

Technology-Based Supports for Aging in Place: Are they Effective?

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Executive Summary

In Canada, there is a growing number of older adults over the age of 65 years. As predicted by the World Health Organization (WHO), Canada will become a super-aged country by 2035. ¹ With this increase in age, it may become more difficult for older adults to perform activities of daily living, which can limit opportunities for aging in place (AIP). Fortunately, there exists a wide range of technology-based supports to help older adults with aging independently in their own home.

The aim of this report is to examine existing technology-based supports aimed at facilitating aging in place. It assesses technologies based on their clinical effectiveness, cost effectiveness and ethical implications. The report gives a snapshot of possible technologies to facilitate AIP while also discussing the extent of research which assesses effectiveness of the aforementioned.

The technology-based supports for AIP have been classified into four different subgroups: 1) behaviour and safety monitoring, 2) fall prevention and monitoring, 3) medication management and optimization, and 4) smart home technology. In assessing clinical effectiveness, the findings show promising opportunities for these technologies to facilitate AIP with unclear outcomes for some health-related domains and health care utilization impacts. Additionally, there were significant gaps in economic evaluations of the four sub-groups of technologies. Some of the available research suggested potential for these technologies to be cost-effective, but overall, the evidence was scarce. Finally, there are significant ethical implications for technologies to facilitate AIP. Some of these implications are privacy, informed consent, autonomy, and equitable access.

Based on the findings, two policy recommendations have been provided. First, policy stakeholders from across jurisdictions should develop partnerships with institutions to create a frame for analyzing the effectiveness of technology-based supports aimed at facilitating AIP. Mainly, they should consider partnerships with institutions that have expertise in economic evaluations as a means to overcome the gaps in this area. Second, community organizations should consider the diversity of their community members when deciding what technology-based supports to deliver. Using a gender-based analysis plus (GBA+), these organizations could ensure that crucial factors such as privacy protection and equitable access are considered for diverse groups of Canadians.



Policy Question

What are some of the effective technology-based supports that can help older adults to age in place?

This policy question is comprised of different terms that need to be defined:

- Effectiveness: The effectiveness of technology-based supports will be conducted using an evidence-based approach called a Health Technology Assessment (HTA). The HTA will be conducted following a similar approach from the one used by the Canadian Agency for Drugs and Technologies in Health (CADTH); an HTA is "a comprehensive evaluation of the clinical effectiveness, cost effectiveness, and the ethical, legal, and social implications of health technologies on patient health and the health care system".^{2(para3)}
- 2. **Technology-based supports** can encompass a wide range of different technologies. For the purpose of this report, technologies have been classified in 4 groups: 1) behaviour and safety monitoring, 2) fall prevention and monitoring, 3) medication management and optimization, and 4) smart home technology. ³
- 3. **Aging in place:** In this report, aging in place (AIP) follows the Government of Canada definition, which defines AIP as "having access to services and the health and social supports you need to live safely and independently in your home or your community for as long as you wish or are able". ^{4(para3)}

Background

For many years now, there has been an increased focus on the change in demographics of populations across the globe. In Canada specifically, the population is aging at such a fast pace that the World Health Organization ¹ is predicting that by 2035, at least 30% of the population will be aged over 60 years old. While certain provinces in Canada are seeing a more rapid increase in the number of older adults in their population, this increase can be observed throughout the country. In fact, the number of Canadians aged 75 years or older is predicted to at least double in each province and territory between 2017 and 2037. ⁵

Aging is a process that involves numerous transitions in many domains of one's life. These transitions may involve changes to the personal self, family structures and to the environment ⁶ and can result in some additional difficulties in multiple areas of daily living, which may lead to undesired and unwanted, but necessary adaptations. As has been documented in the literature, older adults 65 years and older are increasingly having to deal with chronic diseases such as high blood pressure and arthritis ⁷, which may become debilitating and hinder their capability of performing certain activities of daily living. ⁸ Nonetheless, the great majority of older adults aged



65 years or older still reside in private dwellings. ⁹ This trend is consistent for all age groups (65 through 85 years and older) but there is a slight increase in the number of those who reside in community dwellings from 80 years old and onwards.⁹ As discussed in the literature, the functional and cognitive impairments associated with aging ¹⁰ may increase the barriers for some to do so.

To enable older adults to reside in community dwellings, governments and service organizations across Canada are currently providing funding and services that help people receive the assistance they need to AIP.¹¹ One domain called continuing care services includes a wide range of health-related services such as personal care services (e.g., help in activities of daily living), therapy and rehabilitation services (e.g., occupational therapy), and short- and long-term nursing care (e.g., administration of medication). These services are generally offered consistently across the country, but certain jurisdictional differences exist in areas such as social work and psychosocial services.¹¹ In the domain of home supports, older adults can receive assistance with non-medical services such as meal services, home maintenance, transportation, etc. Most notably, these services are highly dependent on the jurisdiction in which they are being delivered which increases inequalities for diverse groups of Canadians.¹¹ Finally, the last domain of governmental and organizational support for older adults to AIP is financial support. Some examples of financial supports include: 1) programs that make housing affordable, 2) relief of property taxes, 3) offset of transportation costs, etc.¹¹ While many programs exist, these are inconsistently offered in the different jurisdictions.¹¹

Some recent innovations in the technological world could supplement current core community supports and increase opportunities for AIP. In fact, many researchers and technology developers are innovating in the field of gerontechnology in attempt "of meeting the challenges that aging, disease, and disability pose for community-residing older adults and their families". ^{12(p184)} In Canada specifically, the AGE-WELL Network of Centres of Excellence, a federally funded initiative, brings together experts from across disciplines (e.g., industry, caregivers, end users, etc.) to develop innovative technological solutions to increase opportunities for older adults to AIP. ¹³ With technologies being developed at increased rates, there is a need to identify which present the best opportunities for older adults to AIP. For this reason, this report aims to discuss the clinical effectiveness, cost effectiveness, and ethical issues of technology-based supports used by older adults living independently in their own homes.

Research Approach

This report uses the CADTH research approach for conducting HTAs. Mainly, it follows the structure of a technology review, which "contains some but not all of the elements of a traditional Health Technology Assessment". ^{2(para4)} This review will focus on the following components:



- 1. Clinical effectiveness of technologies
- 2. Cost-effectiveness of technologies
- 3. Ethical implications

The review of the literature and analysis of the components mentioned above were conducted independently using appropriate databases. The selection of articles was made based on their relevance to evaluating effectiveness of technologies, their year of publication (2010-2020), and language of publication (English). The articles were reviewed and compared for their results on clinical effectiveness, cost effectiveness and ethical implications for the different types of technology-based supports.

Key Findings

The findings have been organized by clinical effectiveness, cost effectiveness and ethical implications. In each section, the current state of evidence will be discussed specifically as it relates to the different types of technologies (see table 1). The findings are by no means a comprehensive review of the literature but a general representation of the available evidence.

	Types of technology-based supports			
	1) Behavior and safety monitoring technologies	2) Fall prevention and monitoring technologies	3) Medication management and optimization technologies	4) Smart-home technologies
Function	Help with remaining safe in performing activities of daily living	Prevention, detection and monitoring of falls	Automated medication management	Integration of multiple technologies into one system
Examples	 Sensors Warning systems Intelligent home devices Wearables 	 Automatic lighting systems Fall monitoring and notification systems Sensor-based systems 	 Automated medication dispensers Information and communications technologies (apps) Sensor pads 	 Integration of: Remote monitoring technologies Alert systems Sensor systems Etc.

Table 1: Technology-based supports that facilitate AIP. ^{2,3,14}

Clinical Effectiveness

For all the technologies described above, there exists some discussion of clinical effectiveness as it relates to their potential to be used for AIP. The results reflect 3 key areas of clinical effectiveness: 1) the capacity of the technology to perform its function adequately, 2) functional outcomes of older adult users, and 3) cognitive outcomes of older adult users.



Behaviour and safety monitoring technologies:

Most articles that discussed effectiveness of these technologies related to the capacity of the technologies to perform their expected function and their potential to be used to support AIP. The rapid development and multiplicity in types of monitoring devices all support **promising opportunities for measuring and supporting individuals in their activities of daily living.** ^{15,16} In one example, sensor technology showed potential in adequately detecting alert conditions of decline which allows earlier intervention by health care professionals. ¹⁵ Nonetheless, there still is limited evidence that discusses the long-term effectiveness of these monitoring technologies on health-related and quality of life outcomes.^{15,16}

Fall prevention and monitoring technologies:

The 2 outcomes that are most discussed for these types of technologies are technological capacity and improvements in functional and cognitive outcomes. For the technological capacity in *fall detection*, technologies **adequately performed the expected task of detecting falls in older adults**. In an example that used sensor video technologies, the technology was able to effectively provide real-time detection of falls by older adults. ¹⁷ Beyond the detection of falls, one important consideration was the possibility of technologies to *prevent* falls by improving functional and cognitive outcomes of individuals. Technologies contributed to **improvements in physical capacities, functional balance, postural balance and lower extremity strength as well as short-term attention spam.** ^{18–20} Nevertheless, there is limited information about clinical effectiveness in terms of health care resource utilization and increased quality of life.

Medication management and optimization technologies:

For medication management and optimization technologies, the results are promising but limited. In the case of electronic multi-compartment medication devices with reminder systems, results suggest that these systems have the **potential to improve medication adherence**. ²¹ One limitation though is that most studies were feasibility studies which did not look at the technology's effect on health-related outcomes. In the case of individuals who had complex regimens, medication dispensing technologies have shown **potential for use but also demonstrated limited effects on health outcomes of individuals**. ²² These results indicate that the adherence rates of older adults to medication regimens can be eased with the use of medication management and optimization technologies but that their **impact on overall health outcomes may be limited**.

Smart home technologies:

For smart home technologies' clinical effectiveness is discussed as the potential for the system as a whole to provide desirable outcomes. Overall, there exists clinical effectiveness



evidence on multiple levels of outcomes (i.e., hospital utilization, quality of life, physical functioning and cognitive functioning). ²³ Smart home technology **did not seem to produce significant decrease in hospital admissions, emergency department visits or hospital days, or improved quality of life.** ²³ Nonetheless, there were still some studies that showed positive effects of smart home technology on quality of life of seniors. ²³ For health-related outcomes, the results are inconsistent where in some instances, smart home technology seems to help maintain or improve physical and cognitive functioning, while in other instances there was no change in health-related outcomes. ^{23–25} This indicates the **need for additional intervention studies looking at health-related outcomes and service utilization outcomes as well**.

Cost Effectiveness

There is limited research available on the cost-effectiveness of technologies that support healthy aging. The few analyses that were retrieved showed promising results although it is difficult to truly conclude that the technologies were in fact cost effective. For behaviour and safety monitoring technologies, the results suggested "a decrease in billable care interventions and in costs of health care, and an increase in care efficiency and postponement of institutionalization". ^{16(p13)} For the category of fall prevention and monitoring, the evaluations that were retrieved looked at interventions and programs such as patient education and exercise training but did not include technology-based supports. ^{26,27} For medication management and optimization technologies, the search yielded no results. There was one instance where an author noted possibilities for these technologies to be cost-effective ³, but no reference or further analysis was provided. For smart home technologies, cost effectiveness could potentially be an argument for including them in an increased number of community dwellings. In fact, in a few studies, the authors performed economic analyses which inferred to their potential for being cost-effective. ²⁴ Overall, the limited number of studies that discussed the economic effects of all the technology-based supports indicate that further analysis is required.

Ethical Considerations

Ethical considerations are at the core of discussions relating to older adults and technology for AIP. Some recurring themes include privacy, informed consent, autonomy and equitable access.

Privacy:

The discussions about privacy revolve around the obtainment and sharing of personal information ²⁸. As discussed earlier, technologies now have the potential to consistently monitor an individual's actions to propose an appropriate course of action if it detects change. This, though, can pose serious threats to a person's private life. For example, in an instance where older adults' falls are monitored via video systems, many of them expressed concerns in regards



to continuously being monitored or even refused to adopt the technology because it would invade on their private lives. ²⁹ Fortunately, advanced functions are now being considered to enable older adults to gain control over what information can be obtained and shared. ²⁹

Informed consent:

For informed consent, there is increasing discussions about difficulties in obtaining consent from those who may not be capable of providing it. ^{28,30} This can be the case notably for individuals living with dementia, but involving the individuals themselves along with family members can facilitate the process and ensures that the person's desires are respected. ³⁰

Autonomy:

It is widely accepted that technologies that facilitate AIP allow individuals to be autonomous and independent. ²⁸ Nonetheless, an increased reliance on technology may also bring a fear where the older adult is completely dependent on the technology or even a fear of losing human contact. ²⁸

Equitable access:

Equitable access to technology is extensively discussed particularly in terms of the impact of various diversity factors on the potential for access and use technology. Determinants of health such as income, education and geographic location significantly impact older adults' opportunity to benefit from technology-based supports for AIP. ²⁸ For example, there are financial barriers associated with adapting older houses for their integration with technologybased supports which inherently decrease opportunities for some to benefit from the technological advancements. ³¹

Overall, there exists extensive discussion around the ethical implications for technology-based supports in AIP. Fortunately, these discussions have led to the development of various technological solutions aimed at giving more control to users over shared and gathered data while also giving rise to changes in laws and regulations on issues such as privacy or equitable access.

Policy Recommendations



Recommendation #1: The federal, provincial, and territorial governments should develop policy-research partnerships with institutions for the purpose of creating a framework for analysis of technology-based supports aimed at facilitating AIP.



Currently, limited and inconsistent evaluations of clinical effectiveness and cost effectiveness of technology-based supports make it difficult to make conclusions about which technology-based supports could effectively and ethically be delivered to older Canadians. This indicates that there is a clear need for a systematic approach to perform effectiveness analyses of technology-based supports.

More specifically, the significant lack of information regarding the economic impact of technology-based supports suggests a need for partnerships with economic research institutions for further and standardized analysis. Another alternative for populating economic evaluations of technology-based supports is by collaborating with Health Technology Assessment organizations. Most notably, CADTH and other HTA producers (i.e., Institut national d'excellence en santé et en services sociaux (INESSS) du Québec or Institute of Health Economics (IHE) of Alberta) could be key partners in the obtainment of the relevant information about these technology-based supports and how to assess them.

This policy recommendation presents both advantages and disadvantages. The advantages are based on its ability to leverage knowledge and capacity within pre-existing facilities or organizations. Also, it would allow for interdisciplinary collaborations of experts while helping to generate crucial and needed information in the field of gerontechnology. The main disadvantage relies on time constraints. Partnerships and collaborations can be challenging since organizations may have to balance competing priorities. One way to overcome this issue could be to provide monetary incentives for graduate students to engage in this work as part of their graduate training.

In the end, a standardized framework or tool for economic assessment of technology could enhance the timeliness and quality of available evidence for decision-making. This could further improve the capacity of community organizations to deliver effective and safe technology-based supports to older adults and facilitate aging in place.



Recommendation #2: The federal, provincial, and territorial governments should support further education and training of community-based organizations on gender-based analysis plus (GBA+)³² in order to enhance equity.

The ethical implications associated with technology-based supports for AIP strongly relate to adequately knowing the end-user. This means that factors such as disability, culture, income or geography could all play a role in older adults' acceptance, accessibility to and use of technology-based supports. Community organizations that deliver such technologies need to be aware of the particular situations of who they are serving. By doing so, they help limit undesired consequences associated with technology use.



A tool such as a GBA+³² which was developed and endorsed by the federal government of Canada would be useful for these organizations to ensure that the diverse identity factors (see figure 1) inform the choice of technology-based supports for AIP. For example, individuals with cognitive disabilities may be ill-equipped to make informed decisions and be protected against undesirable sharing of personal information due to limitations with their cognitive function. Community organizations would need to be sensitive to the types of technologies they deliver in situations like the one mentioned above to limit undesirable consequences that may yield from the technology use. Adequate training and education on GBA+ would allow community organizations to better know the older adults they are serving and therefore deliver technologybased supports that are meaningful and respectful of the end-user.

This option is advantageous as it could allow for ethical delivery of technology where older adults needs and capacities are considered from the outset. The main disadvantage is that training and education requires resources. Mobilizing educators throughout jurisdictions could increase financial requirements on jurisdictions but may present significant advantages over other training methods. To overcome the financial barrier, the federal, provincial, and territorial governments could promote the uptake of the online GBA+ course. This course is free and can be accessed online at any moment. While taking this course may increase awareness, its potential to help with application of GBA+ in practical terms may be limited compared to in-person, targeted training.

Overall, education and training on GBA+ is an opportunity for community organizations to become more familiar with the older adult end-users. Knowing this, these organizations would be better equipped to deliver technologies in an ethical manner that respects the needs and capacities of their members.

Figure 1: Identity factors in GBA+³².





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