calls for verbal updates. There are opportunities for social networking technologies, reverse 911 systems, and related technologies to fulfill the need for communication when the usual lines of communication are not operating or a request has been issued to avoid using phones.

There is also potential for PERS to play a greater role in emergency preparedness. This will be especially true, should these systems succeed in expanding their market share in the future. Currently about 10 % of older individuals in the United Kingdom, and around 1 % in North America, use such devices. Ever since the advent of the first generation of PERS, technological developments have improved the capability of users—older adults, response centers, and first responders—to reach someone in need in the shortest possible time. This was and remains the guiding principle of PERS for seniors when indicated by social and health-related factors such as living alone or having had a recent hospitalization for hip or lower limb surgery (Roush & Teasdale, 1997), or for detecting changes in routine activities of daily living that might be prodromal signs of an impending medical problem (Glascock & Kutzik, 2006).

The next two generations of PERS expanded on the growing need to know where vulnerable older adults live and what are their unique health and social circumstances and to be able to communicate with users who initiate a request for assistance. Currently, fourth generation (4G) PERS devices and services in North America are developing the capability for what is referred to as *reverse alerts*. This refers to response centers or emergency agencies being able to both inform users of an impending disaster—for example, a tornado that has just been seen nearby, rising water, an approaching wild fire, or some biological outbreak causing illness in the community—and confirm that the user has received the alert and is taking protective measures.

This emerging bidirectional communications capability was reported at the 7th World Conference of the International Society for Gerontechnology. One of the authors of this chapter (SH) was commissioned by the PHAC Division of Aging and Seniors to conduct an assessment of the use of PERS as an emergency preparedness and management tool. The analysis of 28 North American PERS companies revealed that (1) PERS communications systems are not generally designed for mass broadcast nor are on-person alert devices usually designed for incoming notices; (2) most PERS systems do not have structural and operational requirements in place to respond to disaster management so that specific groups of older adults could be contacted; and (3) geographic coverage is fragmented: that is, a region may be covered by multiple PERS providers, resulting in even greater difficulty for a local authority to distribute messages (Roush & Gutman, 2010).

While these findings point to the early development of bidirectional 4G PERS capabilities, an inquiry to the Center for Aging Services Technologies (CAST) revealed that only two PERS companies were known to have the capacity for reverse alerts (Alwan, M. Results of CAST report on bidirectional capabilities of U.S. PERS companies, personal communication, May 14, 2010). At the time of the inquiry, one bidirectional system in a long-term care facility near Denver, Colorado, had actually been used to alert residents that a tornado watch was in effect and the residents indicated that they had received the message and were beginning to take appropriate measures. The other system converts text such as a public emergency message displayed on TV into a voice message and transmits it to the in-home device of the user. This company had also just developed an *on the go* feature using GPS for compatible mobile phones to locate and warn people who are away from home and may be in harm's way.

5.7 Emergency Response

Evidence from the response phase of disasters suggests that the needs and resources of the aging population are not well integrated within the guidelines and technical response mechanisms available to the emergency and humanitarian community (IASC, 2008). The UN IASC Cluster System provides an organizing mechanism for system-wide preparedness and capacity for technical response to humanitarian crises. Within this system, age is a crosscutting issue that has been identified as needing more attention (Day, Pirie, & Roys, 2007). Vulnerability risks that need to be addressed include lack of attention to the chronic medical conditions common to older adults (as discussed above) and security issues. These include the need for protection from financial abuse and theft of personal belongings and property during and after evacuation; psychological, physical, and sexual abuse; and other forms of mistreatment and exploitation that may be underestimated as concerns for older adults. Responding effectively to the needs of older adults within the disaster-affected community is often hampered by lack of baseline statistical information on the age distribution and health status of the population prior to an emergency. Data that are collected in response to a disaster are often disaggregated by gender only and do not include sufficient information on age (IASC, 2008). More effective data collection processes are needed to ensure that registration, needs assessments, and morbidity and mortality figures are collected and disaggregated by both age and sex (Day et al., 2007).

5.7.1 Needs Assessment Strategies

There is a need for strategies that use participatory rapid assessment (PRA) techniques (e.g., ranking, resource mapping) to facilitate efforts by older people to self-assess their own needs and capacities when an emergency occurs (HelpAge International, 2000). For efficiency, computer software and Internet-based services should be applied to enhance this data collection and utilization (Kaiser et al., 2003). Research on how to engage older adults in such large-scale technology-based data collection, aggregation, and utilization processes is needed.

Technology-based solutions are also needed to support rapid response by local organizations and relief agencies. A Community Disaster Information System (CDIS) has been developed to enhance relationships between nongovernmental organization (NGO) responders and local agencies and suppliers (Troy, Carson, Vanderbeek, & Hutton, 2008). A pilot test, which was also used to identify ways to improve the CDIS, found it to be beneficial to the NGOs, to the individuals affected by the disaster, and to organizations that provided services and resources. It also encouraged collaboration between the local American Red Cross chapter and the community. Although this system was not created specifically for the older population, it could be adapted to ensure that the users both recognize the potential needs of older adults and have improved access to the resources that are necessary to provide an adequate response to these needs.

5.7.2 Medical Support Strategies

Advanced medical support technologies described under the headings of Telemedicine, Telehealth, and Telecare are systems that integrate various communication and information technologies to perform a specific task: enhancing medical access and support. In mass casualty events, decisions have to be made as to who might live if immediate treatment is received, who might not, and who can wait. Disasters are initially local events, managed by the on-site resources that happen to be present when a situation arises. Where infrastructure allows, resources such as telemedicine and telehealth can be invaluable as a triage aid (Balch, 2008). Telemedicine can provide a visual link between a disaster site and experienced medical personnel at a distant facility, serving as a conduit for transfer of clinical data that can enable treatment to start on site (Chelmsford, 2008). In recent disasters, these technologies have been used in conjunction with mobile communication strategies to supplement local emergency response systems (Turnock, Mastouri, & Jivraj, 2008). Improved outcomes that can result from effective use of telemedicine strategies include a reduction in patient transports (particularly important in disasters when transportation systems are compromised), improved care through better matching of patients to dispatch locations, and synchronization of data between site, dispatch, transport, and receiving center. A survey of 1,801 rural emergency medical services organizations in the United States revealed many had limited resources for managing mass casualty events and a high perceived need for training (Furbee et al., 2006). Telemedicine technologies can both facilitate emergency response training and augment response capacity in the event of an actual emergency.

Where the potential of telemedicine as an emergency response strategy is largely untapped is in the field of chronic disease management. Chronic disease exacerbations comprise a sizable disease burden during disasters (Miller & Arquilla, 2008). A post-Hurricane Katrina study documented challenges in providing services for mental health disorders, diabetes, hypertension, respiratory illness, end-stage renal disease, cardiovascular disease, and cancer (Arrieta, Foreman, Crook, & Icenogle, 2009). Maintaining continuity of medication was the most frequently mentioned problem, with a host of contributing factors including lack of access to pharmacy records and financial barriers. A substantial demand for drugs used to treat chronic medical conditions was identified among Hurricane Katrina evacuees to San Antonio, accounting for 68 % of medications prescribed (Jhung et al., 2007).

As an example, the Ontario Telemedicine Network (Government of Ontario, n.d.b) provides videoconferencing for health professional/patient consultation, thereby improving access to diagnosis and treatment. Its Telehomecare program uses monitoring equipment to link patients with chronic diseases to health professionals to allow better control of chronic diseases such as cardiac failure and diabetes, while an emergency service program uses telemedicine in life-threatening conditions including stroke, critical care, trauma, burns, and mental health crises. Ontario Telehealth (Government of Ontario, n.d.a) provides a phone consultation with a nurse and, if necessary a pharmacist, for health advice and support. It is constantly available (everyday, all hours) and is particularly busy during pandemics. Telehomecare can include community alarm systems, sensors to detect motion or falls, and fire and gas alarms that trigger a warning to a response center (Department of Health, 2005). As these information and communication technologies for medical support expand and become routinely available across healthcare and community settings, their components can be enhanced to improve communication and reach isolated seniors, enabling them to avoid decompensating in a crisis. These technologies have the potential to become significant assets for building disaster resilience among older adults with chronic conditions.

5.7.3 Security Strategies

Survival in the initial stages of a disaster is critically dependent on shelter. Obtaining shelter is one of the six most common problems identified by older people in disasters around the world (HelpAge International, 2000), in part due to misconceptions that extended family, community services, and relief agencies can be counted on to look after older adults (IFRC, 2007). Beyond survival, shelter is necessary for security, personal safety, and protection from the climate and can enhance resistance to ill health and disease. During and after evacuation, there is a need to prevent and respond to the risk of gender-based violence and sexual exploitation. Some of the frail and cognitively impaired older adults housed in the Houston Astrodome following Hurricane Katrina were reported to be victims of robbery and exploitation (Dyer et al., 2006). Temporary shelters should be designed with security in mind (The Sphere Handbook, 2004). The extent to which PERS and other technology could play a role in enhancing shelter security for older adults is largely unexplored. The use of surveillance systems raises concerns about privacy, but older adults' acceptance of in-home monitoring and electronic tracking devices generally supports the trade-off between privacy and safety (Demiris et al., 2004; Landau, Werner, Auslander, Shoval, & Heinik, 2010; Wild, Boise, Lundell, & Fousek, 2008).

A second major security concern is that older displaced persons are often not included in tracing and reunification activities (IASC, 2008). Return, repatriation, and reintegration programs should address the challenge and needs of *unaccompanied old* as energetically as those of unaccompanied children (Day et al., 2007). Finding people potentially affected by a disaster can be a daunting task, especially when searching for older adults with impaired cognition, who may not have the capability to utilize communication tools. Many families could not locate elderly members for days or weeks following Hurricane Katrina due to the lack of a tracking system (Dyer et al., 2006).

Following the 9/11 terrorist attack in New York, many lists of missing people and survivors emerged on the Internet. Although the American Red Cross had a Restoring Family Links program, many people either did not know about this resource or chose to post their search elsewhere. After Hurricane Katrina, the People Finder Project sought to merge all data into one database (Csikszentmihályi, 2010). Data on missing persons were collected from the various web sites by volunteers and a new tool, called the People Finder Interchange Format (PFIF), was used to translate data into a single format that was placed into a central database. The compiled data were then sent to the American Red Cross.

Advancing on this technology, the Google Person Finder was developed following the 2010 Haiti earthquake (Csikszentmihályi, 2010). The Person Finder *scraped* web sites, blogs, and bulletin boards for information, photos, and data, translated it using the PFIF, and sent it to a central database. As part of the People Finder, a widget, or technical code, could be placed on web sites that allowed people to post information or search for missing people. With these advancements in Internet technology, emergency response organizations and service agencies could work together to create a simple tool to collect data on older adults who are missing in a disaster.

5.8 Disaster Recovery

In comparison to other components of emergency management, especially preparedness and response, disaster recovery has received proportionately little attention (Phillips, 2009). The evidence from disasters across the world suggests that recovery processes and supports are insensitive to the specific needs and issues of older people. For older people, disruption to the healthcare infrastructure is a particularly critical issue, as chronic conditions can quickly become acute health crises without sustained treatment and management. Other recovery phase tasks that pose significant challenges for older adults include restoring housing, resettlement, and reestablishing social and economic roles and activities (WHO, 2008).

5.8.1 Reconstruction Strategies

Restoring housing and resettlement is complicated for all people who have been displaced due to a disaster. Longitudinal research in Canada on older adults who lost their homes due to flooding in the province of Quebec revealed persistent negative effects on emotional and social functioning, including mourning for loss of home (Maltais & LaChance, 2007). An analysis of post-disaster reconstruction in

Kobe, Japan, following the 1995 Great Hanshin Earthquake chronicles the practical, social, and emotional challenges encountered by low-income older adults in the years following the disaster as they transitioned through various housing options (Otani, 2010). The recovery and rebuilding of New Orleans following the devastation of 2005 is taking years, and it is likely that many of the more vulnerable segments of the population will be excluded from resettlement in their original communities (Cutter et al., 2006). These evacuees may wish to return to their homes but lack either the financial resources or emotional ability to do so. Affluent homeowners and businesses, including coastal resort properties, have insurance and begin to rebuild quickly. Lower-income neighborhoods with affordable housing, access to public transportation, jobs for less-skilled individuals, and social service networks take longer to reinstate, and the repatriation of displaced residents to these areas may be less of a political and social priority.

Continuity of care from home to temporary accommodation and back to home may be a complicated proposition where smart home technologies and other communication and monitoring systems have provided the environmental support that has enabled a frail older adult to maintain residency in the community rather than in a care facility prior to the disaster. This scenario gives rise to a number of challenges. First, the circumstances encountered in shelters and temporary housing can be particularly disruptive to an older person in fragile health and with compromised mobility (WHO, 2008) with the result that the level of support that was adequate to maintain functioning pre-disaster may no longer suffice post-disaster. Second, the resources to reinstate the environmental supports may be limited, delayed, or totally lacking post-disaster. Third, and perhaps most importantly, this is likely to be a problem for a relatively small proportion of the older adult population and as a result may be low on the priority list of agencies responsible for reconstruction and resettlement.

What is more applicable to a greater number of older adults, particularly low-income renters, is that the disproportionate impact of natural disasters may be attributed in part to the likelihood that they lived in substandard housing in unsafe locations (WHO, 2008). Reflecting the population health approach to understanding vulnerability and resilience, the intersection among health status, economics, and disaster recovery is dramatically illustrated by the lot of older adults and people with functional disabilities after Hurricane Katrina. The New York Times reported that 3 years after the devastation caused by Hurricane Katrina, the majority of people who continued to reside in temporary trailers were older adults and those with mental disorders and physical disabilities (Dewan, 2009). Similarly, economically disadvantaged older adults tended to reside in temporary shelter housing the longest after the earthquake that devastated the Kobe and Osaka areas of Japan in 1995 (Otani, 2010). Reports from the 2011 tsunami and earthquake on Japan's northeastern coast show a similar pattern of delayed recovery for older adults, reflecting a combination of health-related, economic, and social factors (IFRC, 2011).

The reconstruction of housing after disasters has a strong technocratic bias, with an emphasis on safety from a construction and materials standpoint. Unfortunately, projects often fail to address issues at the intersection of housing and livability, including the needs and preferences of the residents for whom the houses are to be built (IFRC, 2001; Twigg, 2002). There is a role for gerontechnology in the field of disaster reconstruction, both with respect to seizing the opportunity to incorporate age-friendly technology within rebuilds and applying gerontechnology methods of inquiry to maximize the fit between proposed new environments and old residents.

For residents of long-term care facilities, short-term recovery issues include restoration of vital services and systems. These may include temporary food, water, and shelter for residents, ensuring they have medical care and prescribed medications, and/or restoring electrical services through emergency generators. Sustained power outages can impact a resident's life-support equipment and have an impact on mobility (e.g., when electric wheelchairs are unusable and elevators are disrupted). Short-term recovery occurs when the immediate threats are halted and both basic services and vital needs are restored. Long-term recovery represents an opportunity to make use of new technologies to enhance the disaster resilience of a facility. The long-term care *Hurricane Summit* sponsored by the Florida Health Care Association in February 2006 (Hyer et al., 2006) was convened to identify issues warranting further coordination between long-term care providers and state and federal emergency operations centers (EOCs). Recommendations included identification and development of computer system enhancements needed to bridge EOC structures with long-term care facilities, development of redundant communication systems, and development of centralized tracking systems.

5.9 Summary and Conclusion

Older adults are at increased risk in emergencies and disasters not because of age per se but because they are more likely to have risk factors for vulnerability, including health problems, increased dependence on healthcare and social services, lower socioeconomic status, and restricted social networks. We have explored the potential for technological solutions to combat this disproportionate vulnerability and increase disaster resiliency for older adults in all phases of emergency management. Prevention-focused technologies that can be implemented to increase resilience to disasters include integrating tracking and mapping systems (GIS and GPS) and intelligent building systems with emergency response services. These resources have the potential to be developed so that they support efforts by first responders to locate and reach older adults who need assistance. Technological advances are needed to improve the function and availability of medical and assistive devices at the personal level, and of communication and notification systems at the community level, under conditions of adversity. Known problems that impact older adults in the recovery stage of a disaster include inadequate needs assessment, insufficient medical support for those with chronic illnesses, and inattention to safety issues including personal security. Technology applications including computer-based assessment tools, remote medical care systems (telemedicine, telehealth, telecare), and computer-assisted monitoring and reunification systems have the potential to contribute to increased disaster resilience for older adults by addressing these problems. In the recovery stage of a disaster, home reconstruction is a dominant issue. There is a need to expand gerontechnology applications, including home adaptations that enable older adults to regain or improve the level of functioning they had in their homes (community or facility based) prior to the disruption that accompanies a disaster.

There is a risk that greater reliance on technology in emergency management can lead to a paradigm where the problems that are most readily addressed by technological innovations receive the lions' share of attention, at the expense of the more difficult vulnerability and response issues (Kiefer et al., 2008). The status quo—disproportionate vulnerability for older adults in emergencies and disasters—is unacceptable. The distinct needs of older adults in community settings, as well as the unique circumstances of older adults who live in long-term care facilities, must be represented in the evolution of technology as an important emergency management resource. Several factors may impact the acceptability, uptake, and demand for technology applications in building disaster resilience for older adults. There is a shortage of outcome studies demonstrating the value of technology for promoting disaster resilience, especially regarding cost-effectiveness and efficiency. Research is needed to quantify the value that disaster technology can hold for older people, both in community settings and in care facilities. For example, although the technology to connect intelligent buildings with emergency management has been under development for some time, the cost to create such a system can be prohibitive and the technological requirements may be more advanced than what a long-term care facility can manage in an already busy day. If not implemented correctly, an intelligent building may also restrict the amount of flexibility a user may have to adjust the system to their changing needs.

There is also a need for educational initiatives that raise awareness of technology's potential benefits as a component of the safety envelope for older adults. For example, among long-term care administrators who have had previous problems using technology, there may be resistance to trying new high-tech devices within their sites (Yu, Li, & Gagnon, 2009). This applies to older adults as well. Simplifying technology for a broad spectrum of users, with varied levels of computer literacy, competence, and comfort, is an ongoing challenge. Much more research on domotics, the field of studying interactions between users and electronic devices, must be conducted (Harrington & Harrington, 2000). And since the older adults of tomorrow will be much more tech-savvy than today's older population, human factors research must be conducted on what various cohorts of end users need and will use.

Practical, relevant research is needed, which takes into account user knowledge and beliefs, the context in which older adults and caregivers interact with given technologies, and the characteristics of the technology itself (Rogers & Fisk, 2010). Designers of technology supports need to work closely with both older adults and other stakeholders to learn how their products and services can be engineered and marketed to promote their use in emergency management. Learning from their feedback would not only improve the design of the technologies but also enhance the processes of technical support. Identification of *best practices* selected from among ongoing efforts, as well as continued planning and implementation of outcome-oriented field pilot tests and larger-scale demonstration projects, is recommended. If we are to expand the technology safety envelope for older adults to include disaster resilience, it will be critical that research on the application of technology for emergency management purposes goes beyond focus groups and self-report surveys to include disaster simulations and exercises, as has been recommended for other assistive technologies (Gutman, 2003).

Age-friendly adaptations to current emergency management practices that would enhance outcomes for older people would in many instances also benefit other population subgroups (IASC, 2006). This is both an argument for greater age sensitivity and inclusiveness in emergency management as a routine practice and an endorsement of the value of technology as a means to this end. Gerontechnology is fundamentally about technological development in context. The potential contribution of technological innovation to disaster resilience will only be realized if it is informed by an understanding of the nature and consequences of human aging and an appreciation of the role and protection responsibilities of communities towards their older members.

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