AGE-WELL position paper on mobile technology and data-informed approaches for healthy aging and aging-in-place.

Data for Healthy Aging Working Group
University of Calgary
August 2020
1. Executive Summary

This position paper was made possible by a grant from AGE-WELL (Aging Gracefully across Environments using Technology to Support Wellness, Engagement and Long Life Network of Centres of Excellence) NCE and the time and contribution of stakeholders critical to the development and adoption of technology for healthy aging and aging-in-place. The purpose of this position paper is to provide guidance on the potential uses of mobile sensors, big data and machine learning for healthy aging, and to recommend how barriers to the development, adoption, and integration of these technologies may be overcome.

Most people desire to stay active and remain socially connected as we age. However, physical and cognitive decline, often inherent in aging, can hinder our ability to stay engaged in the activities we value. Furthermore, most people wish to remain in their homes, which can also become difficult with physical or cognitive impairment, particularly if an individual lives alone.

By 2030, 20 percent of Canada’s population will be 65 or older. As a result, more innovative, evidence-based solutions will be necessary to enable healthy aging and decrease strain on the health- and social care systems. Technologies in smartphones and smartwatches such as reminders and alerts may offer some solutions. Specifically, sensors in these devices are capable of passively capturing person-based (e.g. heart rate, activity level), environmental (e.g. ambient light, noise level), and contextual (e.g. GPS location, social interactions) data. This ‘passive data,’ combined with ‘active data’ entered by the user, such as mood, symptoms, medication history, and meals can create a more comprehensive picture of a person’s health and health-related behaviours.

The integration of these technologies into healthcare is known as mobile health (mHealth). Together with the sophisticated data processing and analysis methods of machine learning, mHealth has the potential to support healthy aging and extend aging-in-place. Indeed, many older persons and caregivers are already using smartphones and smartwatches for purposes related to healthy aging such as tracking physical activity, increasing social connectedness, maintaining independence, monitoring vital signs, and tracking medications and symptoms.

However, the full potential of mHealth in this field is not being realized in part because devices and apps are often not designed to compensate for the cognitive or physical impairments that can increase with age. Additionally, devices are often tested on young, healthy adults, causing health care providers to question the efficacy of the results, and clinical relevance of the data when the devices are used by older adults. Finally, the capabilities of the technologies, including the ability to passively collect personal and personally identifiable information have outpaced regulations creating concerns about the privacy, security, and ownership of data collected by proprietary devices and software. For the technology to reach its full potential, these concerns will need to be addressed, so that the information gained from accurately monitoring can be used to develop
impactful interventions for healthy aging and aging in place. However, to reach the intervention phase, we must first address and act on the barriers to developing monitoring technologies which accurately reflect the needs and concerns of older Canadians.

This paper is the work of the Data for Healthy Aging (D4HA) Working Group - a group of stakeholders interested in the integration of mobile technology and data-informed approaches to support healthy aging. The working group consisted of representatives from the technology industry, health policy, academia, older persons, caregivers, and health care providers. The D4HA Working Group identified four statements that together form the position presented in this paper. Position 1 holds that mobile and sensor technologies, big data and machine learning have enormous potential for use in promoting healthy aging and aging-in-place in Canada. Position 2 identifies that older persons, family caregivers, healthcare providers, technology developers, and policy makers are important stakeholders in the development, adoption and integration of these technologies within our current systems of care. Position 3 acknowledges that stakeholders experience significant barriers in the development, adoption, and integration of these technologies. Position 4 argues that these barriers must be addressed in order to successfully expand the appropriate use of sensors, big data, and machine learning for promoting healthy aging and aging-in-place in Canada.

A central argument of this paper is that barriers to development, adoption and integration could be addressed by involving a group of stakeholders similar to the D4HA from initial concept through to post market evaluations of the technologies. In order to facilitate and encourage this process, AGE-WELL and other granting organizations should specify that applicants for funding demonstrate collaboration with organizations or persons representing at least one of the above stakeholder groups with preference given to applications representing three or more groups. Forming partnerships at such an early stage will demonstrate a commitment to developing technology that meets the requirements of consumers (i.e. older adults, caregivers), and other key stakeholders (e.g. health care providers, policy makers). Applications must also explain how the device or technology will improve efficiency and cost effectiveness over current systems and methods. In order to address issues of trust and privacy, apps and devices intended to support health or facilitate health-related decisions should be developed according to the regulations in the Canadian Directive on Automated Decision Making. The Directive is intended to ensure artificial intelligence is used “in a manner that reduces risks to Canadians and federal institutions, and leads to more efficient, accurate, consistent, and interpretable decisions” (Treasury Board of Canada Secretariat, 2019). Additionally, an app library should be developed with a list of health-related apps that have been evaluated for reliability, safety, and efficacy. AGE-WELL may be in an ideal position to lead this initiative based on the organization’s experience developing The Consumer Guideline for Locator Technologies website (AGE-WELL, 2016). Finally, policy makers and national healthcare organizations should advocate for and fund academic research evaluating the impact of regulatory requirements
on consumer confidence in, and the development of technology for healthy aging. These recommendations are summarized in Table i.

Table i. Summary of the recommendations made in this position paper.

<table>
<thead>
<tr>
<th>Recommendation</th>
<th>Description</th>
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<tr>
<td>Recommendation 1:</td>
<td>Development of mHealth technology must involve stakeholders throughout the process.</td>
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<td>Recommendation 2:</td>
<td>Technology developers should adhere to Canadian and international guidelines regulating the collection, use, and disclosure of personal data.</td>
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<td>Recommendation 3:</td>
<td>Funding and testing of mHealth for healthy aging should be based on ensuring the efficacy and effectiveness of the technology</td>
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<td>Sub-recommendation 3.1:</td>
<td>Grants that support the development of mHealth for healthy aging, must specify that the technology be tested by participants who are representative of end-users.</td>
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<td>Sub-recommendation 3.2:</td>
<td>Grants for the development of mHealth should be awarded to organizations demonstrating collaboration with at least one additional stakeholder.</td>
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<td>Sub-recommendation 3.3:</td>
<td>Funding agencies (e.g. AGE-WELL, academic institutions, Canadian Institutes of Health Research) should support economic evaluations of mHealth technologies.</td>
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<tr>
<td>Sub-recommendation 3.4:</td>
<td>Funding agencies (e.g. AGE-WELL, academic institutions, Canadian Institutes of Health Research) should support academic research examining the impact of regulations aimed at securing personal electronic data.</td>
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<tr>
<td>Recommendation 4:</td>
<td>AGE-WELL or a similar, trusted organization should host an online platform with a list of apps that have been screened for efficacy, usability, and security of personal data.</td>
</tr>
<tr>
<td>Recommendation 5:</td>
<td>Technology developers should focus on integrating mHealth into, or with familiar devices and platforms.</td>
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</table>

Note: further description and justification of the recommendations can be found in sections 5-8

Development of this position paper was stakeholder-driven and conducted in accordance with AGE-WELL’s Procedures for the Development and Approval of AGE-WELL Position Papers in Technology and Aging.¹ The structure and content of our position paper reflects both the requirements laid out by AGE-WELL and the guidance of our D4HA working group members. For example, acronyms are avoided based on advice from one D4HA working group member who noted older persons with dementia may have difficulty remembering the words they represent. The content of this paper is based on the results of two workshops conducted with the D4HA working group. Drafts of this paper were further refined through review and

feedback with working group members. Non-systematic literature searches were used to address specific concerns and provide context on issues identified by working group members. Please see appendices A through D for a summary of the paper development process (appendix A), a detailed timeline of the development of the position paper (appendix B), the initial paper proposal (appendix C), and details of the workshops (appendix D).

This paper focuses on the potential use of mobile technology and data-informed approaches for healthy aging. The first premise of this paper is that these technologies and approaches have enormous potential for use by all older adults, including, but not limited to, those with cognitive and physical impairments as well as family caregivers, care providers and policy makers. As such, while this paper may provide examples that feature specific challenges and risks associated with aging (e.g. risk of falls, cognitive decline, dementia), these examples are not intended to limit the scope of this paper. Future position papers exploring the use of mobile technologies and data-informed approaches to care for older-adult subpopulations with specific cognitive or physical impairments are highly encouraged.
2. Authorship

Data for Healthy Aging Working Group

The (D4HA) Working Group was assembled to provide leadership and guidance for the development of this position paper. Working group members represented the perspectives of older adults (Linda Tyre and Roger Marple), family caregivers (Lisa Poole and Marj Preugschas), technology developers (Jim McDade and Sarah Akierman), health care providers (David Hogan and Maeve O’Beirne) and health policy (Scott Fielding). Joon Lee (project lead and working group chair) and Ruth Ann Rebutoc and Georgina Freeman (project support and working group joint secretaries) were responsible for writing and updating drafts, incorporating working group and AGE-WELL community feedback, and coordinating working group meetings. For more information on working group roles, responsibilities and activities, please see Appendix D: Data for Healthy Aging Working Group meeting agenda, workshop photos, and terms of reference.

Member Bios

Linda Tyre

Linda Tyre is a trained Nurse, Educator and Manager. She has experience the Director of Volunteer Services at the Cross Cancer Institute and developed the Patient Representative Service for cancer patients in Northern Alberta and the North West Territories. Until her retirement, Linda served as the Director Patient Representative Services at Cross Cancer Institute. Linda’s concern for cancer patient care is evident by her continued service as a volunteer patient advisor and volunteer patient actor at the Cross Cancer Institute. Linda is a life-long learner and looks forward to tackling the challenges of healthcare and aging-in-place in Canada.

Roger Marple

Roger Marple lives in Medicine Hat, Alberta and is the proud father of three grown children and grandfather to one grandson. He is an avid sports enthusiast, enjoys playing tennis and golf, loves to travel and knows his way around the kitchen with a real appetite for baking. Roger worked for Alberta Health Services, and worked in supply management for over 23 years. He also has young onset Alzheimer’s disease. Roger joined the Alzheimer Society of Canada’s advisory group to help raise awareness of the needs of people with dementia, including the specific needs of people living with young onset and/or early stage dementia. Roger serves on the board of directors of the Alzheimer Society of Alberta and Northwest Territories and is active in supporting dementia research in Canada. Since his diagnosis in 2015, Roger has made it his mission to dispel myths about the disease and the stigma associated with dementia. He is a firm believer that you can live well with this disease regardless of challenges and is passionate about sharing his message of hope.
Lisa Poole
Lisa Poole is a care partner. She provides insight from the perspective of lived experience: her father, John, has vascular dementia. Lisa is the Co-chair of Dementia Advocacy Canada, the founder and editor of Dementia Connections Magazine. In addition, Lisa is on the board of Gordie Howe Center for Alzheimer’s Research and Education Society (Gordie Howe C.A.R.E.S.), and is a member of Dementia Network Calgary’s Strategic Council and AGE-WELL’s Older Adults and Caregivers Advisory Committee.

Marj Preugschas
Marjorie is a care partner. She graduated from the University of Alberta and worked as a Social Worker for a number of years. She spent many years assisting family members that required extensive treatment within the healthcare system. Her experience has been in rural Alberta, where she and her husband raised their three children on the family farm. She continues to be an active community volunteer.

Jim McDade
Jim McDade is the Chief Operating Officer and Owner of Aware360. Aware360 provides solutions integrating people, technology (e.g. wearables, smartphone applications, location-based sensors) to improve people’s health and safety. Jim is the former CTO and CIO of Alberta Health Services and currently sits on the board of the Canadian Centre to End Human Trafficking. Jim holds a Computer Science degree from the University of New Brunswick and an MBA from McGill University.

Sarah Akierman
Sarah Akierman is a Project Manager at Vivametrica Ltd., a health analytics company that builds tools to measure health by utilizing mobile and wearable technology, big data, and machine learning methodologies. She is responsible for developing and implementing all client-related contracts in both health and wellness and the insurance industry around the globe. She holds a M.Sc. in Biological Science specializing in host-pathogen interactions and a B.A and B.Sc. from the University of Calgary.

Maeve O’Beirne
Maeve O’Beirne PhD, MD, CCFP is a Family Physician and Director of the Patient Medical Home and Quality in the Department of Family Medicine at the University of Calgary. Her research interests are in Patient Safety and maternal/child health. She is also involved in improving care for medically complex patients by incorporating the determinants of health into primary care.
David B. Hogan
David Hogan is a specialist in geriatric medicine. He joined the University of Calgary in 1990 where he held the Brenda Strafford Foundation Chair in Geriatric Medicine for 25-years and is now the Academic Lead of the Brenda Strafford Centre on Aging. David served in a number of national leadership positions for the Royal College of Physicians and Surgeons of Canada and the Canadian Geriatrics Society. He has authored over 290 peer-reviewed publications. National and Provincial awards include the 2019 AMA Medal for Distinguished Service. He has a particular interest in the application of environmental design and innovative technology in dealing with the challenges of an aging society.

Scott Fielding
Scott Fielding is the Senior Provincial Director of the Emergency and Seniors Health Strategic Clinical Network in Alberta. He has been an employee of Alberta Health Services (AHS) for the past 18 years and has held a number of administrative and leadership roles. He has worked directly with Alberta Health and the Ministry of Health acting as a clinical advisor on healthcare delivery matters. He holds a degree in nursing from Central Connecticut State University, and a Masters of Business Administration.

Joon Lee
Joon Lee is an Associate Professor of Health Data Science and the Director of the Data Intelligence for Health Lab at the Cumming School of Medicine, University of Calgary. He holds a joint appointment in the Departments of Community Health Sciences and Cardiac Sciences. He holds a PhD in Biomedical Engineering from the University of Toronto, and a BASc in Electrical Engineering from the University of Waterloo. He completed a 3-year postdoctoral fellowship in Medical Data Science at the Harvard-MIT Division of Health Sciences and Technology. His research applies data science, machine learning, and artificial intelligence to a wide range of health applications including medicine and public health.

Ruth Ann Rebutoc
Ruth Ann Rebutoc is a Research Associate with W21C. She has a BA in Anthropology from the University of Calgary, and an MSc in public health from the University of Lethbridge. Specializing in qualitative and quantitative methods, she partners these techniques to produce a greater depth of knowledge and increase the generalizability of the research. Her work at W21C focuses on how AI can be used to monitor and improve various aspects of health including aging-in-place. Her research interests include costs and sustainability of the healthcare system, policies dictating access to care, and the integration and effectiveness of AI in healthcare.
**Georgina Freeman**

Georgina Freeman is a Senior Research Associate at W21C. She has a background in Biological Sciences (BSc ’09, University of Calgary) and Biomedical Ethics (MSc ’12, McGill University). She specializes in qualitative research methods, focusing on the design, conduct and analysis of focus groups and interviews. She supports W21C’s Home Health and Aging-in-Place portfolios. Georgina’s research interests include health technology development and integration, co-design methods, patient experience, and quality of evidence.
3. Introduction

The 2016 census revealed that Canada now has fewer persons 14 years of age and younger than persons 65 years of age and older (Grenier, 2017). Of this population, 85 percent have stated their preference is to age in place (Peterson, 2019). Aging-in-place is defined as “the ability to live in one’s own home and community safely, independently, and comfortably, regardless of age, income or ability level” (Centers for Disease Control and Prevention, 2017). It should be no surprise that Canadians, as they age, wish to remain at home for as long as possible. Home is often associated with family, familiarity, warm memories as well as a sense of identity, belonging, and community. Aging-in-place may also confer benefits in both mental and physical health. Studies comparing those aging-in-place to those in an institutional setting demonstrate that older persons who age in place are more active and better able to maintain social connections and autonomy (Puri et al., 2017). Additionally, seniors who age-in-place often need less assistance with daily living, have better cognitive function, and less depression than their counterparts in nursing homes (K. I. Kim, Gollamudi, & Steinhubl, 2017). Aging-in-place is also, generally, less expensive than institutionalized care (Puri et al., 2017).

Regardless of the potential benefits accorded by aging-in-place, all older persons are still at risk of a number of health concerns, including falls (Sukreep, Elgazzar, Chu, Nukoolkit, & Mongkolnam, 2019) and cognitive decline (Arnhold, Quade, & Kirch, 2014) related to the aging process. More than a third fall each year with approximately 10 percent of those falls resulting in serious injury (K. I. Kim et al., 2017). They also typically have one or more chronic illness (Roberts, Rao, Bennett, Loukine, & Jayaraman, 2015). In fact, approximately two-thirds of older Canadians are living with multiple chronic illnesses (Roberts et al., 2015).

**Position 1:** Mobile and sensor technologies, big data, and machine learning have enormous potential for use in promoting healthy aging and aging-in-place in Canada.

Given the growth in the number of older Canadians facing these health challenges, new evidence-based solutions are required to effectively support aging-in-place. One potential solution is the use of mobile health (mHealth) defined as, “medical and public health practice supported by mobile devices” (World Health Organization, 2011), such as smartphones, patient monitoring devices, personal digital assistants (PDAs), wearables and other wireless devices. A wide variety of mobile devices are used in mHealth systems, from home blood pressure monitors, to smart phones and wearable technology, to implantable devices such as cardioverter-defibrillators. However, for the purposes of this paper, we will focus on the potential of personal mobile devices (i.e. smart phones, tablets) and smart wearables such as activity trackers and smart watches.

Smartphones and smart wearables have dramatically expanded the types and amount of data that can be collected from users. Sensors embedded in these devices can collect data continuously, even outside the home while people go about their daily lives. In addition, these data are most often viewable on apps (defined as an
application, especially as downloaded by a user to a mobile device) that may ask for supplementary information, for example, about symptoms, diet, or mood. Together, these data can give health care providers a more complete picture of their patient’s health and health-related behaviours, contributing to the possibility of more accurate diagnoses and earlier interventions. For example, a recent systematic review of sensing technologies used to monitor behavioural symptoms of dementia showed that half of the studies reviewed found that high temporal resolution data on motion was a valid proxy for behaviours such as sleep disturbances, agitation and wandering (Husebo et al., 2020). Furthermore, with Bluetooth or Internet access, these devices are capable of communicating with other mobile devices, transmitting data to health care providers, or sending alerts to users and caregivers.

Over time, the combination of automatically collected (or ‘passive’) and manually entered (or ‘active’) data often results in large volumes of complex, ever-growing information. This information is often referred to as “big data” and can provide a record of various aspects of a person’s daily activities. As stated, sensors in mobile devices have the ability to collect data continuously – recording various aspects of a person’s daily activities. Machine learning often facilitates the process of converting this data “into meaningful and actionable information” (Baig, GholamHosseini, Moqeem, Mirza, & Lindén, 2017, p. 115). Machine learning is a branch of computer science that uses vast quantities of data to create algorithms that can find patterns, categorize information, or make predictions for new data. In regard to mHealth, one example of how machine learning is currently being used is in the examination of sleep. Multiple studies have shown that smartphones can be used to passively collect environmental data including the level of ambient light and noise; device data including battery power, information regarding processes the device is running and screen state; movement (using the accelerometer); bedtimes; alarms (signifying wake-times); and ‘active’ data such as level of tiredness to estimate duration and quality of sleep (Mohr, Zhang, & Schueller, 2017). This approach to collating multiple sources of information which describe different elements of a complex process is potentially transferable to many other areas of our lives, offering great potential to understand, track, and intervene to promote healthy aging in Canada.

**Position 2:** Older persons, family caregivers, healthcare providers, technology developers, and policy makers are important stakeholders in the development, adoption, and integration of mHealth technologies within our current systems of care. These stakeholders experience barriers in the development, adoption and integration of mHealth technologies in Canadian health systems.

Despite this potential, mHealth research is in its infancy and many questions still need to be answered regarding development, adoption, and effectiveness. For example, aging-associated cognitive and physical
decline could hamper the ability of older adults to use mobile technology and features of mHealth. A lack of experience with the technology and inadequate training can result in features not being used and a drop in overall adherence. Clinicians need to be convinced that a specific mHealth intervention is effective and appropriate before they will recommend it to older patients. Thousands of apps claim to support or manage various aspects of health, but these claims need to be validated. While many studies mentioned above report positive outcomes for participants, most were often small pilot studies that do not prove effectiveness on a broader scale (Mohr, Zhang, & Schueller, 2017). Taking a “one size fits all” approach based on these results would likely lead to disappointing outcomes. Clinicians, older persons, and their caregivers will then need guidance on which claims have been proven by rigorous evaluation. Demonstrations of effectiveness must also prove that mHealth systems will not flood health care providers and caregivers with superfluous, inaccurate data and alerts. Regarding the technology, questions remain about who will develop the devices, own and access personal data collected by the sensors, and create and update the algorithms. Privacy is a central concern for health care providers, caregivers, and older persons. As mentioned above, sensors in mobile devices and smart wearables have the ability to collect copious amounts of personal and environmental data, often with only tacit consent from the user (Anaya, Alsadoon, Costadopoulos, & Prasad, 2018). Finally, the cost of purchasing mobile devices could pose a significant obstacle for individuals, insurers, or the healthcare system preventing its widespread use, and making moot questions about possible benefits.

**Position 3: Stakeholders have a role to play in identifying and addressing barriers to development, adoption and integration of mHealth technologies in Canada.**

The mission of AGE-WELL is to foster the creation of technologies and services that benefit older adults and caregivers. These technologies and services help older Canadians live safe, social, independent and healthy lives. Mobile devices and data-informed approaches to care are examples of technologies and services for which AGE-WELL supports stakeholder-driven, transdisciplinary research, knowledge mobilization and commercialization activities. The development of this position paper adhered to AGE-WELL processes, which reflect AGE-WELLs overall principles and approach to developing accurate, impactful knowledge. The content of this paper was guided by a stakeholder-led working group (the Data for Healthy Aging [D4HA] working group) representing diverse perspectives in the development, adoption and integration of mobile sensors and data-informed approaches to healthy aging and aging-in-place. The national AGE-WELL community reviewed the paper to ensure its content was relevant and actionable in the larger Canadian context. This process allows AGE-WELL to increase the reach and impact of this position paper. This paper addresses the specific benefits and challenges of mobile and wearable technology, big data and machine learning for healthy aging and aging-in-place. The purpose of this paper is to provide guidance and recommendations for how AGE-WELL, its
partners, community members and other stakeholders can help appropriate technologies and services become commercially available to older Canadians and integrated into our health systems. The recommendations held within this paper focus on how the different stakeholder groups, funding agencies and bodies such as AGE-WELL can contribute to the elimination of barriers to the development, adoption and integration of these technologies.

The position paper is divided into 10 sections. Following the executive summary and statement of authorship (sections 1 and 2), section 3 provides an overview of Canada’s aging population and the potential benefits and challenges of data-informed approaches to healthy aging and aging-in-place. Section 4 provides a statement of the position taken by the D4HA working group in this paper. Section 5 describes in detail the potential benefits of sensor technologies and data-informed approaches to healthy aging and aging-in-place. Section 6 discusses stakeholders and how they might be impacted by the adoption and integration of these technologies. Section 7 addresses the problems and challenges of developing and using these technologies in relation to healthy aging. Section 8 contains the D4HA working group recommendations for overcoming the social and technical challenges associated with the development, adoption and integration of these technologies in healthcare. Section 9 gives a brief summary of the literature that was used to inform this paper. Finally, Section 10 explains how this position paper supports AGE-WELL’s crosscutting activities, and how it relates to other position papers, policies, and documents published by AGE-WELL. In addition to the main content of this paper, appendices provide further context as to the paper’s development process and resulting recommendations. Appendices A through D provide a summary (Appx. A), a detailed account (Appx. B), and additional supporting materials (Appx C&D) of the development and review process.
4. Statement of Position

Mobile and sensor technologies, big data, and machine learning have enormous potential for use in promoting healthy aging and aging-in-place in Canada. However, barriers to their development, adoption and integration into the healthcare system limit the current use of these technologies. Technologies that are poorly matched to the needs of end-users (older adults, family caregivers, healthcare providers) are unlikely to be adopted. Technologies that do not take into account the context in which they are used (e.g. at the meeting point between public healthcare and the private home) are unlikely to be integrated into daily care practice. Lack of access to end-users and a lack of understanding of the context in which these technologies are used are major barriers to the development of adoptable, integrated technologies. End-users, along with technology developers and policy makers are important stakeholders in the development, adoption and integration of mobile health technologies and data-informed approaches to care into our health system. Each of these stakeholders has a role to play in improving the use of these technologies to promote healthy aging and aging in place in Canada. Below, Table 1 breaks down the four positions taken by this working group as to the enormous potential of these technologies, as well as the social and technical challenges that act as barriers to achieving that potential.

Table 1. The four positions and purpose of the data for healthy aging position paper.

<table>
<thead>
<tr>
<th>Position 1</th>
<th>Mobile and sensor technologies, big data, and machine learning have enormous potential for use in promoting healthy aging and aging-in-place in Canada.</th>
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<td>Position 3</td>
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<td>Position 4</td>
<td>These barriers must be addressed in order to successfully expand the appropriate use of sensors, big data, and machine learning for promoting healthy aging and aging-in-place in Canada.</td>
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**Purpose**

*This position paper provides guidance on the potential uses of mobile sensors, big data and machine learning for healthy aging and recommends how barriers to the development, adoption and integration of these technologies may be overcome.*
5. Potential of the Technology

This section addresses Position 1 of the data for healthy aging position paper, that mobile and sensor technologies, big data, and machine learning have enormous potential for use in promoting healthy aging and aging-in-place in Canada.

Increases in life expectancy offer opportunities to older persons and society that have not previously been possible. On the other hand, the associated rise of age-related diseases and other conditions pose serious challenges for older persons, their caregivers, health care providers, and the healthcare system. Older adults often express a preference to age-in-place where they can retain the ability to make their own choices while maintaining their independence and social connections. The health- and social-care system is also strained with over-crowded hospitals in many urban centres, long wait-lists for placement in residential care facilities, and ever-increasing expenditures.

As stated in section 3, mHealth is the use of mobile and sensors technology to collect and analyze both health and non-health-related data for the purposes of monitoring and communicating information about the state of someone’s health. In research on wearables and healthcare, the term ‘wearable’ most often refers to consumer-grade activity trackers such as Fitbit® or smart watches such as Apple Watch®. This paper will use this definition. Equipped with multiple sensors, these devices are capable of continuously collecting environmental (e.g. ambient light, noise level), person-based (e.g. activity level, blood pressure), and contextual (e.g. GPS coordinates, social interactions) data. Continuous or unsupervised monitoring of consenting persons means that physicians and other health care providers could potentially have access to a wealth of real-world data previously unavailable to them (Fasano & Mancini, 2020). When combined with active data such as symptoms, meals, and blood pressure, this information is known as patient generated health data. Patient generated health data is defined as “health-related data – including health history, symptoms, biometric data, treatment history, lifestyle choices, and other information-created, recorded, gathered, or inferred by or from patients or their designees (i.e. care partners or those who assist them) to help address a health concern” (Wood, Bennett, & Basch, 2015). Another key, but possibly implied aspect of patient generated health data, is that it is collected, at least partially, if not entirely outside of a clinical context.

Patient generated health data can be expanded further with the addition of sensors that can provide contextual data such as GPS coordinates, browsing history, social interaction (i.e. messaging apps, phone calls), and social context (i.e. people in the vicinity of the user). Together this information becomes known as personal sensing (B. Kim & Lee, 2018).

As more and more people carry their mobile devices with them, new sources of data are available to give insight into behaviour relevant to a person’s health while requiring little effort on the part of the user once they have provided their consent. For example, a mobile device may have apps capable of capturing GPS
coordinates, heart rate, and financial transactions that could indicate if someone went to a gym. Given the nearly continuous, ubiquitous, and disparate nature of these data streams, personal sensing results in vast amounts of raw data that must be transformed into clinically useful and actionable information. Machine learning most often facilitates this process (Price, 2018).

Machine learning can be described as a four-step process whereby a computer 1) analyzes data, 2) “learns” from the data 3) automatically generates a model based on the “knowledge” gained from the data within a predefined construct, and 4) uses the model to solve a problem and make a prediction, or categorize information. The data that informs the algorithm is often referred to as “big data”. Big data refers to a large volume of diverse, quickly changing data that adds value (Barton, 2019).

For a representation of this process, please see Figure 1 (B. Kim & Lee, 2018). Figure 1 is a visualization of the data to knowledge process by which raw data collected from sensors embedded in mobile devices is processed into clinically relevant information.

Figure 1. Data to Knowledge Sense-making Framework

Outside healthcare, machine learning has been used, for example, to improve predictions of down-wind smoke emissions from wildfires. In one study (Yao et al., 2018) topographical (i.e. terrain, elevation, land use) and meteorological (i.e. wind, time of day, season) data were analyzed alongside information about fire activity (i.e. intensity, size, location) using a machine learning algorithm to better predict the concentration of smoke emissions at ground-level and therefore public health risk.

Within healthcare, machine learning is being used for a wide array of applications – for example, to improve the prediction of patient outcomes in intensive care units (Pirracchio et al., 2019), and prognosis for persons with lung cancer (Yu et al., 2016). One study used a machine learning technique known as natural
language processing to take advantage of a patient’s complete electronic health record - including physician notes, in order to predict outcomes in the intensive care unit (ICU) (Marafino et al., 2018). Machine learning is uniquely suited to analyze data from electronic health records that inevitably contain information from various sources (e.g. laboratory tests, patient histories, sensor data, physician notes) taken at irregular intervals, and which may have missing data. In the study, clinical trajectory modeling, enriched with natural language processing was able to retrospectively predict mortality with 92 percent accuracy compared to 83 percent when only using laboratory results or vital sign data obtained within 24 hours of admission. It is important to note that incremental improvements such as the ones shown here in the prediction of outcomes will not necessarily change the decisions made by health care providers and patients or improve outcomes (Peltan, Beesley, & Brown, 2018).

The fields of mHealth and personal sensing are young. As of the writing of this position paper, most mHealth is focused on its use as a monitoring tool. Monitoring is the first step towards the use of mHealth as a decision-making tool for care providers in determining appropriate intervention or treatments. By collecting large volumes of data on both healthy older adults and those who are experiencing cognitive or physical decline, a better understanding disease processes is formed, which can ultimately inform better treatments and supports for all older adults. Researchers are already testing the potential of mHealth across a variety of treatment areas with the goal of improving diagnoses, predictions, and as a result, hopefully patient outcomes. In one study, researchers at Johns Hopkins’ University examined the ability of a machine learning algorithm to measure the motor symptoms of patients with Parkinson’s disease (Zhan et al., 2018). Currently measures of Parkinson’s disease are typically determined by physicians and are therefore examiner dependent and assessed in clinic. As part of the study, researchers developed and tested the ability of an Android smartphone app (HopkinsPD) and a mobile Parkinson’s disease score to assess “five activities (voice, finger tapping, gait, balance, and reaction time)” (Zhan et al., 2018, p. 877) considered indicators of the motor symptoms of Parkinson’s disease. By providing frequent, objective, real-world assessments the authors argue that the app could enhance clinical care and evaluation of novel therapeutics for Parkinson’s disease.

This example highlights some of the major strengths of machine learning, which are the ability to: 1) process large quantities of data from multiple sources, 2) make adjustments for missing data, 3) learn from incoming data; and, 4) update an algorithm based on this information without constant manual intervention. With higher data processing capacity and ability to triangulate between different types of data, machine learning may contribute to developing novel interventions, for instance more efficient or standardized diagnoses, treatments and/or supports for individuals living with diverse forms of physical and/or cognitive decline. Consequently, older adults living with chronic conditions may be able live at home longer as knowledge gained from machine learning algorithms could result in more effective care with a reduction in the number of critical
events. Reducing the number of critical events could also benefit the healthcare system in the form of fewer emergency or urgent visits and hospital admissions (Chow, Ariyarathna, Islam, Thiagalingam, & Redfern, 2016; K. I. Kim et al., 2017; Van Veen et al., 2019).

Economic evaluations of mHealth monitoring technologies are also new, but the research that has been done reports some promising results. One potentially cost-saving aspect of some mHealth interventions includes regular, consistent interactions, real-time feedback, and communication with healthcare professionals across a patient population outside a clinical setting. For example, several studies examined the use of short messaging systems (i.e. text messages) to provide medication and appointment reminders (Anglada-Martinez et al., 2015; DeKoeckkoek et al., 2015; Hamine, Gerth-Guyette, Faulx, Green, & Ginsburg, 2015), or messages designed to support self-management of health-related behaviours. For example, in several studies apps were used to generate automated (sometimes personalized) text messages to support persons trying to lose weight (Marcolino et al., 2018; Siopis, Chey, & Allman-Farinelli, 2015), manage diabetes (Kitsiou, Pare, Jaana, & Gerber, 2017; Rehman et al., 2017), or HIV (Cooper, Clatworthy, Whetham, & Consortium, 2017; DeKoeckkoek et al., 2015). These studies reported improvements to medication adherence, appointment attendance, and better self-management of health-related behaviours resulting in lower viral loads, weight loss and lower blood glucose levels, and mitigation of risky or health-behaviours.

As in the D4HA working group, physicians in one study were concerned about the potential influx of messages from patients that might require responses increasing the workload for healthcare professionals (K. I. Kim et al., 2017). However, in a study examining the impact of text message reminders on medication adherence in patients with HIV, a physician did posit the possibility that if medication adherence increased, viral load would decrease, ultimately decreasing patient acuity and thus workload across the system (Cooper et al., 2017).

If individuals or healthcare systems will be asked to pay for mHealth, understanding how the intervention(s) supports health and reduce personal or system costs will be a key to implementation.

These benefits are potentially significant with major implications for older persons, caregivers, and health care providers as well as policy makers, and technology developers. The next section will address how these stakeholders might contribute to the development, adoption and integration of effective mHealth approaches within the health care system.
6. Stakeholders and Benefits of the Technology

This section addresses Position 1 and Position 2 of the data for health aging position paper. Position 1 is that mobile and sensor technologies, big data, and machine learning have enormous potential for use in promoting healthy aging and aging-in-place in Canada. Position 2 is that older persons, family caregivers, healthcare providers, technology developers, and policy makers are important stakeholders in the development, adoption and integration of these technologies within our current systems of care.

“Patients and providers equally anticipate a greater role of wearable activity trackers in managing health and achieving high quality care and patient satisfaction” (Puri et al., 2017). Successful implementation of mHealth for the promotion of healthy aging and aging-in-place will require collaboration from a diverse group of stakeholders throughout the entire process from initial conception to development and then adoption. The following section is the result of D4HA working group discussions. This section explains how the different stakeholder groups may contribute to the development and adoption of mHealth technologies and how each group might benefit from these technologies. Table 2 defines each of the stakeholder groups.

Table 2. Definitions of stakeholders

<table>
<thead>
<tr>
<th>Older Adult</th>
<th>An individual over 65.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Family Caregiver</td>
<td>An individual who supports a relative, partner or loved one in managing their health and wellness needs.</td>
</tr>
<tr>
<td>Care Provider</td>
<td>A health professional or practitioner, including physicians, nurses, home care management teams, health care aides and allied health professionals.</td>
</tr>
<tr>
<td>Technology Developer</td>
<td>An individual who builds or creates software, hardware and/or mobile applications.</td>
</tr>
<tr>
<td>Policy Maker</td>
<td>An individual involved in the creation and amendment of rules, guidelines and laws.</td>
</tr>
<tr>
<td>Researcher</td>
<td>An individual who systematically investigates phenomena for the purposes of increasing understanding and sharing knowledge.</td>
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</tbody>
</table>

Benefits of Stakeholder Engagement and Collaboration

A central point is the need for technology developers to engage older persons, caregivers, care providers, and policy makers prior to designing new devices or apps and throughout the development process. Older adults and caregivers are direct sources of information about the specific needs of the target population. In addition, physicians and other health care providers could provide technology developers with an aggregate
understanding of what systems and features would benefit specific patient populations (e.g. older persons with heart failure or dementia) as well as what physical characteristics would best facilitate usability among older persons. “Physicians could also provide developers with advice on how to integrate the information into workflows (i.e. electronic medical records)” (D4HA physicians).

The benefits of stakeholder engagement were demonstrated during the development of this paper. While industry representatives said it was often difficult to enroll enough older participants to test devices, D4HA health care providers noted that in Alberta there are two Practice Based [primary care] Research Networks, “which would be an excellent way for these companies to recruit both providers and patients” (D4HA physician). Accessing participants through these networks would also alleviate problems “with patient confidentiality because each patient would be asked if they wanted to participate and sign a consent form” (D4HA physician).

Finally, members of the D4HA working group stressed the need for policy makers to be consulted so they can alert developers to potential privacy concerns, system vulnerabilities, the likelihood of integrating mHealth approaches within the current healthcare system, and financial challenges.

Technology developers also acknowledged the role older persons should play, saying they “could facilitate the development of technology by providing use-case scenarios and user journeys (or experiences) with the technology” (D4HA industry representative).

Benefits to all stakeholder groups

Continuous monitoring was cited as a central feature of mobile and sensor technology that could enable a cascade of other features. Paired with alerts and reminders (i.e. appointments, medications) that can be shared with caregivers and physicians, continuous monitoring was viewed as a way to potentially enhance safety and independence. Further, stakeholders discussed the potential of big data and machine learning as a way to collect information from multiple devices and analyze it at an individual- or population-level. Knowledge gained could then be used to better understand disease trajectories, influence public health policy, and help individuals understand how to reduce their risk for adverse outcomes. This knowledge could help developers identify new opportunities for technology development, and allow caregivers and health care providers to better care for older persons, including helping to guide end-of-life decisions.

Benefits to Older Adults

As mentioned in Section 5, potential benefits of mHealth systems for older persons wishing to age-in-place include: personalized feedback, safety alerts to caregivers and/or health care providers and detection of important changes in health, integration with the user’s patient health record, and the facilitation of communication with health care providers.
Older adults in the D4HA working group emphasized the ability of these systems to support independence and safety in consenting individuals through reminders, GPS apps, and alerts. Speech recognition was viewed as a critical component of these systems because it eliminates the need to write reminders or remember how to use calendar and GPS apps, which may become difficult to operate with declining memory, sensory function, and/or manual dexterity. This group also discussed the potential of machine learning algorithms to collect and analyze data from multiple connected devices in order to learn how older persons actually interact with technology to facilitate the development of apps and devices that are more functional for this population.

**Benefits to Caregivers**

Caregivers refer to non-professional (i.e. un-paid) providers of care who are often, but not always, family members of older persons. While caregivers are often critical to the decision and ability of older persons to delay institutional care, no research was found examining their perspectives on how mHealth could facilitate aging-in-place, the challenges they might face implementing an mHealth system, or how they might facilitate adoption by their older care recipient.

Despite being overlooked, many of the potential benefits for older persons work in tandem with those potentially received by caregivers. For example, the growing connectivity of many apps and devices allows reminders and alerts to be sent to caregivers in case of a critical event such as a fall (B. Kim & J. Lee., 2018). Other information such as blood glucose or activity level can also be shared across devices giving caregivers the ability to remotely monitor older persons. Finally, GPS – a common feature in most smartphones and smart wearables can enable caregivers to access the location of care recipients. These features can give caregivers peace of mind.

With regard to development and adoption, caregivers in the D4HA working group want mHealth technologies and apps that would encourage older persons to engage in better management of their own health. They discussed the ability of mobile and sensor technologies to facilitate this goal. Many applications establish virtual social networks or have the ability to link results and progress to social media platforms, which can facilitate peer support for isolated adults. They also suggested caregivers could facilitate adoption by purchasing the devices and providing feedback on whether or not it supports aging-in-place.

When discussing big data and machine learning for mHealth, caregivers theorized that big data collected from wearables and mobile technology, if analyzed on a population level, could provide insight into disease trajectories. In turn, this knowledge could help them understand how to better care for family members. This group also suggested that insight gained from this information could be used to educate the public, influence health policy, and help individuals understand how to reduce their risk of chronic disease.
**Benefits to Physicians**

A wide variety of healthcare providers are involved in supporting healthy aging. However, this position paper is guided by members of the D4HA working group, therefore we were only able to include the viewpoint of physicians at this time. This is a limitation of this position paper. Future work in this area should ensure that there is representation from a variety of healthcare providers.

As stated above, mHealth systems could provide physicians and their teams with a wealth of real-world data about their patients, including symptoms, biometric measures, and activities relevant to their overall health. During consultations with the D4HA working group, physicians discussed the potential of this data - if provided in a useable format to help them better understand the needs of individual patients and create personalized treatment plans.

Regarding development and adoption, physicians want devices that can be integrated with a person’s electronic medical record and facilitate communication with their patients. “This would create a kind of ‘virtual visit’ allowing physicians and other care providers to remotely monitor patients with chronic illnesses such as heart failure as well as the ability to encourage positive lifestyle choices such as diet and exercise” (physician representative). Physicians in the D4HA working group suggested that they and other medical professionals could contribute to the development of mHealth systems by facilitating the testing of products among consenting patients and providing input on their usability and utility.

While technology developers suggested older adults could provide use-case scenarios of technology, one physician member said technology development should start with users’ “personal journeys to identify potential areas where technology might offer a solution” (physician representative). Too often technology is developed and presented as a solution to a problem without enough initial user engagement. As a result, the solution, (or technology in this case) doesn’t meet the needs of the user, much less address the problem it was meant to solve.

Finally, physicians suggested that, given the ability of machine learning to analyze data from diverse sources in near real-time, the extracted information could potentially be used to integrate precision medicine into the care of individual patients. These technologies could also potentially help determine a patient’s prognosis and therefore “facilitate end-of-life decisions” (physician representative).

**Benefits to Policy Makers:**

Like caregivers, the inclusion of policy makers in research on the development and adoption of technology for aging is rare and in the case of policy makers it has generally been confined to issues of privacy and data security. (Challenges related to privacy will be addressed in Section 7.)

Consistent with other members of the D4HA working group, policy advisors also noted the potential of big data and machine learning to capture and analyze both population- and individual-level data to support
public health policy. In addition, a need for “environments that support the development of health-focused technology” (policy representative) was conveyed, along with the suggestion that policy makers could help address this need by making connections between developers and either organizations or users.

For a summary of benefits and challenges noted by the D4HA working group, please see Table 3 in Section 7.
7. Challenges of Implementing the Technology

This section of the position paper addresses Position 3 and Position 4 of the data for health aging position paper. Position 3 states that “stakeholders experience significant barriers in the development, adoption, and integration of these technologies in Canadian health systems.” Position 4 states that “these barriers must be addressed in order to successfully expand the appropriate use of sensors, big data, and machine learning for promoting healthy aging and aging-in-place in Canada.”

Like most new ideas, the benefits and challenges of data-informed approaches to healthy aging and aging-in-place are often intertwined with benefits produced in one area resulting in challenges in another. For example, as noted in Section 6, for the successful adoption of mHealth (i.e. mobile devices and apps), technology developers will need to engage with older persons, caregivers, and health care providers throughout the design process. However, health care providers in the D4HA working group acknowledged they often lack time to participate in the development of new technology. Further, assistance during testing could also require health care providers, developers, and policymakers to contribute time and potentially other resources to the process, which raises questions about the funding of such projects and who is responsible for providing that funding.

This section will discuss fundamental challenges to the successful development and adoption of mHealth. It is based on workshop discussions with the D4HA working group. Corroboration in the literature was sought for concepts raised by the working group. As in the previous section, there were universally held concerns regarding mHealth, which in this case related to privacy, usability, and cost. These concerns are well represented in the literature, with recent studies, including a scoping review, showing that cost, usability issues and privacy were among the top concerns of seniors when it came to adopting mobile health technologies safety (Wang et al., 2019; Rocheleau et al., 2020).

Concerns over Privacy

Privacy was a concern because of the amount and type of passive data being collected through personal sensing. As stated in Section 5, personal sensing uses sensors embedded in mobile devices and wearable technologies to collect health- and non-health-related data. Passive data is collected without direct involvement of the user. For example, a passive system like a Fitbit® doesn’t need the user to actively track and record their daily step count because it independently gathers and stores that information. Passively collected personal information is a privacy concern because this data can be used to identify individuals. For example, just four time-stamped location data points, passively collected by smartphones can form a unique geographic pattern that can identify 95 percent of individuals (Mohr et al., 2017). Privacy breaches are a major concern particularly among older adults experiencing cognitive decline, as they may not have a full understanding of how their personal information is being used or shared (Chalghoumi et al., 2019).
The volume and personal nature of the data collected also raises several questions about the management and ownership of this data. Foundationally, who owns this personal information? Who has access to it? How will the data be stored, transferred, and maintained? Regarding ownership of the data, could a private company sell personal data collected from the devices to pharmaceutical or insurance companies? Likewise, would developers of the technology be able to charge for access to the data? If mobile or wearable data are uploaded or integrated into a user’s electronic health record, who will ensure the security and accuracy of the data transfer, and its usability between the systems? These are questions that D4HA physicians want answered before recommending specific mHealth interventions to patients.

Canada does have laws regulating the collection, use, and transfer of personal data, including health data. At the federal level, the Personal Information Protection, and Electronic Documents Act (PIPEDA) regulates the “collection, use, and disclosure of personal information” (Office of the Privacy Commissioner of Canada, 2019a) by private companies. Several provinces, including Alberta, have laws deemed “substantially similar” to PIPEDA, which are used in place of the federal regulation except in the case of federal or inter-provincial operations. PIPEDA, and substantially similar Acts, were enacted to ensure organizations obtain an individual’s consent prior to the collection of personal data. Additionally, individuals must be given the contact information of someone within the organization who can answer questions about the legality and purpose of the collection, and be allowed to challenge the accuracy of the data collected and conclusions drawn from it (Office of the Privacy Commissioner of Canada, 2019a). A Knowledge and Consent principle within these Acts also stipulates that the above information be conveyed in a manner that is transparent and understandable to the individual (Government of Canada, 2019). Regulation of personal data by public institutions is governed by The Privacy Act at the federal level or substantially similar Acts (e.g. Alberta’s Health Information Act) at the provincial and territorial level (Office of the Privacy Commissioner of Canada, 2018).

Critics of these regulations have pointed to a lack of enforcement powers and consequences for organizations accused of violating the principles (Glustein, 2019; House of Commons Canada, 2018). There is also debate about which Acts apply when both private and public entities are involved in the collection, use and transfer of personal data. For instance, if an individual transfers data from a personal mobile device to a physician, who may then need to disclose the information to other healthcare professionals at a hospital or long-term care facilities, multiple provincial and federal Acts may apply. In this scenario, the physician and long-term care facility are considered to be using and disclosing the data for “commercial activities” while the hospital is publicly funded and therefore governed by provincial healthy privacy Acts (e.g. Alberta’s Health Information Act).

Additionally, in an attempt to be flexible and responsive to rapidly evolving technology, Canadian Acts are “technology neutral” meaning the principles outline the objectives to be achieved without reference to
specific devices, software, companies, or even functions (e.g. passive collection of data) (Government of Canada, 2019). This ambiguity and lack of enforcement has often resulted in self-regulation by technology developers (Office of the Privacy Commissioner of Canada, 2019b).

The Government of Canada does recognize the need to update its privacy laws (Office of the Privacy Commissioner of Canada, 2019b) but so far the effort has only resulted in papers and recommendations from different groups including the Standing Committee on Access to Information, Privacy and Ethics report, “Democracy Under Threat: Risks and Solutions in the Era of Disinformation and Data Monopoly (House of Commons, 2018) and Innovation, Science and Economic Development Canada’s “Proposals to modernize PIPEDA” (Government of Canada, 2019).

In the meantime, the United States and European Union are filling the gap. In May of 2018, the General Data Protection Regulation (GDPR) came into effect across the European Union (European Commission, 2018a). Like Canadian privacy Acts, the purpose of the General Data Protection Regulation is to ensure individuals “know, understand, and consent” to the collection of their personal data and have the right to access and dispute the information. The General Data Protection Regulation also stipulates that companies be clear and explicit about exactly what personal data is collected (e.g. first and last name, home address, phone number, social media profile, IP address), and give users the option to opt-in rather than opt-out of data collection. This law applies to all personal data collected from citizens of the European Union, even if the data is shared and analyzed outside of member nations (European Commission, 2018b). While there are similarities of intent with the Canadian Acts, one significant difference in the General Data Protection Regulation is the enforcement mechanisms. Companies found guilty of violating the terms of the General Data Protection Regulation, can be fined up to 4 percent of their global annual revenue (Government of Canada, 2018).

In addition to privacy, there are questions about the funding, sustainability and reliability of data-informed approaches to managing health. Private companies may not make raw data available if it is collected through proprietary technology. Lack of access to raw data or the algorithms used to analyze it could call into question the validity of the data processed by a private company. Machine learning algorithms will also need to respond to changes in the technologies people use and how they use it. For example, an algorithm designed to analyze outgoing and incoming calls as an indication of social connectedness will become obsolete if texting or video chat become more popular among older persons. Who is responsible for updating the algorithms that accurately capture the changing face of technology and its uses? Finally, if personal sensing data is deemed valuable because it can delay costly institutionalized care, who funds maintenance of the data and pays for the devices?

Along with access to end-users, industry representatives stated that access to aggregate or de-identified health data would help ensure the utility of a new mHealth device. A physician in the D4HA working group
pointed out a paradox of obtaining funding for new healthcare technologies: developers are expected to have a working model and clear use-case in order to obtain funding. However, if stakeholders are to be involved in designing a system, this implies either considerable stakeholder-involved work would need to be done without funding, or funding would need to be obtained prior to developing a prototype of the technology.

**Concerns over Usability**

Usability was a common concern both in the literature and among D4HA working group members. As people age, impaired manual dexterity, as well as sensory and cognitive decline become more common though not universal. Diminished eyesight and hearing loss can make apps and messages hard to see and alerts or reminders hard to hear. As an older adult in the D4HA working group noted, “shaky hands can affect a user’s ability to press the right buttons in the app, while cognitive decline can cause a person to lose a mobile device” (older adult representative). Indeed, fear of losing the devices was common in the literature as well as concerns about dropping and breaking the technology (Cajita, Hodgson, Lam, Yoo, & Han, 2018; Isaković, Sedlar, Volk, & Bešter, 2016; Puri et al., 2017). Other common complaints were small text or icons, and low visual contrast.

Cognitive decline, and inexperience with mobile devices and wearables also presented challenges to usability. Several studies as well as physicians, caregivers, and older persons in the D4HA working group mentioned limited prior experience and inadequate training as deterrents to purchasing devices or using an app. Surprisingly, a scoping review of wearable technology found that “user concerns were the least addressed topic” in the literature, trailing behind explorations of the technology, information delivery, security and safety (Loncar-Turukalo, Zdравevski, da Silva, Chourvarda, & Trajkovik, 2019). Another article noted technology developers often lack a basic understanding of user needs (Cabrita, Tabak, & Vollenbroek-Hutten, 2019). Involvement of older adults with cognitive or physical limitations is not only possible, but necessary. A 2017 study by Chalghoumi et al. found that “people who have cognitive impairments are capable of taking part in research and technology processes, and should be included in these processes.” Involving individuals with cognitive disabilities in research and design of mobile sensing devices and data-informed approaches to care is also ethically important on a number of fronts. Not only are older adults with cognitive disabilities more at risk for privacy violations (Chalghoumi et al., 2017), but there are questions around capacity to consent to monitoring and data sharing, equitable access to devices, and risk of social isolation due to increased use of technology mediated social interaction (Wangmo et al, 2019). These ethical questions are best addressed by engaging with older adults with cognitive disabilities in discussions of the design and use of mobile technologies and data-informed approaches to care.

Older adults are adopting technology at a rapid pace. A 2019 Pew Research Center article reported that 73 percent of persons 65 and older are active on the Internet, and just over half (53 percent) own a smartphone
(Livingston, 2019). However, the rate at which technology is changing, coupled with potential cognitive and physical impairment means older adults will need to be continually consulted as devices and software evolve.

Concerns over Cost

Apart from age-related health challenges, inadequate battery power and cost were cited as deterrents to adoption. Cost of the devices, which often become out-dated within a few years, was noted as a factor in the literature and among the D4HA working group.

Wireless connectivity is another issue for data-informed approaches to healthy aging. If the goal of mHealth is to maintain or improve monitoring of patients while reducing the number of clinic visits, high-speed Internet access will be key. However, a 2015 survey by Statistics Canada found less than 65 percent of households in the lowest income quintile in Canada had home Internet access (Canadian Medical Association, 2019). Home Internet access was less common in rural areas where 15 percent of households did not have an Internet service provider. Internet access in rural areas is up to 25 percent slower than those in urban areas according to the Canadian Internet Registration Authority (Canadian Medical Association, 2019). Slower speeds or complete lack of Internet access can result in lost data and delayed feedback, which could result in critical alerts being missed, thus negating the potential value or purpose of monitoring devices.

Together with the cost of the devices, there is a cost associated with providing remote healthcare services. Currently, most provincial healthcare funding structures and cost-recovery models are based on in-person visits. These structures will need to be adjusted to accommodate a broader range and higher use of remote monitoring and electronic communications (e.g. email, text messaging, and video-conferencing).

According to a 2014 survey, many physicians already correspond with patients via email. However, only 5 percent reported being compensated for email consultations (Canadian Medical Association, 2018).

Members of the D4HA working group pointed out additional challenges that were not prevalent in the literature:

Policy Representatives

In order for policy makers to advocate for public funding of mHealth, technology developers will need to “explain how new technology can be integrated with older technology,” in addition to “[explaining the need for change… [and] how the technology will lower [healthcare] costs and increase efficiency” (policy representative).

Care Providers

In order to endorse mHealth, physicians need “evidence on the validity and reliability of the data collected” (physician representative). Implementation that engages the end user and integrates with usual care processes appear to be a critical factor. Sensor data can be called into question for a number of reasons. For instance, do different types of sensors collect or produce equivalent data? What evidence is available for data
variability across devices or populations? With the use of healthy, college-age adults to test sensors in wearables, how applicable is the evidence from these studies to a population of older users? Small population sizes are also a concern; most studies examining the use of mobile devices to aid healthy aging have typically only included between seven and ten participants (Mohr et al., 2017). Like policy advisors, health care providers want evidence on long- and short-term cost effectiveness of devices for mHealth.

There were concerns that inadequate user training could lead to a drain on physician and nurse resources as they are called upon to instruct patients on how to use devices or apps, and how to upload data. As noted by Nicholas and Miller (2019), “technology can’t work if there isn’t a human around to install it, log in, input data for a profile and features, to reset it if it crashes, notice that it’s run out of battery, to explain how to use it, or to ensure it fits users’ abilities and needs.” A lack of support for device set-up and data upload may limit the number of older adults effectively using mHealth approaches with their care providers.

D4HA working group physicians also raised concerns about an overload of irrelevant data from remote monitoring, which can detract from the provision of care. In order to prevent information overload on the part of care providers, older adult users can be supported in identifying monitoring devices that are appropriate for their health needs and provide data in a usable, manageable form for their caregivers.

**Older Adults**

Finally, there were some concerns about navigating the volume of mHealth apps available in the marketplace. Although mHealth is relatively new, apps claiming to support or improve health were made available in app stores almost immediately after their launches. One study found an app claiming to help manage diabetes was made available on July 17, 2008 for iOS, just one week after the launch of the Apple App Store® (Mohr et al., 2017). Since then, both Apple® and the Google app platforms have been flooded with various health maintenance, or health promoting apps.
Table 3. Potential benefits and challenges of the development and adoption of data-informed approaches for healthy aging and aging-in-place.

<table>
<thead>
<tr>
<th>Potential Benefits</th>
<th>Challenges</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Continuous data collection from multiple mobile devices provides real-world information about aspects of a person's health and health-related behaviours</td>
<td>• Privacy: Who will own and be able to access personal health data?</td>
</tr>
<tr>
<td>• Real-time alerts can be sent to the user, healthcare professionals, and caregivers based on data collected from a device</td>
<td>• Policy has not kept pace with the ability of devices to collect and transfer personal information</td>
</tr>
<tr>
<td>• Data-informed approaches (i.e. big data and machine learning) can process and analyze data from multiple, personal mobile devices in order to inform a more complete picture of a person's health and improve prediction of outcomes</td>
<td>• Machine learning algorithms will need to be updated based on how the technology changes and how users interact with it</td>
</tr>
<tr>
<td>• Potential to integrate the real-world data collected from mobile devices into patient medical records and improve personalized care</td>
<td>• The cost of the devices may discourage adoption</td>
</tr>
<tr>
<td>• Many applications facilitate social connectedness and encourage peer support, which could benefit isolated adults</td>
<td>• Technology developers lack access older persons to test the devices and ensure they meet the needs of the target population</td>
</tr>
<tr>
<td>• Real-time feedback can encourage users to take a more active role in managing their health</td>
<td>• Currently there is a lack of funding for development of the devices, and ongoing support for data collection, maintenance, and integration with the healthcare system</td>
</tr>
<tr>
<td>• Functions such as reminders and alerts can increase safety and support independence</td>
<td>• Lack of evidence for the efficacy and effectiveness: Most studies examining benefits of mobile devices for older persons have been small, pilot studies using young, healthy adults as participants</td>
</tr>
<tr>
<td>• Big Data and Machine learning can process and analyze population-level data giving physicians a better understanding of disease trajectories and leading to more rigorous, evidence-based health policies</td>
<td>• Physical or cognitive impairments could hinder the ability of some older adults to use the devices</td>
</tr>
<tr>
<td>• Population-level data collection and analysis through machine learning could help technology developers build devices and applications that are more functional for the target population</td>
<td>• There is a lack of regulation for apps claiming to support health.</td>
</tr>
<tr>
<td>• Better awareness and self-management of health could lower the instances of emergency department visits and hospital admissions</td>
<td>• The data collected from the devices can be difficult for physicians to interpret and analyze</td>
</tr>
</tbody>
</table>
8. Recommendations

The purpose of this position paper is to provide guidance on the potential uses of mobile sensors, big data and machine learning for healthy aging and make recommendations as to how barriers to the development, adoption and integration of these technologies may be overcome. In this section, we make recommendations on how different stakeholder groups, as well as funding agencies and bodies such as AGE-WELL can contribute to the elimination of barriers to the development, adoption and integration of these technologies.

Canada’s population is aging rapidly. By 2030, over 20 percent of the population will be 65 or older (Government of Canada – Action for Seniors Report 2014). As noted in Section 3, 85 percent of Canadians plan to age-in-place, which can be made more difficult by declining physical and/or mental health. The risk of chronic disease also increases with age, with over 10 percent of seniors currently living with two or more serious illnesses (Roberts et al., 2015). Chronic illness, frailty, and disability increase the cost of healthcare for individuals and the system.

The goal of this position paper was to discuss the untapped potential of mobile and wearable technology along with, big data, and machine learning to promote healthy aging and extend aging-in-place, while acknowledging the challenges of development and adoption. Section 7 is the result of D4HA working group discussions about the challenges that will need to be overcome in order for these technologies to support aging-in-place, as well as some possible solutions. Some challenges will require more discussion among members of the individual stakeholder groups. For example, while health care providers want to be involved in the development of new mHealth solutions, time is often a constraining factor. While no solution was offered, other challenges were met with potential solutions. Therefore, the following is a list of recommendations for AGE-WELL, its partners, and community. For a summary of these recommendations delineated by stakeholder role, see Table 4 at the end of this section.

**Recommendation 1: Development of mHealth technology must involve stakeholders throughout the process**

There is a lack of evidence for the safety (B. Y. Kim & Lee, 2017), scalability, and effectiveness (Mohr et al., 2017) of mHealth. As noted in Section 7, physicians want to see larger studies that don’t just demonstrate clinical efficacy but also effectiveness in “real-world” contexts before recommending mHealth interventions to patients. Older adults and caregivers also expressed frustration with mHealth solutions that did not take into account physical or cognitive challenges that may be experienced by users. Discussions with the D4HA working group and a literature review advocated for a stakeholder-involved process during the development and adoption of mHealth to address these problems. However, the industry representatives in the D4HA working group noted challenges to creating these partnerships – particularly with older persons, on a large enough scale.
to demonstrate effectiveness. Involvement of older adults in the design and development process reflect an agency-centric approach, which focuses on the perspective and choices of older adults, and supports the full participation of older adults with cognitive limitations (Wayne, 2019).

Therefore, technology developers should coordinate with health care providers to understand what they view as “clinically relevant information”.

Health care providers should also work with technology developers to facilitate access to older adults in support of increasing the power and generalizability of mHealth studies.

AGE-WELL could also use its connections to facilitate partnerships between technology developers and community organizations in order to support stakeholder-involved development of mHealth for healthy aging and aging-in-place.

Finally, whereas most published studies have taken place in developed nations, more trials should be conducted within different populations world-wide (Chib, van Velthoven, & Car, 2015; Krah & de Kruijf, 2016; Sinha & Schryer-Roy, 2018).

**Recommendation 2: Technology developers should adhere to Canadian and international guidelines regulating the collection, use and disclosure of personal data**

Privacy was also a universal concern among members of the D4HA working group - most often expressed in regard to ensuring informed consent and the security of personal data. Medical devices are regulated by the Food and Drug Act (Government of Canada, 2019a). However, these regulations have not kept pace with advances in mHealth. As stated, Canada has several Acts- both federal (i.e. The Privacy Act, PIPEDA) and provincial regulating the collection, use, and disclosure of personal data. The overarching goal of these Acts is to ensure individuals give consent prior to the collection of their personal data; are informed when and why it is being collected; have the right to ask questions about their information and challenge any perceived inaccuracies.

Health Canada is also in the process of developing guidelines “to allow for a more targeted pre-market review of digital health technologies” (Government of Canada, 2018a). A draft document was released for comment in January 2019. In June of 2019, Health Canada also released a “Guidance Document [for the] Pre-market Requirements for Medical Device Cybersecurity” (Government of Canada, 2019b). While not legally binding, technology developers should adhere to these guidelines and document this process throughout development. This approach will give more peace of mind to consumers and may aid adoption.

Despite some questions (addressed in Section 7 above), technology developers should adhere to the principles in these Acts when writing privacy policies. In addition, the Government of Canada has published a Directive on Automated Decision-Making, which regulates the implementation of automated decision systems used by federal institutions. The Directive, proscribes regulations for: 1) assessing algorithms used to make or
facilitate decisions, and making the results public; 2) ensuring transparency by explaining how decisions are made and providing access to source codes used to power algorithms; 3) maintaining the efficacy of the data used to make decisions by testing for biases, conducting risk assessments, consulting with experts and legal authorities, and adhering to institutional ethics regulations; 4) allowing clients access to resources and information to challenge decisions made by automated systems; and 5) reporting the results of efficacy and effectiveness analyses. The Directive is intended to regulate automated decision systems. However, Technology developers who plan for data collected by their devices or software to be used as part of, or integrated with, patient medical records should also adhere to these requirements.

In addition to Canadian Regulations, the General Data Protection Regulation of the European Union came into effect May 2018. As discussed in Section 7, this law establishes stricter standards for consent than Canadian Acts including allowing individuals to opt in to data collection rather than the current industry standard of needing to opt out. This law also establishes more severe consequences for violation including large fines. Global technology companies will undoubtedly adhere to these standards. Therefore, in order to ensure the highest level of consumer trust and compete in international markets, technology companies operating in Canada are advised to adopt the regulations set out in the General Data Protection Regulation.

The European Union also recently (April 8, 2019) published a set of “Ethics Guidelines for Trustworthy AI” (European Commission, 2019). According to this document, technology should provide for:

1. Human agency and oversight - The technology should provide knowledge in a way that is transparent and not manipulative, meaning the persons interacting with the system should know what data was used to inform the algorithm and should be able to interact with and even challenge the technology.

2. Technical robustness and safety: In other words, every effort should be made to anticipate and prevent harm to hardware and software.

3. Privacy and Data governance. According to this principle, the users’ data should be protected from unlawful and unethical use throughout the lifecycle of the technology. Additionally, the data should be free from “socially constructed biases, inaccuracies, errors, and mistakes” (European Commission, 2019, p. 17)

4. Transparency: Persons using the technology should be able to examine the data and understand the data collection methods.

5. Diversity: This guideline also addresses the principle of assessing and eliminating unfair cultural biases that may be a part of the data collection or analysis methods.
6. Accountability: Is linked to transparency as it more explicitly addresses the principle that users should be able to examine and understand the methods of data collection and analysis including the algorithms used by the technology to formulate outcomes/output.

These regulations should be used as a guide for mHealth interventions developed outside the E.U. (e.g. in Canada). In addition to having a template for ethical development and implementation, mHealth developed following this system might be more easily brought to market within the E.U. and vice versa.

**Recommendation 3: Funding and testing of mHealth for healthy aging should be based on ensuring the efficacy and effectiveness of the technology**

3.1 Grants that support the development of mHealth for healthy aging, must specify that the technology be tested by participants who are representative of end-users.

As discussed in Section 7 and Recommendation 1, there is inadequate evidence of the safety, efficacy, and effectiveness of mHealth for healthy aging. In response, industry representatives said there is a lack of funding to support the development and testing of mHealth solutions. Therefore, in order to ensure the efficacy of mHealth data, organizations such as AGE-WELL and academic institutions should fund testing of mHealth devices. Grants should specify that participants using the technology during testing be representative of the intended end-user population. In other words, older persons, of a similar health status, should test devices that will be promoted to older persons.

3.2 Grants for the development of mHealth should be awarded to organizations demonstrating collaboration with at least one additional stakeholder.

AGE-WELL and other granting organizations should specify that applicants for funding are conditional on collaboration with organizations or persons representing stakeholders invested in technology for healthy aging with preference given to applications representing three or more groups. Forming partnerships at such an early stage will demonstrate a commitment to developing technology that meets the requirements of consumers (i.e. older adults, caregivers), and other key stakeholders (e.g. health care providers, policy makers).

3.3 Funding agencies (e.g. AGE-WELL, academic institutions, Canadian Institutes of Health Research) should support economic evaluations of mHealth technologies.

The D4HA working group policy representative also stressed the need for technology developers to explain how the technology will improve efficiency and cost-effectiveness as a part of care. In order to support evidence of economic benefits, organizations focused on healthy aging and academic institutions should also fund and participate in economic evaluations of mHealth technology.

3.4. Funding agencies (e.g. AGE-WELL, academic institutions, Canadian Institutes of Health Research) should support academic research examining the impact of regulations aimed at securing personal electronic data.
In order to evaluate the effect of regulations on the development and adoption of mHealth, policy makers, national healthcare organizations such as Health Canada, and organizations such as AGE-WELL should also fund academic research aimed at understanding 1) the impact of these guidelines on developers and 2) if the guidelines increase trust and confidence of health care providers in mHealth.

**Recommendation 4: AGE-WELL or a similar, trusted organization should host an online platform with apps that have been screened for efficacy, usability, and security of personal data.**

Policy makers, national healthcare organizations such as Health Canada, and organizations such as AGE-WELL should also fund academic research aimed at understanding 1) the impact of these guidelines on developers and 2) if the guidelines increase trust and confidence of health care providers in mHealth. Finally, with the plethora of apps claiming to support health, older persons and caregivers expressed a desire for a regulatory body that can validate such claims. While a solution was not suggested during D4HA working group discussions, a search of the literature revealed app validity is a common concern, for which some governments and healthcare professionals have developed solutions. One such example is Britain’s National Health Service, which hosts an app library as part of its website. The library lists apps that can be filtered by category (e.g. healthy living, cancer, etc.) and that have been evaluated for “usability, quality, accuracy, or evidence of the app” (B. Y. Kim, Sharafoddini, Tran, Wen, & Lee, 2018). Another example is iMedicalapps.com. This physician-run website lists apps that have been evaluated by physicians, medical students, mHealth analysts and other healthcare professionals. To promote the use of safe and effective apps, AGE-WELL could host an app library similar to Britain’s National Health Service, or iMedicalapps.com. The structure and guidelines for inclusion have already been established by these organizations, which could serve as a basis for AGE-WELL’s own platform. AGE-WELL already has some experience developing criteria to assess mHealth. A project lead by Dr. Lili Liu and supported by AGE-WELL guides consumers in choosing GPS-enabled devices to help locate persons with Alzheimer’s disease or other forms of dementia who may be “at risk of becoming lost” (AGE-WELL, 2016). In another project, researchers developed a rating scale for mHealth apps available in Google Play and iTunes stores. Researchers asked health care providers and older adults, including some with mental health conditions, to use the scale to “[rate] the quality of 11 mental health apps” (Canadian Association of Occupational Therapists, 2020). The study found, ratings were similar among the test group. These projects as well as the examples referenced above could serve as models for AGE-WELL, or a similar organization’s own app library.

**Recommendation 5: Technology developers should focus on integrating mHealth into, or with familiar devices and platforms**

In response to an earlier draft of this position paper, an AGE-WELL community member and caregiver expressed concern over the proliferation of single-function technologies for managing health at home. The D4HA
working group identified this concern as a significant barrier to the adoption of data-informed approaches to health care. In addition, the D4HA working group discussed how, by focusing on technology integration, this barrier might be addressed.

D4HA members acknowledged that approaches requiring the use of multiple single-use technologies, each with their own user interface and associated learning curve, is an impractical approach to data-informed approaches to healthy aging. Additionally, D4HA older adult and caregiver members noted that these personal monitoring devices should be developed with integration into healthcare structures (such as EMRs or patient portals) in mind. Here, there was a tension between the interests of older adults and those of their health care providers. Older adult members wanted the data they collected to be integrated into the systems used by their healthcare providers, while healthcare providers were concerned that this could result in a deluge of patient information of suspect validity that could be difficult to utilize.

Industry representatives noted that integrating multiple applications into a single platform or device may require a more cooperative model of technology development that allows different developers to work with one another on a single platform. Industry representatives also acknowledged that integration of data generated by personal monitoring devices into healthcare systems will require consultation with older adults and care providers to ensure that both group’s needs are met.

Therefore, instead of developing new devices the D4HA working group recommends that technology developers focus on integrating multiple functions into a familiar device or platform already used by the end user.
Table 4. Roles of stakeholder groups in addressing barriers to the development, adoption and integration of mHealth technologies.

<table>
<thead>
<tr>
<th>Role</th>
<th>Recommendation</th>
<th>Addressing the need for Stakeholder Involved Development</th>
<th>Addressing issues of safety, privacy, data security</th>
<th>Addressing issues of trust in apps and devices</th>
<th>Understanding the impact of regulations on consumer confidence and technology development</th>
<th>Addressing the lack of funding for mHealth studies</th>
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<tbody>
<tr>
<td>AGE-WELL</td>
<td>Facilitate partnerships between technology developers and patient, caregiver and older adult community organizations.</td>
<td>Tied project funding to inclusion – specify that study participants must be representative of target end-user groups.</td>
<td>Expand the current Consumer Guideline for Locator Technologies website to include a library of validated, reliable health apps.</td>
<td>Fund research into the impact of regulations on consumer confidence and technology development.</td>
<td>Fund post-market economic evaluations of devices, apps and data-informed approaches to healthy aging.</td>
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<tr>
<td>Older Adults &amp; Family caregivers</td>
<td>Participate in organizations that advocate for and facilitate inclusion in technology development.</td>
<td>Advocate for inclusion in research evaluating the safety, efficacy, appropriateness of technologies.</td>
<td>Volunteer for organizations that provide information on validated, reliable health apps and devices.</td>
<td>Advocate for research on how regulations impact technology development and adoption.</td>
<td>Advocate for more research into the impacts and outcomes of data-informed approaches to care.</td>
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<tr>
<td>Care Providers</td>
<td>Connect patients and family caregivers to community organizations that advocate for and can facilitate inclusion in technology development (e.g. Alzheimer Society of Canada, Canadian Association of Retired Persons).</td>
<td>Connect with technology developers in an advisory role. Inform developers of relevant safety, privacy and data security concerns in your practice.</td>
<td>Seek out, advocate for and connect patients and family caregivers with credible, reliable information on validated health devices and applications.</td>
<td>Participate in research that studies the impact of the regulatory environment on how you incorporate data-informed approaches into your care practice.</td>
<td>Advocate for more research into the use of data-informed approaches to care in the healthcare system. Partner with researchers and technology developers.</td>
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<tr>
<td>Technology Developers</td>
<td>Connect with organizations that facilitate access to older adults and caregivers. Work closely with older adults, caregivers and care providers early in the development process.</td>
<td>Adhere to the Canadian Directive on Automated Decision Making and Health Canada’s Guidance Document [for the] Pre-market Requirements for Medical Device Cybersecurity.</td>
<td>Work with older adults, caregivers and care providers to understand what is considered relevant information about the validity of your device. Make that information available.</td>
<td>Participate in research that investigates how the regulatory environment impacts your ability to develop technologies for integration into the healthcare system.</td>
<td>Make it clear how your device, app or software will improve user and/or caregiver quality of life while also being efficient and cost-effective for the healthcare system.</td>
<td></td>
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<tr>
<td>Policy Makers</td>
<td>Tie funding to inclusion – offer support for technology developers that work with closely with older adults, caregivers and care providers.</td>
<td>Support technology developers who partner with researchers to understand and address issues of safety, privacy and data security associated with their device or software.</td>
<td>Support technology developers in demonstrating the credibility of their technology. Support community organizations in making that information available.</td>
<td>Fund academic research evaluating the impact of regulatory requirements on consumer confidence in and the development of technology for healthy aging.</td>
<td>Support research into the cost-effectiveness, efficiency and potential impacts of data-informed approaches to care on older adult and care-giver experience.</td>
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</tr>
<tr>
<td>Researchers</td>
<td>Conduct research on how stakeholder involvement in the technology development process impacts technology adoption and integration.</td>
<td>Run evaluation studies in older adult populations. Investigate the impact of new devices on safety, privacy and data security.</td>
<td>As much as possible, make data on the safety, efficacy, clinical usefulness of new devices publicly available and accessible to lay people.</td>
<td>Research the impact of the regulatory environment on technology development, integration, and consumer confidence.</td>
<td>Conduct research into the cost-effectiveness, efficiency and potential impacts of data-informed approaches to care.</td>
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9. Review of the Literature

The following is a brief review of the literature that helped inform this position paper in conjunction with D4HA working group discussions. The search was targeted - based on the four positions of this paper and therefore examined: 1) research on the potential of mobile and wearable technology to support healthy aging; 2) the importance of involving stakeholders (i.e. older adults, caregivers, policy makers, and health care providers) during the development and implementation of mHealth technologies; 3) the implementation of big data and machine learning to facilitate mHealth systems and; 4) challenges stakeholders face in the development and adoption of mHealth systems.

The potential of mHealth to help manage chronic disease is already being explored in relation to aging-in-place. Much of the research has focused on the ability of mHealth to support persons living with chronic kidney disease (Campbell et al., 2016; Havas, Bonner, & Douglas, 2016; Ong et al., 2016), heart failure, (Cajita, Hodgson, Budhathoki, & Han, 2017; B. Y. Kim & Lee, 2017), diabetes (Arnhold et al., 2014; Greenwood, Blozis, Young, Nesbitt, & Quinn, 2015), and chronic obstructive pulmonary disease (Ding, Karunanithi, Kanagasingam, Vignarajan, & Moodley, 2014; Vorrink, Kort, Troosters, Zanen, & Lammers, 2016). Overall, evidence from these studies has been positive although not conclusive. These studies highlight the potential of mHealth to have a positive impact on healthy aging as well as the wide range of mHealth systems.

For example, in a small (27 individuals) and brief (13-week) pilot study of an mHealth app there was suggestive evidence that these technologies could help some older persons improve their diabetic control (Dugas et al., 2018). In another small pilot study an mHealth system, integrated into usual care for those with advanced kidney disease helped with blood pressure and medication management while improving patient confidence (Ong et al., 2016). Specifically, an app installed on smartphones reminded participants to take medications, monitor blood pressure, track their symptoms, and record laboratory tests. Based on the data entered, an algorithm in the app either gave feedback to the patients and/or an alert to physicians. Adherence was high - more than 80 percent of participants made use of the app despite the fact that more than half had no experience with smartphones. As a result of the mHealth system, participants reported feeling more empowered to participate in their own health management, and physicians perceived patients to be better educated about their disease. Clinical outcomes included a reduction in blood pressure and the identification of 75 medication contraindications.

In a study involving patients with chronic obstructive pulmonary disease, patients were given a smartphone and asked to record symptoms on an app. Input was monitored by remotely by healthcare professionals who intervened when necessary. During the six-month study patients had fewer primary care and emergency department visits, and fewer hospital admissions (Ding et al., 2014). The previous study was relatively simple compared to a randomized clinical trial that asked patients with Type 2 diabetes to not only
record symptoms but also blood sugar levels on a glucometer connected to a tablet computer via USB (Greenwood et al., 2015). Participants were required to attend a one-hour session demonstrating proper use of the system and monitored by a healthcare professional throughout the study. At the end of the six-month trial, participants in the test group showed improvement in three self-care behaviours.

Though promising, these studies do not prove a causal link between aging-in-place and better health. It is also possible that being in better health enables you to stay at home longer, explaining the associations seen. As noted in Section 6, policy makers and caregivers are largely overlooked in the literature on the development and adoption of mHealth. The inclusion of policy makers is confined to how they can address privacy concerns, while caregivers are referenced in terms of how they can facilitate adoption.

Older adults are the focus of literature discussing the challenges and facilitators of development and adoption. Common themes in these articles are: predefined goals (B. Y. Kim & Lee, 2017), automated feedback and alerts (Arnhold et al., 2014; Cajita, Hodgson, Lam, Yoo, & Han, 2018), support from family members or peers (Kampmeijer, Pavlova, Tambor, Golinowska, & Groot, 2016), usability (Arnhold et al., 2014), cost (K. I. Kim et al., 2017), previous experience with similar technology (Cajita et al., 2018), and adequate training (Cajita et al., 2018; B. Y. Kim & Lee, 2017).

While mHealth for healthy aging is an established field of study, the addition of big data and machine learning are new. However, these methods for processing and analyzing data are already being explored across a wide range of topics in mHealth for healthy aging and aging-in-place. For example, one study used a machine learning algorithm to analyze the data from a smart watch as well as patient daily self-reported feelings to improve diagnosis of depression (H. Kim et al., 2019). Two studies were found that used machine learning algorithms to analyze data collected by smart wearables to detect activities of daily living (Boateng, Batsis, Halter, & Kotz, 2017; Wu, Feng, & Sun, 2018). One growing area of research involving machine learning with mHealth for healthy aging is fall detection. Several studies were found that used machine learning algorithms to examine data from wearable activity tracker or mobile devices to detect falls with varying degrees of accuracy ((K. I. Kim et al., 2017)Tsinganos & Skodras, 2017, 2018).

While these studies demonstrate the potential of the technologies, there are some critical limitations. As noted in Sections 7 and 8, most studies examining the ability of mHealth solutions to monitor activity or health and detect critical events used healthy, college-age participants to train and test the devices and algorithms (B. Y. Kim & Lee, 2017). As an example, only one study was found that used older persons to test the ability of a smart wearable to detect falls (Marschollek et al., 2011). Finally, many of studies found were pilot and/or feasibility studies (Mohr et al., 2017) resulting in a low number of participants and limited potential for replication (Cajita et al., 2018).
10. Relationship of Position Paper to other AGE-WELL Activities

This section addresses the relationship of the Data for Healthy Aging Position Paper to other AGE-WELL papers, reports and documents, as well as the implications for AGE-WELL related activities including policy, professional education, research and practice. Here we will demonstrate that our position paper falls within the framework of AGE-WELL’s crosscutting activities and complements previous work completed under this framework. We will define the principles that underlie the relevant crosscutting activities, provide examples of these principles in action at AGE-WELL, and describe how our position paper fits within that framework.

**AGE-WELL’s Crosscutting Activities**

AGE-WELL has identified four crosscutting activities around which they have developed supports and best practices for network researchers and partners: knowledge mobilization, commercialization and technology transfer, transdisciplinary working, and training and mentorship (AGE-WELL NCE, 2019a). The goals of these crosscutting activities are threefold: (1) to drive innovation and the commercialization of products, systems and services, (2) to influence policy and practice to enhance the health and quality of life of older persons, and (3) to create new business opportunities for Canadian industry and social enterprises (AGE-WELL NCE, 2015a). As described in the following paragraphs, our position paper intersects with three of the four cross-cutting activities: knowledge mobilization, commercialization and technology transfer, and transdisciplinary working.

**Knowledge Mobilization**

**Defining Knowledge Mobilization**

AGE-WELL defines knowledge mobilization as a means of “connecting people with people and people with evidence” and “getting the right information to the right people in the right format at the right time” (AGE-WELL NCE, 2017a). The stated goal of AGE-WELL’s knowledge mobilization activities is to influence decision-making among key stakeholders, including older persons, caregivers, as well as government, industry and community partners (AGE-WELL NCE, 2017a).

**Knowledge Mobilization in Action**

The AGE-WELL position paper *The Application of Big Data and ICT-Based Systems to Support Older Adults: A consensus report* provides a record of a consultative planning process that resulted in a set of recommendations for the development of a database of smart home and sensor data accessible to Canadian researchers (AGE-WELL NCE, 2015b). The planned database would complement other large datasets, such as the Canadian Longitudinal Study on Aging (CLSA) and would allow for the generation of new insights into the daily lives of older persons, opening up new opportunities for innovation and technological development (AGE-WELL NCE, 2015b). The paper describes the infrastructure and partnerships that would need to be in place in order for such a database to be possible. In addition, the paper poses a series of questions (about data ownership,
clinical relevance and social/ethical considerations) that would need to be answered in order for data sharing partnerships to be effective (AGE-WELL NCE, 2015b). The report *Disrupting Alzheimer’s: The Opportunities for Technology in Alzheimer’s Disease* provides a framework for innovation that will lead to the development of effective technological solutions for the challenges of living with and caring for those with Alzheimer’s disease (AGE-WELL NCE, 2016a). The framework recommends design processes (for example, co-creating technologies with older persons and caregivers) and technology products (for example, integrated systems rather than stand alone products) that are likely to be successful (AGE-WELL NCE, 2016a). These two documents provide examples of “getting the right information to the right people in the right format at the right time” in order to influence stakeholder decision making. The consensus report provides instructions for researchers and data stewards on how to build partnerships and advocate for the development of an accessible database of sensor data. The *Disrupting Alzheimer’s* report provides guidance for technology developers who are interested in developing technologies for Alzheimer’s patients and their families. While this framework was developed to guide the development of technologies for Alzheimer’s disease specifically, it can be more broadly applied to the development of technologies for older persons.

**Our Contribution to Knowledge Mobilization**

Like the consensus report and the *Disrupting Alzheimer’s* report, our position paper is a knowledge mobilization endeavour. The goal of our position paper is to provide information and guidance to a variety of stakeholders (older persons, family care givers, professional care providers, technology developers and policy makers) on how they can best leverage their experiences, connections and capacities to foster the integration of machine learning and Big Data approaches for healthy aging. In addition, Recommendation 4 (see Section 8) addresses how AGE-WELL can leverage its role as a trusted source of information in order to guide older persons, caregivers and physicians in the purchase of effective, clinically valid technologies for healthy aging.

**Commercialization and Technology Transfer**

**Defining Commercialization and Technology Transfer**

Commercialization is the means by which a new product or service becomes available to consumers (AGE-WELL NCE, 2017b). For AGE-WELL, the goal of commercialization is to provide older persons and caregivers with access to “cutting-edge social and technological solutions” that will improve their lives, health and wellbeing (AGE-WELL NCE, 2017b).

**Commercialization and Technology Transfer in Action**

Two start-up success stories, made possible through AGE-WELL funding and support, provide models for effective commercialization and technology transfer.

Braze Mobility Inc. is an AGE-WELL start-up that received initial funding through the 2016 Strategic Investment Program (AGE-WELL NCE, 2016b). In 2017, Braze Mobility launched their smart wheelchair, a
sensor-based collision avoidance system that detects obstacles and provides audio, visual or vibration feedback to the user, at the AGE-WELL Annual Conference (AGE-WELL NCE, 2017c). Building on their AGE-WELL funding, the development of Braze Mobility’s smart wheelchair system was supported by grants from the Ontario Brain Institute’s ONtrepreneurs Program, the National Research Council of Canada’s Industrial Research Assistance Program, the Ontario Bioscience Innovation Organization’s Capital Access Advisory Program, the Ontario Centres of Excellence and the Impact Centre Semaphore Research Cluster at the University of Toronto (AGE-WELL NCE, 2018a). In addition to these grants, Braze Mobility also won cash awards at the Power Play Pitch Competition at Toronto Rehab and was named a TiE50 award winner at TiEcon (a prestigious international start-up competition) (AGE-WELL NCE, 2019b). By the fall of 2018, their smart wheelchair system was available for purchase through their website at www.brazemobility.com, providing a new commercial option for mobility and independence for people with visual-perceptual difficulties and older persons with dementia (AGE-WELL NCE, 2017d).

Winterlight Labs Inc. is a speech analyzer that can detect cognitive impairment early by examining linguistic clues in the way a person describes an image such as pitch, tone and choice of words (AGE-WELL NCE, 2018a). In 2016, Winterlight Labs Inc. won the AGE-WELL Pitch Competition: Technology to Support People with Dementia, which earned them one year free membership in the AGE-WELL network (with access to more than 200 companies and research experts in the field of technology and aging) and mentorship from the Global Council on Alzheimer’s Disease (GCAD) (AGE-WELL NCE, 2016c). In 2017, Winter Light Labs were named one of the Top 10 Artificial Intelligence Start-ups in Toronto (AGE-WELL NCE, 2017e). In 2018, Winterlight Labs established a partnership with Johnston & Johnston Innovation to develop a digital biomarker of Alzheimer’s disease (AGE-WELL NCE, 2019c). Currently, Winterlight Labs are working with Revera (“provider of retirement living homes, retirement communities and dedicated long-term care services for seniors”) to assess the use of their tool in senior care settings (AGE-WELL NCE, 2018a; Revera, 2019).

Our Contribution to Commercialization and Technology Transfer

Braze Mobility and Winterlight Labs leveraged AGE-WELL connections and resources to build collaborations with research, government, community and industry partners to develop commercializable products. Our position paper provides recommendations for how stakeholders from these groups (research, government, community and industry) can leverage their experiences and work together to develop products that are readily adopted and impactful in the lives of older persons and caregivers. In this way our recommendations follow the model of success demonstrated by Braze Mobility and Winterlight Labs. Further, Recommendation 3 (see Section 8) suggests how AGE-WELL could support evaluations of devices and apps that assess and demonstrate their economic value.
**Transdisciplinary Working**

**Defining Transdisciplinary Working**

Transdisciplinary work pairs academics from diverse disciplines with experiential stakeholders, such as older persons, caregivers, industry and community partners and policy makers, to solve complex social problems and develop innovations that have real-world impacts (AGE-WELL NCE, 2017f).

**Transdisciplinary Working in Action**

In 2018, AGE-WELL produced a position paper called “Unpacking Transdisciplinarity in Aging and Technology: A Scoping Review” that reviewed the benefits, barriers and challenges of transdisciplinary work (AGE-WELL NCE, 2018b). The review found that transdisciplinary work can enhance a researcher’s scientific productivity and capacity, raise public awareness of relevant research, and increase the impact of research on policy. However, this approach can be challenging to implement (AGE-WELL NCE, 2018b). Transdisciplinary work requires “deliberate, sustained efforts from all participants and institutions” and a “collective level of ‘openness’” to uncertainty and the ideas of others. In addition, transdisciplinary work is considered a “labour intensive” approach that is associated with “elongated timespans” (AGE-WELL NCE, 2018b). A second AGE-WELL position paper, “Smart Wheelchairs in Assessment and Training (SWAT): State of the Field” also highlighted the importance of transdisciplinary working (AGE-WELL NCE, 2018c). In this paper, a workshop consensus found that collaboration between physicians, researchers, and entrepreneurs was valuable to the “transfer and uptake of knowledge and technology from the lab to the clinic”, as well as moving innovations from concept to commercial availability (AGE-WELL NCE, 2018c). The proceedings of the workshop also found that the absence of certain perspectives, and conflict between the needs and objectives of different stakeholder groups can pose challenges to effective transdisciplinary working (AGE-WELL NCE, 2018c).

AGE-WELL Workpackage 8 addresses “Ethical, Cultural and Social Aspects of Technology” and has investigated “how assistive technologies are accessed by Canadians” as well as “the influence of ethical, security and privacy factors in technology adoption” (AGE-WELL NCE 2020). The publications produced by the WP8 teams provide useful context for engaging older adults and other stakeholder groups in transdisciplinary working related to the development, adoption and integration of novel assistive technologies. Publications from WP8 teams provide rich context for engaging older adults with cognitive disabilities in discussions of mobile technologies and data-informed approaches to healthy aging. Publications from WP8 have addressed factors influencing technology adoption (Rocheleau et al., 2020), specific risks experienced by individuals with cognitive disabilities related to these technologies (Chalghoumi et al., 2017), the value and feasibility of engaging those with cognitive disabilities in the design and development process (Chalghoumi et al., 2019) and providing an ethical framework that supports the inclusion of older adults in health care innovation (Wayne, 2018). This position paper focuses on the broader population of older adults, including
those with cognitive disabilities. Readers are encouraged to review WP8 publications for a more in-depth exploration of the role of older adults with cognitive disabilities in the development, adoption and integration of mobile health, assistive technologies and data-informed approaches to care.

Our contribution to transdisciplinary working

The Data for Healthy Aging Working Group was founded as a transdisciplinary advisory panel representing the perspectives of academics, policymakers, industry partners, older persons, professional care providers and family caregivers. The stakeholder representation at the core of our position paper allows us to more effectively target our recommendations for how transdisciplinary working can be used to develop adoptable technologies in the area of big data, machine learning and AI. Recommendations 1 and 2 (see Section 8) directly address the ways in which AGE-WELL can support transdisciplinary working in the development of data-informed technologies for healthy aging: by facilitating partnerships between technology developers and stakeholder groups, and by supporting technologies that incorporate end-user perspectives into their development.

Summary

The Data for Healthy Aging position paper fits within the AGE-WELL’s Crosscutting Activities framework, directly addressing three of four constructs of the framework (transdisciplinary working, commercialization and technology transfer, and knowledge mobilization). As such, the recommendations in this paper complement the findings of previously published AGE-WELL reports, documents and position papers, which were also published under this framework. For a list of references from this section, please see Appendix F.
11. References


Livingston, G. (2019). Americans 60 and older are spending more time in front of their screens than a decade ago.


Appendix A. summary of the position paper development process. Chronology of steps to develop and review the position paper.

March 2019
- Position paper proposal is submitted to and approved by the AGE-WELL Scientific Directors and Workpackage 7 Leads.

August-November 2019
- First draft of the position paper is written and approved by the Data for Healthy Aging Working Group.

April-June 2019
- Stakeholder groups are identified and representatives are invited to join the Data for Healthy Aging Working Group.

December 2019
- First draft of the position paper is submitted to the AGE-WELL Scientific Directors and Workpackage 7 leads for feedback.

July 15, 2019
- First meeting of the Data for Healthy Aging Working Group to generate and approve position paper content.

January 2019
- An updated draft is submitted to the AGE-WELL Community forum for feedback.

February 2020
- Second meeting of the Data for Healthy Aging (D4HA) Working Group to review and respond to AGE-WELL community feedback.

February 2020
- Second draft of the position paper is submitted to the AGE-WELL Research Management Committee.

March 31, 2020
- Final draft of the position paper is submitted to the AGE-WELL Workpackage 7 Leads.
Appendix B. Detail of the position paper development and review process, including expertise contributing to the position paper.

January 2019
Project onboarding with HQP Georgina Freeman (Research Associate, W21C, University of Calgary) and Project Lead Dr. Joon Lee (Associate Professor, Health Science Data, University of Calgary). The purpose of the position paper and project timeline is discussed. The AGE-WELL position paper process is reviewed. The need for a stakeholder-driven working group to guide the development of an AGE-WELL position paper is identified. An initial draft of the project proposal and a detailed project timeline based on the AGE-WELL position paper process are composed.

February 2019
HQP Georgina Freeman is added to the AGE-WELL member’s forum. Working group stakeholder groups are identified. A stakeholder recruitment strategy and Terms of Reference for the Data for Healthy Aging Working Group are developed. Initial contact is made with Imagine Citizens, an independent group that facilitates citizen participation in health-care system improvement initiatives. Imagine Citizens agrees to facilitate the recruitment of older adults and family caregivers for the Data for Healthy Aging Working Group once the project is approved by AGE-WELL. The position paper proposal document is finalized.

March 2019
The position paper proposal is submitted to the AGE-WELL Scientific Directors (Andrew Sixsmith and Alex Mihhailidis) and Workpackage 7 Leads (Don Juzwishin and Paul Stolee) on March 5, 2019. Approval for the position paper is given on March 22, 2019. See Appendix C for the position paper proposal.

April 2019
Initial invitations are sent to stakeholder group representatives as identified through Imagine Citizens and W21C networks. HQP Ruth Ann Rebotoc (Research Associate, W21C, University of Calgary) is added to the research team. Dr. Maeve O’Beirne and Dr. David B. Hogan join the Data for Healthy Aging Working Group as physician stakeholder representatives.

May 2019
Scott Fielding joins the Data for Healthy Aging Working Group, as the policy stakeholder representative. Through Imagine Citizens, Linda Tyre and Roger Marple are recruited as older adult representatives, and Lisa Poole and Marj Preugsachs are recruited as family caregiver representatives. Planning is initiated for the Working Group’s first meeting in July 2019.

June 2019
Technology representatives Sarah Akierman and Jim McDade join the Data for Healthy Aging Working Group. Dates for the first Working Group meeting are selected. The meeting agenda is developed. The meeting is a workshop format designed to gather Working Group member perspectives.

**July 2019**

The first Data for Healthy Aging Working Group meeting was held on July 15, 2019. At the meeting, the members approved the working group terms of reference, and participated in a workshop designed to capture their perspectives on data-informed approaches to healthy aging and aging-in-place. See Appendix D for the Working group meeting agenda, photos and working group terms of reference.

**August - October 2019**

A targeted literature scan was performed in response to issues and inquiries raised by D4HA Working Group members, and to provide an update to the references provided in the White Paper (Mobile & Sensor Technology, Big Data and Artificial Intelligence for Healthy Aging) on which this position paper is based. In addition, an environmental scan was performed of all AGE-WELL publications and activities that may be relevant to or impacted by the position paper.

Results from the Data for Healthy Aging Working Group workshop, literature scan and environmental scan are synthesized. The position paper is draft is based on the synthesis of all the three data sources.

**November - December 2019**

An initial draft of the position paper was reviewed by the D4HA Working Group. This draft was revised according to their feedback. With approval from the Working Group, a revised draft of the position paper was submitted to the AGE-WELL Scientific Directors and Workpackage 7 Leads for review.

**January – February 2020**

A revised draft based on the feedback from the AGE-WELL Scientific Directors and Workpackage 7 Leads was circulated to the working group and approved. The twice revised draft of the position paper was submitted to the AGE-WELL Community Forum for feedback. The AGE-WELL Community feedback was collated and shared with the Data for Healthy Aging Working Group. The Data for Healthy Aging Working Group met to discuss and respond to the AGE-WELL Community feedback. At this meeting, the D4HA working group additionally discussed a knowledge mobilization plan for the final, published position paper based on the best way to engage each of their respective stakeholder groups. An updated draft of the position paper was submitted to the AGE-WELL Research Management Committee for approval.

**March - July 2020**

The draft was held under review with the AGE-WELL Research Management Committee. The Covid-19 pandemic delayed review of the draft manuscript. The Data for Healthy Aging Working Group addresses AGE-WELL Research Management Committee feedback and resubmits to AGE-WELL Workpackage 7 Leads.
Appendix C. Position Paper Proposal

AGE-WELL Position Paper on

Mobile & Sensor Technology, Big Data and Artificial Intelligence for Healthy Aging

Mobile and sensor technologies, big data and artificial intelligence have an enormous potential for use in healthy aging. Mobile and sensor technologies collect large volumes of health data ("big data") that can be interpreted by Machine Learning (ML) and Artificial Intelligence (AI). When properly interpreted, big data can help us understand human health and behavior. This allows us to better guide our approaches to public health and medical care. In healthy aging, the accurate interpretation of sensor data could allow us to better care for seniors in their homes. Improved home and community care provides options for seniors who may wish to manage their health outside of a formal care setting. This allows them to maintain their independence, while continuing to receive support from their family members and care providers. In addition, increased use of home or community care resources could reduce the overall strain on the healthcare system brought about by Canada’s increasing senior population.

A coordinated approach is necessary to leverage the use of sensors, big data, AI and ML for healthy aging. Older adults, their families, care providers, policy makers and technology developers are important stakeholders in the development, use and adoption of these technologies in Canada. We propose the creation of a stakeholder-driven working group to develop an AGE-WELL position paper. The working group, led by Dr. Joon Lee, will be comprised of 6-8 stakeholders representing the fields of technology development, health policy, and healthy aging (care providers, older adults, family caregivers). The position paper will provide guidance on the potential uses of sensors, ML and AI for healthy aging. The working group will identify barriers to the use, development and adoption of these technologies in Canada and will provide recommendations for how these barriers may be overcome. The position paper will be developed based on an existing white paper by Dr. Joon Lee and Ben Kim titled Mobile & Sensor Technology, Big Data and Artificial Intelligence for Healthy Aging. The working group will meet in-person for two draft-development workshops. All versions of the paper will be reviewed and approved by members of the working group via email. Staff at W21C, an AGE-WELL core facility, will assist Dr. Lee in identifying potential stakeholders, assembling the working group, facilitating the draft-development workshops, and writing the position paper.
Appendix D. Data for Healthy Aging Working Group meeting agenda, workshop photos, and terms of reference.

AGE-WELL Position Paper Working Group Meeting Agenda

Mobile & Sensor Technology, Big Data, and Artificial Intelligence for Healthy Aging

Monday, July 15, 2019

9:45am – 2:15pm

3280 Hospital Drive NW, Calgary, AB T2N 4Z6

TRW Building, Ground Floor, W21C Multipurpose Room

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<thead>
<tr>
<th>Time</th>
<th>Session Title</th>
<th>Lead(s)</th>
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<tbody>
<tr>
<td>9:45 am – 10:00 am</td>
<td>Arrival &amp; Light Refreshments</td>
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<tr>
<td>10:00 am – 10:15 am</td>
<td>Welcome &amp; Introductions</td>
<td>Joon Lee</td>
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<tr>
<td></td>
<td>• Working Group member introductions</td>
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<td></td>
<td>• Review and approve meeting agenda</td>
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<tr>
<td>10:15 am – 10:45 am</td>
<td>Project Purpose &amp; Overview</td>
<td>Gina Freeman</td>
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<tr>
<td></td>
<td>• Introduction to AGE-WELL</td>
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<td></td>
<td>• Purpose of the Position Paper</td>
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<td>• Role of the Working Group</td>
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<td>• Timeline of the Project</td>
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<td></td>
<td>• Review and approve Terms of Reference</td>
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<tr>
<td>10:45 am – 11:30 am</td>
<td>Position Paper Topic Review</td>
<td>Joon Lee</td>
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<td></td>
<td>• Review White Paper concepts</td>
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<td></td>
<td>• General discussion</td>
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<td></td>
<td>• Q&amp;A</td>
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<tr>
<td>11:30 am – 12:15 pm</td>
<td>Lunch</td>
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<tr>
<td>12:15 pm – 2:00 pm</td>
<td>Discussion: Position Paper Outline &amp; Draft</td>
<td>Gina Freeman</td>
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<td>• Introduce Position Paper outline and draft</td>
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<td></td>
<td>• Solicit feedback and suggestions for each section</td>
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<tr>
<td>2:00 pm – 2:15 pm</td>
<td>Wrap up &amp; Next Steps</td>
<td>Joon Lee</td>
</tr>
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</table>
Mobile & Sensor Technology, Big Data and Artificial Intelligence for Healthy Aging

AGE-WELL Position Paper Working Group Terms of Reference

**Mandate**

The Working Group will act as a strategic advisory body providing leadership and guidance for the development of an AGE-WELL Position Paper on the use of mobile and sensor technologies, big data and artificial intelligence for healthy aging.

**Working Group Composition**

Chair: Joon Lee

Joint Secretaries: Georgina Freeman, Ruth Ann Rebutoc

**Active Members:**

- **Technology Development**
  - Jim McDade (Aware360)
  - Sarah Akierman (Vivametrica)

- **Health Policy**
  - Scott Fielding (Seniors Health SCN)

- **Care Provider**
  - David B. Hogan (Geriatrics)
  - Maeve O’Beirne (Primary Care)

- **Older Adults**
  - Linda Tyre
  - Roger Marple

- **Family Caregivers**
  - Lisa Poole
  - Marj Preugschas

**Term of Commitment**

The term of commitment is approximately nine months. In the event that a member is no longer able to continue their involvement, the remaining Working Group members will make suggestions and vote on a replacement. Additional members may be added to the Working Group upon member consensus.

**Financial Reimbursement**

Involvement in the Working Group will be voluntary. Members of the Working Group will not be paid for their time. Travel costs and fees incurred for parking or public transit will be reimbursed.

**Workshops**

The Working Group will convene for two in-person draft development workshops, scheduled for the Summer and Winter of 2019. The Chair and Secretary will develop the workshop agendas. Agendas will be circulated to all members via email prior to each workshop. Workshop proceedings will be audio recorded and field notes will be taken for use in position paper draft development.

**Position Paper Drafts**

The Working Group will serve primarily as an advisory body of experts, and as such, will not be called on to write or make updates to position paper drafts. The Chair and Secretary are responsible for writing and updating the position paper drafts and circulating them via email with the Working Group. The Working Group is
responsible for reviewing and approving position paper drafts in a timely fashion prior to its submission to
AGE-WELL.

Conflicts of Interest
If a real or perceived conflict of interest arises for any Working Group member, that member shall voluntarily
disclose the conflict to the Working Group prior to any detailed discussion or decision-making related to the
issue at hand. The Working Group shall discuss the nature and magnitude of the conflict in order to determine
whether to proceed with discussions involving the person in conflict, whether to ask the person in conflict to
abstain from decision-making protocols specific to the conflict, or whether to ask the participant to remove
themselves from further discussions on the matter. The individual at conflict shall abide by the decisions of the
Working Group.

Responsibilities
The Working Group will be responsible for the following:

- Review the Mobile & Sensor Technology, Big Data and Artificial Intelligence for Healthy Aging white
  paper.
- Attend two (2) in-person position paper draft development workshops.
- Provide guidance, direction, and recommendations regarding the structure and content of the AGE-WELL
- Review and approve each draft of the position paper in a timely fashion. Drafts will be developed by the
  Chair and Secretary and circulated via email.
- Facilitate key relationships between the Working Group and relevant external organizations.
- Alert the Working Group to potential opportunities or challenges that concern the successful development
  of the position paper.
- Review and make decisions regarding the composition of the Working Group in the event that a member
  can no longer fulfill their role for the duration of the project or that additional representation is required.
Appendix E. References for Section 10: Relationship of Position Paper to Age-WELL’s Crosscutting Activities.


