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Creating Age-friendly Communities

Housing and Technology

Edited by

Joost van Hoof, Hannah R. Marston,
Katie Brittain and Helen Barrie

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Cover image courtesy of Marion Duimel

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About the Editors

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Joost van Hoof works as a full professor of Urban Ageing with the Faculty of Social Work & Education of The Hague University of Applied Sciences in The Netherlands. Since December 2017, he has also been affiliated with the Department of Spatial Economy, Faculty of Environmental Engineering and Geodesy, Wrocław University of Environmental and Life Sciences in Poland. His research interests lie in the domain of age-friendly cities, housing for older people and gerontechnology. He has a background (MSc) in Building Physics and Services at Eindhoven University of Technology, and obtained his doctoral degree (PhD) from the same university in 2010. In addition, he obtained the Eur Ing qualification from the European Federation of National Engineering Associations in 2007. In 2019, he gained his higher doctoral degree (DSc) in the field of engineering and technical sciences from Warsaw University of Life Sciences.

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Dr Hannah R. Marston is a Research Fellow in the Health and Wellbeing Strategic Research Area at The Open University, UK, and her research takes an inter- and multi-disciplinary approach, intersecting across the fields of gerontechnology, social sciences, and technology. She gained her PhD from Teesside University, UK in 2010, focusing on videogames and older adults. Her previous research projects include Technology In Later Life (TILL) (2015–17); and her current ones include COVID-19: Technology, Social Connections, Loneliness, and Leisure Activities international study; COVID-19: Dating Apps, Social Connections, Loneliness, and Mental Health in a Pandemic study; and Adapt Tech, Accessible Technology study. She has published over 40 journal papers, 9 book chapters, and has presented her work to policy makers and to national and international audiences. Hannah was a panel member for "Game and Interaction design for Older Adults: That Means You (Someday)", PAXOnline.

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Katie R. Brittain is Professor of Applied Health Research and Ageing in the Population Health Sciences Institute at Newcastle University, UK. Katie is a social gerontologist with an educational background in sociology. This has enabled her to pursue her research interests in the social impact that illness can have on the lives of older people. During her time as an applied health researcher, Katie has researched and published widely around the impact of ill health on older people and their carers. More recently, her work has focused around how aspects of the physical, social and technological environments pose challenges and opportunities for older people and their wider community.

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Preface to ”Creating Age-friendly Communities: Housing and Technology”

The “Creating Age-friendly Communities: Housing and Technology” publication presents contemporary, innovative, and insightful narratives, debates, and frameworks based on an international collection of papers from scholars spanning the fields of gerontology, social sciences, architecture, computer science, and gerontechnology. This extensive collection of papers aims to move the narrative and debates forward in this interdisciplinary field of age-friendly cities and communities.

About the cover: Maurice (b. 1951) lives in Rijswijk, a neighbouring municipality of The Hague. The picture shows him in a vacant office building which he is retrofitting into his own age-friendly home.

Joost van Hoof, Hannah R. Marston, Katie Brittain, and Helen Barrie
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Editorial

Creating Age-Friendly Communities: Housing and Technology

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Taking an international perspective of healthy ageing, people are living longer and are generally in better health than previous generations. Yet, given the rapidly increasing number of older adults, this demographic shift puts an increased level of stress on worldwide healthcare systems. The vast majority of older adults wish to age-in-place, to continue to live in their choice of residence for as long as they can. Yet, there is a small but significant percentage of older people who make use of long-term care services, including homecare, rehabilitation services, and social support. According to the Organisation for Economic Co-operation and Development (OECD) [1], cities in particular have large numbers of older citizens and are home to 43.2% of the older population. In order to stimulate and support urban ageing [2–6], cities can be improved to facilitate a more age-friendly environment. One way to support older people to live the life they wish to live is through the age-friendly cities initiative of the World Health Organization, a world-wide programme to improve cities to meet the needs of older citizens [7–9]. An age-friendly city offers a supportive environment that enables residents to grow older actively within their families, neighbourhoods, and civil society, and offers extensive opportunities for their participation in the community [10]. In addition, an age-friendly city optimises opportunities for health, participation, and security in order to enhance quality of life as people age [7].

According to the OECD [1], ageing societies pose diverse challenges, such as redesigning infrastructure and urban development patterns, social isolation, lack of accessibility and affordable housing. When referring to age-friendly cities, there are a lack of studies looking at the outcomes of age-friendly city approaches [3]. There are several questions that need to be addressed when building age-friendly places, inclusive environments and/or technologies. With advances in technology, engineering and design these domains offer a wide range of solutions to support daily function, activities and participation; facilitate the provision of healthcare, and offer means for leisure to older people. Too often, end-users of architectural and technological solutions are not consulted in the design processes and the implementation of the solutions in practice. Their inclusion in these processes is paramount to the success of the proposed and implemented solutions. Therefore, the purpose of this Special Issue is to present an overview of studies addressing recent advances in age-friendly cities in relation to housing (including urban planning) and technology, both in the broadest sense of the word. Apart from a focus on active and healthy ageing in cities, similar challenges can be found in rural areas too.

Creating age-friendly communities and environments are key in the 21st century, which cannot be ignored and must be continuously reviewed and refined to ensure respective environments—be-it housing of all environmental types encountered in one's housing career (for instance, own home, nursing home, assisted living [11]), neighbourhoods and other public spaces; or the technologies that enable and assist with living independently—are up-to-date and meet the needs of the respective residents, carers and visitors. At the turn of the 21st century, citizens, residents, businesses, organisations, educationalists, health practitioners and policy makers were actors in society; be-it as spectators, observers, developers, entrepreneurs, care staff or other, engaged in the design, development, implementation and refining of information communication technologies and peripheral devices and software. The first two decades of the new millennium have been phenomenal from the standpoint of technology integration within the day-to-day lives of citizens.

The WHO framework of age-friendly cities and communities [7] outlines very clearly the eight domains that make-up this framework and to date there has been a growth in research and collaboration between academe, policy makers, stakeholders and citizens on an international scale. The model itself can be extended to include the implementation of technology in the daily lives of older people [12,13]. Gerontechnology aims at good health, full social participation and independent living up to an advanced age, and to understand through research, development, design of products and services the means of increasing quality of life [14]. Both older people and carers may be amongst the end-users of such technological solutions [15]. Many contributions to this special issue deal with technology for older people.

This special issue of *Healthcare* on "Creating Age-Friendly Communities: Housing and Technology" is timely, comprising twelve papers [16–27] that traverse and intersect across the fields of gerontology, health and social care, social sciences and gerontechnology.

Statistics show age-related, long-term conditions such as dementia are a primary focus and concern for Western developed countries. There are currently over 47 million people worldwide living with dementia and this number is projected to increase to 75 million by 2030, and 135 million by 2050 [28]. Thus, the accepted papers surrounding dementia have focused on the perspectives of healthcare professionals in conjunction with meaningful activities for individuals diagnosed with dementia residing in a nursing home environment [16,25], and installing and using aids and adaptations within the home to create a physical environment that is more dementia-friendly [19]. Furthermore, exploring and understanding technology use associated with care of individuals living with dementia in the community from the perspective of stakeholders [23] is equally important as a systematic review to ascertain the current landscape and offer readers the ability to see what areas need greater improvement and expansion.

Five papers [16,17,19,20,23] take the standpoint of technology use and deployment within various social contexts as a means of contributing to the national and international discussions and debates surrounding the age-friendly landscape. Across these accepted papers, we have demonstrated the growth in multi-and-cross disciplinary research, which intersects at various disciplines across academia but also at policy levels associated with national [29] and devolved governments [30,31]. Huisman and Kort [17] present the research study "Two-Year Use of Care Robot Zora in Dutch Nursing Homes: An Evaluation Study" focusing on the deployment of Zora the robot into fourteen residential care environments, and reported on the barriers experienced by healthcare professionals, which included software failures and the start-up time, whilst the enablers of using such technology were seen positively by service users, adding additional value to the work given by the healthcare professionals. Marston and Samuels [18] take a position standpoint, focusing on the use of virtual assistants within the home and the benefits such virtual assistants can have on dependent children and carers in later life. The respective authors extend their position by opening up the discussion surrounding the age-friendly environment, and the need for greater intergenerational focus, by proposing a series of recommendations and future work to expand the fields of gerontology, social science and gerontechnology. Chadborn and colleagues [20] discuss the positive and negative perceptions and attitudes towards digital health technologies. Conducting a citizen jury approach, Chadborn and colleagues were able to execute a deliberative inquiry into such benefits as well as risks surrounding smart health technologies and systems. Findings from this empirical research ascertained respective participants felt their views were largely ignored by organisations who were responsible to implementing such systems. Wang and colleagues [21] explored the perspectives of ambient-assisted living and artificial intelligence technologies by older adults taking a user-centered design approach as a preliminary stage to participating in a co-design process. A survey was deployed to collect privacy perspectives, followed by two 90-minute focus groups with 31 community residents. Findings highlighted low digital literacy, which included unfamiliar terminology coupled with physical challenges, making technology adoption difficult. However, positive facilitators showed participants eagerness to learn, be part of co-production, and to understand their data. Furthermore, participants showed an interest in having their voice heard relating to the design of specific technologies to successfully age-in-place. Marston and colleagues [24] reported the overall findings from the Technology In Later Life (TILL) study, which was conducted across four sites located in two countries (United Kingdom and Canada). The sites were either rural or urban, and the study aimed to understand the role in which technology impacts the lives of adults aged 65+ years. Recommendations were proposed as a way of improving the lives and social connectedness of older citizens, while for many participants living in rural locations, the use of technology such as Skype was greater for maintaining a connection with children and grandchildren living across the country or on a different continent. Lee and colleagues [22] explore in their body of work "Living Alone Among Older Adults in Canada and the U.S.", Canadian and American data sets to understand the living arrangements of older adults and how one's living arrangement can affect wellbeing, whilst informing respective housing needs. In a second part of the data analysis, they explore the various factors of immigrants who live alone. Based on these findings, Lee and colleagues propose a greater need for innovative design and technology relating to age-friendly housing, in particular for older adults who live alone, and state that attention is needed when designing age-friendly housing for immigrants who may have different needs, requirements and cultural preferences. Barrie and colleagues [26] explore and discuss external environments, relating to the impact of good design and accessibility to mobility, independence, quality of life, and the ability of older adults to age-in-place. This paper deployed a citizen science approach to data collection, using an audit tool on smartphones to assess neighbourhood public green spaces. Citizen science data included photographs, geo-coded location, survey data, and qualitative-based comments. This submission uses an existing and popular methodological approach found in natural sciences, but less prevalent in the social sciences to understand, from the older residents' perspective, what makes a good public green space for ageing well.

Finally, the last paper in this special issue is a scoping review by Marston and colleagues [27], exploring contemporary literature surrounding mobile electrocardiogram devices available on the market to consumers and offer healthcare professionals the opportunity to remote monitor patient's health concerns of arrhythmia and palpitations. The "Mobile Self-monitoring ECG Devices to Diagnose Arrhythmia (AR) that coincide with Palpitations: A Scoping Review" offers an insight into how specific technology can be deployed and used by specific professions and citizens. The respective authors propose future work and recommendations to extend this work and include the need for work to be conducted and evaluated in low, middle, income countries, and different geographic locations, and to understand the adoption and adherence of this type of technology from both the patient and provider perspective.

Age-friendly initiatives focusing on how communities can support older people to age-in-place have gathered momentum in academic and policy circles [32]. However, although there is a growing evidence base that demonstrates the positive impact that age-friendly environments can have on older people, many environments still remain a challenge for older people. Technologies aimed at supporting older people to age-in-place have been proposed as one solution to overcoming these environmental challenges. We know that older people are situated within a complex array of 'material/physical, social and psychological relations and affects' and that there is a need to go beyond just focusing on technological innovation as a solution [33]. The papers in this collection clearly highlight the complexities around what constitutes an age-friendly environment, from the perspective of older people, people with dementia, formal and informal carers, and health and social care professionals. Living arrangements and environments in the broadest sense are explored in this volume of work as to how they impact on ageing. Supporting nursing home residents in meaningful activities [25], the impact of living alone [22], the use of aids and adaptations to support well-being [19] and the importance of public green space [16,26] all contribute to a discussion as to how to create an age-friendly environment. Importantly, a number of included papers highlight the 'expert' role older people have in their daily experience of the environments in which they live [26] and research in this area needs to move away from technological innovations that are not rooted in this expertise. The implementation of citizen science methodologies follows that of co-design and co-research [34–36], a movement that may lead age-friendly cities to become age-inclusive cities. When creating age-friendly communities, including housing and technology, the voices of people of all age groups matter and should be heard. The scholarly work included in this special issue may help societies move forward in the quest to become truly age-friendly.

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References

1. OECD. *Ageing in Cities*; OECD Publishing: Paris, France, 2015; ISBN 9789264231146.
2. Van Hoof, J.; Kazak, J.K. Urban ageing. *Indoor Built Environ.* **2018**, *27*, 583–586. [CrossRef]
3. Van Hoof, J.; Kazak, J.K.; Perek-Białas, J.M.; Peek, S.T.M. The challenges of urban ageing: Making cities age-friendly in Europe. *Int. J. Environ. Res. Public Health* **2018**, *15*, 2473. [CrossRef] [PubMed]
4. Buffel, T.; Phillipson, C. Urban ageing: New agendas for geographical gerontology. In *Geographical Gerontology: Perspectives, Concepts, Approaches*; Skinner, M.W., Andrews, G.J., Cutchin, M.P., Eds.; Routledge: London, UK, 2018; pp. 123–135, ISBN 9781138241152.
5. Buffel, T.; Phillipson, C. A manifesto for the age-friendly movement: Developing a new urban agenda. *J. Aging Soc. Policy* **2018**, *30*, 173–192. [CrossRef] [PubMed]
6. Kazak, J.; van Hoof, J.; Świąder, M.; Szewrański, S. Real estate for the ageing society—The perspective of a new market. *Real Estate Manag. Valuat.* **2017**, *25*, 13–24. [CrossRef]
7. World Health Organization. *Global Age-Friendly Cities: A Guide*; World Health Organization: Geneva, Switzerland, 2007; ISBN 9789241547307.
8. Plouffe, L.; Kalache, A. Towards global age-friendly cities: Determining urban features that promote active aging. *J. Urban Health* **2010**, *87*, 733–739. [CrossRef] [PubMed]
9. Buffel, T.; Phillipson, C. Can global cities be 'age-friendly cities'? Urban development and ageing populations. *Cities* **2016**, *55*, 94–100. [CrossRef]
10. Caro, F.G.; Fitzgerald, K.G. (Eds.) *International Perspectives on Age-Friendly Cities*; Routledge: New York, NY, USA, 2016; ISBN 9780415720717.
11. Van Hoof, J.; Kort, H.S.M.; van Waarde, H. Housing and care for older adults with dementia. *A European perspective. J. Hous. Built. Environ.* **2009**, *24*, 369–390. [CrossRef]

12. Marston, H.R.; van Hoof, J. Who doesn't think about technology when designing urban environments for older people? A case study approach to a proposed extension of the WHO's age-friendly cities model. *Int. J. Environ. Res. Public Health* **2019**, *16*, 3525. [CrossRef]
13. Van Hoof, J.; Dikken, J.; Buttiġieġ, S.C.; van den Hoven, R.F.M.; Kroon, E.; Marston, H.R. Age-friendly cities in the Netherlands: An explorative study of facilitators and hindrances in the built environment and ageism in design. *Indoor Built. Environ.* **2019**. [CrossRef]
14. Van Bronswijk, J.E.M.H.; Bouma, H.; Fozard, J.L. Technology for quality of life: An enriched taxonomy. *Gerontechnology* **2002**, *2*, 169–172. [CrossRef]
15. Oude Weernink, C.E.; Felix, E.; Verkuijlen, P.J.E.M.; Dierick-van Daele, A.T.M.; Kazak, J.K.; van Hoof, J. Real-time location systems in nursing homes: State of the art and future applications. *J. Enabling Technol.* **2018**, *12*, 45–56. [CrossRef]
16. De Boer, B.; Beerens, H.C.; Katterbach, M.; Viduka, M.; Willemse, B.M.; Verbeek, H. The physical environment of nursing homes for people with dementia: Traditional nursing homes, small-scale living facilities, and green care farms. *Healthcare* **2018**, *6*, 137. [CrossRef] [PubMed]
17. Huisman, C.; Kort, H. Two-year use of care robot Zora in Dutch nursing homes: An evaluation study. *Healthcare* **2019**, *7*, 31. [CrossRef] [PubMed]
18. Marston, H.R.; Samuels, J. A review of age-friendly virtual assistive technologies and their effect on daily living for carers and dependent adults. *Healthcare* **2019**, *7*, 49. [CrossRef]
19. Evans, S.; Waller, S.; Bray, J.; Atkinson, T. Making homes more dementia-friendly through the use of aids and adaptations. *Healthcare* **2019**, *7*, 43. [CrossRef]
20. Chadborn, N.H.; Blair, K.; Creswick, H.; Hughes, N.; Dowthwaite, L.; Adenekan, O.; Pérez Vallejos, E. Citizens' juries: When older adults deliberate on the benefits and risks of smart health and smart homes. *Healthcare* **2019**, *7*, 54. [CrossRef]
21. Wang, S.; Bolling, K.; Mao, W.; Reichstadt, J.; Jeste, D.; Kim, H.-C.; Nebeker, C. Technology to support aging in place: Older adults' perspectives. *Healthcare* **2019**, *7*, 60. [CrossRef]
22. Lee, S.M.; Edmonston, B. Living alone among older adults in Canada and the U.S. *Healthcare* **2019**, *7*, 68. [CrossRef]
23. Van Boekel, L.C.; Wouters, E.J.M.; Grimberg, B.M.; van der Meer, N.J.M.; Luijkx, K.G. Perspectives of stakeholders on technology use in the care for community-living older adults with dementia: A systematic literature review. *Healthcare* **2019**, *7*, 73. [CrossRef]
24. Marston, H.R.; Genoe, R.; Freeman, S.; Kulczycki, C.; Musselwhite, C. Older adults' perceptions of ICT: Main findings from the Technology in Later Life (TILL) study. *Healthcare* **2019**, *7*, 86. [CrossRef]
25. Groenendaal, M.; Loor, A.; Trouw, M.; Achterberg, W.P.; Caljouw, M.A.A. Perspectives of healthcare professionals on meaningful activities for persons with dementia in transition from home to a nursing home: An explorative study. *Healthcare* **2019**, *7*, 98. [CrossRef] [PubMed]
26. Barrie, H.; Soebarto, V.; Lange, J.; Mc Corry-Breen, F.; Walker, L. Using citizen science to explore neighbourhood influences on ageing well: Pilot project. *Healthcare* **2019**, *7*, 126. [CrossRef]
27. Marston, H.R.; Hadley, R.; Banks, D.; Del Carmen Miranda Duro, M. Mobile self-monitoring ECG devices to diagnose arrhythmia that coincide with palpitations: A scoping review. *Healthcare* **2019**, *7*, 96. [CrossRef] [PubMed]
28. Alzheimer's Disease International. Policy Brief for G8 Heads of Government. The Global Impact of Dementia 2013-2050. London: Alzheimer's Disease International. 2013. Available online: https://www.alz.co.uk/research/GlobalImpactDementia2013.pdf (accessed on 26 September 2019).
29. Marston, H.R.; Musselwhite, C. Ageing: Science, Technology & Healthy Living; Written evidence (INQ0010), Questions 5–8. Science and Technology Committee (Lords), UK. 2019. Available online: http://data.parliament.uk/writtenevidence/committeeevidence.svc/evidencedocument/science-and-technology-committee-lords/ageing-science-technology-and-healthy-living/written/104933.html (accessed on 24 October 2019).
30. Waights, V.; Bamidis, P.; Almeida, R. Technologies for Care—The Imperative for Upskilling Carers. In *Knowledge Exchange Seminar Series 2017–18*; Stormont: Belfast, UK, 2018.
31. Marston, H.R.; Freeman, S.; Genoe, R.; Kulcyzki, C.; Musselwhite, C. The Cohesiveness of Technology in Later Life: Findings from the Technology. In *Later Life (TILL) Project Knowledge Exchange Seminar Series 2017–2018*; Stormont: Belfast, UK, 2018.

32. Buffel, T.; Handler, S.; Phillipson, C. (Eds.) *Age-Friendly Cities and Communities: A Global Perspective*; Policy Press: Bristol, UK, 2018; ISBN 978-1-4473-3134-6.
33. Buse, C.; Martin, D.; Nettleton, S. Conceptualising 'materialities of care': Making visible mundane material culture in health and social care contexts. *Sociol. Health Illn.* **2018**, *40*, 243–255. [CrossRef]
34. Kort, H.S.M.; Steunenberg, B.; van Hoof, J. Methods for involving people living with dementia and their informal carers as co-developers of technological solutions. *Dement. Geriatr. Cogn. Disord.* **2019**, *47*, 149–156. [CrossRef]
35. Van Hoof, J.; Verbeek, H.; Janssen, B.M.; Eijkelenboom, A.; Molony, S.L.; Felix, E.; Nieboer, K.A.; Zwerts-Verhelst, E.L.M.; Sijstermans, J.J.W.M.; Wouters, E.J.M. A three perspective study of the sense of home of nursing home residents: The views of residents, care professionals and relatives. *BMC Geriatr.* **2016**, *16*, 169. [CrossRef]
36. Van Hoof, J.; Verboor, J.; Oude Weernink, C.E.; Sponselee, A.A.G.; Sturm, J.A.; Kazak, J.K.; Govers, G.M.J.; van Zaalen, Y. Real-time location systems for asset management in nursing homes: An explorative study of ethical aspects. *Information* **2018**, *9*, 80. [CrossRef]

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Article

The Physical Environment of Nursing Homes for People with Dementia: Traditional Nursing Homes, Small-Scale Living Facilities, and Green Care Farms

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Abstract: It is well recognized that the physical environment is important for the well-being of people with dementia. This influences developments within the nursing home care sector where there is an increasing interest in supporting person-centered care by using the physical environment. Innovations in nursing home design often focus on small-scale and homelike care environments. This study investigated: (1) the physical environment of different types of nursing homes, comparing traditional nursing homes with small-scale living facilities and green care farms; and (2) how the physical environment was being used in practice in terms of the location, engagement and social interaction of residents. Two observational studies were carried out. Results indicate that the physical environment of small-scale living facilities for people with dementia has the potential to be beneficial for resident's daily life. However, having a potentially beneficial physical environment did not automatically lead to an optimal use of this environment, as some areas of a nursing home (e.g., outdoor areas) were not utilized. This study emphasizes the importance of nursing staff that provides residents with meaningful activities and stimulates residents to be active and use the physical environment to its full extent.

Keywords: physical environment/space; nursing homes; small-scale living; green care farms; engagement; social interaction

1. Introduction

The importance of the physical environment for the well-being of people with dementia is well recognized. The ecological theory of aging and the environmental press model developed over 30 years ago stated that the fit between the environment and an individual's cognitive and physical capacities is associated with the ability of people with dementia to age in place [1,2]. The built environment can avoid agitated or diffusing behavior, which might cause unnecessary harm [3,4]. Furthermore, it can support people with dementia to attain their full potential by positively influencing their autonomy, support their quality of life and well-being and attain the best possible potential of independence [4–6].

Literature reviews showed the importance of various environmental aspects for people with dementia (e.g., sunlight, sounds, view, spatial layout, nature, orientation, music, privacy, autonomy, windows, comfort, facilities, staff, group size, non-institutional character, and domesticity) [6–8].

Especially for people with dementia, the environment supports the physical and cognitive requirements of an individual, implying the importance of a balance between the person and the environment. Studies suggest that it is recommended to build nursing homes of smaller size with an open-plan environment in which visual access is favored. These support orientation and social interaction, and facilitate caregiving for nurses, as residents can be located more easily [9]. Sensory stimulation should also be taken into consideration. On the one hand, it is important that stimulus reduction features are considered to assure that residents are not overwhelmed by too much information (environment press) or noise. On the other hand, the design should highlight useful stimuli such as familiar cues to bathrooms and exits to safe outside areas [9]. Another essential design feature of a nursing home is to create an atmosphere of familiarity with elements of the past, as this is what people with dementia most easily recall. It is also important to consider privacy by providing private spaces, in which residents can be alone or in close company of a friend. Moreover, public spaces for community activities and other social interaction are important. It is also of great interest to support people with their activities of daily living, to allow them to have their own routines and to provide a homelike atmosphere [10].

The substantial evidence of the role of the physical environment for people with dementia affects the nursing home care sector. There is increasing interest in the design of the physical nursing home environment and how this supports person-centered care [5,11–13]. For instance, a homelike environment positively influences residents' daily activities and social interactions [14]. Advances in the nursing home care sector focus on the development of small-scale, homelike care environments such as green care farms (GCFs). GCFs provide care for people with dementia in a small-scale homelike facility in which a familiar atmosphere and normal daily living is emphasized. People with dementia have the opportunity to engage in activities with, e.g., crops, livestock and woodland, in which they can make use a unique physical environment consisting of several areas on the farm such as the kitchen, shed, gardens, farmyard, and stables. Freedom of movement is emphasized and giving people with dementia autonomy on their own lives (and the choices they make) is a central part of providing care at GCFs [15–17].

Consequently, a shift from a traditional medical model towards a psychosocial homelike model of care takes place [18]. Instead of long corridors and shared rooms, nursing homes are increasingly small-scaled and homelike with a familiar physical environment. Hence, a sense of at-hominess is created by providing meaningful experiences of choice, mastery, and social interactions [11,18].

Several instruments have been developed to map the physical environment of a care facility [9,19–22]. These instruments include aspects such as maintenance, cleanliness, safety, lighting, domesticity, noise, and familiarity. However, these measurement instruments are rarely focused on people with dementia and often focus on traditional medical environmental aspects, such as the presence of safety bars and slippery floors. Hence, they do not comprehensively assess all factors of importance to well-being of people with dementia. Most studies that compare different types of nursing home environments provide a general description of the physical environment (e.g., large-scale versus small-scale), and focus on measuring generic, broad outcomes such as quality of life, and quality of care outcomes such as falling incidents and medication use [23,24]. Furthermore, only few studies investigate whether differences in environmental aspects between nursing homes lead to benefits for nursing home residents with dementia in terms of their daily life (e.g., activities or social engagement). Some studies suggest that a high-quality care environment leads to residents that are more active, engaged, and have a better quality of life [10,12,13,25]. However, research on how a physical environment is used by residents is scarce.

In this paper, two studies are described. First, an evaluation of different care environments was carried out using the OAZIS-Dementia, an assessment tool specifically developed for the Dutch nursing home context. It was investigated whether there are differences in terms of the physical environment between traditional nursing homes, small-scale living facilities, and green care farms. Second, a study was conducted in which how different nursing home environments are used by their residents was assessed.

2. Materials and Methods

2.1. Study Design

Both studies used a cross-sectional observational study design, and were part of a larger research project investigating the effects of green care farms for people with dementia [15]. This study was declared not to be invasive for people with dementia by the medical ethics committee of the Maastricht University Medical Centre (14-05-003).

2.2. Study 1

2.2.1. Setting

Two types of nursing homes for people with dementia were compared: traditional nursing home wards and small-scale living facilities. The latter consisted of three subtypes: (1) stand-alone small-scale living facilities; (2) small-scale living facilities on the terrain of a larger nursing home; and (3) green care farms. Table 1 provides a brief description of each type of nursing home. In total, the physical environment of 18 nursing home wards was mapped.

Table 1. Description of the types of nursing homes.

Type of Nursing Home	**Brief Description**	**Prominent Characteristics of the Physical Environment**
Traditional nursing home ward	$\geq$20 residents on the ward Differentiated tasks for staff Routines and rules of the organization determine daily life	Large building, long corridors, shared rooms, hospital-like atmosphere, separate kitchen, facilities such as a restaurant and activity areas are attached to the ward
Small-scale living facility on the area of a larger nursing home	Maximum of 8 residents Joint household Meals (including dinner) prepared inside the home three times a day Integrated tasks for staff Small team of caregivers Residents and informal caregivers determine daily life	Homelike situation, single rooms, familiar interior, common living room attached to kitchen, facilities such as a restaurant and activity areas are attached to the ward, outdoor area accessible
Stand-alone small-scale living facility	Has the same characteristics as a small scale living facility on the terrain of a larger nursing home, however situated in a neighborhood Aims at close connections with the community and opportunities to maintain a social network.	Archetype house, single rooms, familiar interior, common living room attached to kitchen, no direct access to facilities provided at a larger nursing home, outdoor area accessible
Green care farms	A type of stand-alone small-scale nursing home facility in a rural area Both care and agricultural activities are important. House on the area of the farm.	Homelike situation, archetype house, single rooms, familiar interior, common living room attached to kitchen, freely accessible outdoor areas, stables, gardens, animals

2.2.2. Instruments

The OAZIS-Dementia was developed to measure the physical environment of long-term care environments in a Dutch setting [15]. During the development of the OAZIS-Dementia, face validity and content validity were taken into account in various ways. Existing literature and instruments [6–9,20,26,27] were reviewed systematically by two researchers to investigate whether the items were relevant for Dutch nursing homes for people with dementia.

Subsequently, the relevance of the theme items was discussed with experts in nursing home care (care professionals, researchers, real-estate controllers, and location managers). During these discussions, the categories of the OAZIS-Dementia and the specific items were addressed in detail. A pilot test in three nursing homes during the development of the instrument showed that the inter-rater reliability of the OAZIS-Dementia was high, with an ICC of 88.

The OAZIS-Dementia consists of 72 items, which assess aspects of the environment on a five-point Likert scale, ranging from 1 (not at all) to 5 (completely). The checklist is divided into seven categories that emerged from reviewing the existing literature and existing instruments: (1) privacy and autonomy; (2) sensory stimulation; (3) view and nature; (4) facilities; (5) orientation and routing; (6) domesticity; and (7) safety. Higher scores indicate a higher probability for the environment to have a positive effect on its residents. Table 2 summarizes the categories measured with example items that were scored for each nursing home. Each item in the OAZIS-Dementia has the same weight in terms of calculating total scores. The OAZIS-Dementia is available upon request.

Table 2. OAZIS-Dementia categories and example items.

Category	Item No.	Examples
Privacy and Autonomy	Item 1–7	Residents have a single room Washrooms are discrete
Sensory Stimulation	Item 8–25	Daylight glare and harsh reflections are prevented or can be individually regulated with blinds Staff can regulate temperature
View and Nature	Item 26–36	Residents have views of nature and greenery There are animals present
Facilities	Item 37–45	The outdoor area is accessible for people using a wheelchair or walker There are several spatial facilities on the ward to meet other residents
Orientation and Routing	Item 46–52	The structure of the ward is open Use of clear icons/nameplates to denote toilet and bathroom
Domesticity/Small Scale	Item 53–69	The ward has its own front door with a doorbell The staff does not wear uniforms
Safety	Item 70–72	There are devices dedicated to security present at the toilets Floors are not slippery

2.2.3. Procedure

Two researchers (who were involved in the development of the OAZIS-Dementia) visited all wards for another observation study several times. The researcher, who visited a ward most frequently, filled out the OAZIS-Dementia for that specific ward. The OAZIS-Dementia was filled out during the third or fourth visit, so that the researcher was already familiar with the environment. It took approximately 1 h to fill out all items. The designated scores were reviewed by the other researcher and, in the case of disagreements, discussed.

2.2.4. Data Analysis

All 72 items were scored on a five-point Likert scale. For each category, an average value was calculated by adding the item scores and dividing them through the number of items. A final score on the OAZIS-Dementia was calculated in the same manner. Descriptive statistics were used to check for differences between the types of nursing homes.

2.3. Study 2

2.3.1. Setting

Three nursing homes were included in this study, which all have been purposefully built according to the principles of small-scale, homelike care environments. All three nursing homes can be categorized as a small-scale living facility on the area of a larger nursing home (from the categorization of Study 1). Below, a more specific description per nursing home is given.

Nursing Home 1 (NH1) had six single standing residential units with eight residents with dementia in each. The units were accessible individually via an entrance door either on street level or a stairway. The three buildings were purposely built as archetypal houses. Every resident had his or her own bedroom (215 ft^2) including a bathroom, shared with a resident on the opposite side. Space for staff was organized in the entrance area for privacy and confidentiality of the residents. Nevertheless, staff took their breaks within the common spaces of the residents.

Nursing Home 2 (NH2) had six residents per unit designed specifically for people with dementia. Every resident had his/her own bedroom, with a room (190 ft^2) including a sink. Two bathrooms were shared amongst the six residents. Nursing staff had no private or separate space. Spaces for nursing equipment or exits to leave the unit were not freely accessible for residents. The main ground floor of the facility accommodated a hairdresser, restaurant, physiotherapist, reception area, and offices for managerial and administrative work and an accessible enclosed outdoor garden including an animal shelter.

Nursing Home 3 (NH3) incorporated 71 apartments, of which 32 were occupied by residents with dementia and 39 by residents with somatic disorders. Each resident had their own unit (450 ft^2) consisting of a kitchen, bedroom, and private bathroom, furnished with familiar belongings from the residents' previous homes. In addition to private apartments, the units had a communal kitchen/dining area and large living area to share with another unit on the same floor occupying another eight residents. On ground level, there were administrative offices for management or nursing and medical personnel, and a physiotherapist practice. The facility was built in the countryside surrounded by other apartment complexes. Outside, garden areas were accessible by residents accompanied by family, friends or personnel.

2.3.2. Instruments

To identify environmental features of the different settings in the study, the OAZIS-Dementia was used in each setting. Additionally, there were two 10-h observations per nursing home (8.30–18.30), composed of one-day shift and one-evening shift. Night shifts were deliberately excluded, as residents were assumed to sleep during this timeframe. During these observations, the extent to which residents used the physical environment was observed. A subset of the aspects of daily life observed with the Maastricht Electronic Daily Life Observation tool (MEDLO-tool) was used [28]. The MEDLO-tool is a tablet-based observational tool that assesses aspects of daily life.

The following aspects of daily life were observed: (1) the engagement in an activity (yes/no); (2) the location where an activity occurred (4 options); and (3) the social interaction (type of social interaction, and with whom). Table 3 gives an overview of the aspects that were observed to map the usage of the physical environment in terms of daily life. The MEDLO-tool was demonstrated to be a valid, feasible and reliable observation tool with high absolute agreement (86%) between observers and Kappa values between 0.5 and 1.0. Thus, the MEDLO-tool has good psychometric properties [28].

Table 3. Scoring options during observations.

Aspects of MEDLO-Tool	Operationalization	Scoring Options
Engagement in activity	Five category options	Yes, active engagement (participating in activity) Yes, passive engagement (focus on activity) Yes, engagement with something else No, not engaged (gazing without focus) No, not engaged (sleeping)

Table 3. *Cont.*

Aspects of MEDLO-Tool	Operationalization	Scoring Options
Location	Five category options	Communal area on the ward Own room Communal area off the ward Outside
Level of social interaction	Five category options	No social interaction No social interaction, resident attempts to interact, gets no response No social interaction, environment attempts to interact, but resident does not respond Yes, interaction with someone else Yes, interaction with two or more people
Type of social interaction of environment towards resident	Five category options	Negative restrictive (interaction that oppose or resist resident's freedom of action without good reason, or ignore resident as a person) Negative protective (providing care, keeping safe or removing from danger in a restrictive manner without explanation or reassurance) Neutral (brief, indifferent interactions) Positive care (interactions during the appropriate delivery of care) Positive social (interactions principally involving "good, constructive, beneficial" conversation and companionship)
Social interaction with whom	Five category options	Staff Other residents Family and/or friends Others Combination of the above

2.3.3. Procedure

The researchers who were involved in data collection for Study 2 received a short training on how to use the OAZIS-dementia and the MEDLO-tool. The training consisted of studying the instruments and their manuals, and discussing these with the main researchers (who were involved in developing both tools). Example situations were discussed to make sure observers would score the same situation in the same manner. These discussions were also carried out during data collection.

Furthermore, for this study, the observation procedure of the MEDLO-Tool, and the aspects observed were slightly altered, due to practical reasons (available time/resources), and the aim of the study (most relevant aspects of daily life were chosen). Residents were observed for 1 min each on a randomized basis. Each resident was observed during a 1-min "snapshot" before moving on to the next resident, until all residents with dementia residing in the small-scale unit at the time of observation were captured. After 20 min, the first observation round was finished, filling in all items of the MEDLO-tool. This procedure was repeated on six observation days for a 10-h observation shift (08:30–18:30). Every 2 h, observers took a 30-min break.

2.3.4. Data Analysis

First, the OAZIS-Dementia scores were calculated as in Study 1. Second, descriptive analysis on the aspects of daily life was conducted. For engagement and social interaction, percentages were calculated. A percentage thus indicated the proportion of the observations that a resident was engaged in an activity, or had social interaction. For the other aspects that were observed (location, type of social interaction, and social interaction with whom), the percentages of the individual scoring options were calculated.

3. Results

3.1. Study 1

Comparison between Types of Nursing Homes

Table 4 shows the mean scores on each category of the OAZIS-Dementia per nursing home type. Furthermore, a total score is given. Lowest values are presented in orange and highest values in green. In general, all types of small-scale, homelike care environments score better on environmental aspects compared with traditional nursing homes, especially green care farms. Green care farms have high scores on most categories (privacy and autonomy, view and nature, orientation and routing, and domesticity), resulting in the highest total score as well.

Traditional nursing homes have the lowest values on almost all categories (privacy and autonomy, sensory stimulation, view and nature, orientation and routing, and domesticity), resulting in the lowest final total score. The stand-alone small-scale living facilities have the lowest on the facilities category. Small-scale living facilities on the terrain of a larger nursing home have the highest score on sensory stimulation and facilities. No differences were found for the safety category across the nursing home types.

Table 4. Scores on the OAZIS-Dementia per type of nursing home.

OAZIS-Dementia Categories	Traditional Nursing Home Ward (n = 4)	Small-Scale Living Facility on the Terrain of a Larger Nursing Home (n = 6)	Stand-Alone Small-Scale Living Facility (n = 3)	Green Care Farm (n = 5)
Privacy and autonomy	2.8	4.0	4.7	4.7
Sensory stimulation	3.5	4.4	3.7	4.2
View and Nature	2.9	3.6	3.0	4.3
Facilities	3.6	4.2	3.3	3.7
Orientation and routing	2.5	3.6	3.7	3.8
Domesticity	2.1	4.2	4.3	4.5
Safety	4.3	4.4	4.3	4.3
Total	3.0	4.1	3.8	4.2

3.2. Study 2

3.2.1. Comparison between nursing homes

Table 5 presents the outcomes of the OAZIS-Dementia assessment for each nursing home. All nursing homes scored above 3 on every item, indicating high overall scores for each nursing home. Minimal differences were found on the total scores (4.1, 3.9, and 4.1). Largest differences were found on the categories of privacy and autonomy, and domesticity. Especially, the domesticity items include not only physical environmental aspects (e.g., homelike appearance) but also items on organizational environmental aspects, such as whether residents can decide the time they want to get up and go to bed.

Table 5. Scores on the OAZIS-Dementia per nursing home.

OAZIS-Dementia Categories	Nursing Home 1	Nursing Home 2	Nursing Home 3
Privacy and autonomy	4.9	4.3	5.0
Sensory stimulation	3.8	3.8	4.2
View and nature	3.6	3.6	3.8
Facilities	4.4	4.0	4.3
Orientation and Routing	3.6	3.9	3.3
Domesticity	4.2	3.3	3.7
Safety	4.3	4.3	4.7
Total	4.1	3.9	4.1

3.2.2. Use of the Physical Environment

In total, 2043 observations were conducted, 807 observations in NH1, 524 in NH2, and 712 in NH3. The number of six residents living in this facility can explain the comparatively lower number of observations in NH2. The other nursing homes accommodate eight residents per unit, resulting in a higher number of observations.

Table 6 provides an overview of where residents spent their time during the observations, how often they were engaged in an activity, and whether they had social interaction. Residents of NH1 spent 54% in communal areas. Residents directly found themselves in different communal areas upon leaving their bedrooms. In contrast, resident rooms of NH2 and NH3 were located along the hallways. Overall, residents of NH2 spent most time in communal areas (78%, see Table 6), and residents of NH3 the least (40%). Private rooms furnished with own belongings, which were recognizable for residents, were used more often. This was observed in NH1 (34%) and in NH3 (57%) where residents had their own apartments with different housing areas (kitchenette, living room, bedroom, bathroom). Residents of NH2, which had the least homelike bedroom and the least volume in space, spent 9% of their time in private space, over the course of observations. NH1 had an outdoor patio, which was used in 8% of the observations. The balcony of NH2 was used in 4%. Easily accessible balconies of NH3 have not been observed to be utilized by residents (see Table 6).

When activities took place, residents mostly engaged in that main activity. Participation was observed to be highest in NH1 (92%), followed by NH3 (87%). NH2 had the least engagement in activities with 82%. When residents were not engaging in main activities, they were engaged with something else, gazing, or sleeping. Residents often fell asleep at the dining tables after mealtime.

Most social interaction was observed for NH1 (54%), followed by NH2 (52%), and NH3 (37%). Residents in all three nursing homes spent most of their time interacting with staff within the communal areas that were observed. Those in NH1 had more interaction with other residents than the other two nursing homes. All nursing homes had mostly positive social interactions. In all nursing homes, the amount of interaction with family, friends or others was very low (<5%).

Table 6. Percentages on location, engagement and social interaction.

Category		Nursing Home 1	Nursing Home 2	Nursing Home 3
Location	Communal area on the ward	54%	78%	40%
	Own room	34%	9%	57%
	Communal area off the ward	4%	9%	3%
	Outside	8%	4%	-
Engagement in an activity		92%	82%	87%
Social interaction		54%	52%	37%
Social interaction with whom	Staff	35%	37%	49%
	Other residents	29%	15%	13%
	Family and/or friends	1%	5%	1%
	Others	9%	12%	11%
	Combination of the above	26%	32%	27%
Type of social interaction	Negative restrictive	1%	-	-
	Negative protective	1%	1%	2%
	Neutral	8%	16%	24%
	Positive care	39%	25%	24%
	Positive social	52%	59%	50%

4. Discussion

Results of the current study indicate that the physical environment of small-scale living facilities for people with dementia has more potential to be beneficial for residents' daily life than the physical environment of traditional large-scale nursing homes. Traditional nursing homes did not facilitate privacy and autonomy, sensory stimulation, view and nature, orientation and routing, and domesticity. However, this study also found that having a potentially beneficial physical environment does not automatically lead to an optimal use of this environment. Specific areas of a nursing home (e.g., the outdoor area) were not utilized. Nursing staff appeared as an important factor for whether the potential of the space was used.

Linking the physical environment to outcomes concerning daily life is important to investigate the person–environment fit (P-E fit). Small-scale, homelike nursing homes may have a better P-E fit for residents living with dementia [29] as they promote activity engagement and quality of life [30]. Matches are needed among a person's needs, his/her abilities, and environmental demands to support positive outcomes such as a higher well-being, better nutrition, less medication, and more person-centered care [31–33]. However, the P-E fit may decrease for residents when the dementia progresses and environmental demands may exceed functional abilities, resulting in lower activity engagement [34]. This study found that especially green care farms adopt a positive physical environment for residents with dementia. In another study, we found that residents of green care farms displayed a more active daily life, were more socially active, came outside more often, and were more actively engaged than residents in traditional nursing homes [25]. These results suggest that the positive environmental components of green care farms may positively impact their daily life [25,35].

Results of this study suggest that nursing staff can be of importance for stimulating the optimal use of a stimulating physical environment. In alignment with the ecological theory of aging, activity involvement, high quality of life, and well-being for residents can be achieved by adjusting/tailoring activities to different coping capabilities of older adults. Therefore, nursing staff should consider individual preferences, and cognitive and physical conditions [30]. Moreover, interaction and engagement by staff with residents foster a person-centered care approach [36–38], can arouse cognitive abilities of people with dementia [39], and provide a meaningful use of the physical environment. Therefore, staff are decisive for the use of different areas more purposively [40].

There is also a need for nursing staff to adapt their work to encourage residents to participate in daily activities in their nursing home [38]. If the built environment can support this adaptation, the likelihood of nurse encouragement may increase. For the staff working in an environment with smaller facilities, tasks are more integrated and less specialized than in traditional wards [15]. In these small-scale environments, nursing staff have responsibility not only for essential nursing tasks such as medication administration and personal care, but for food preparation, housekeeping, and social and recreational activities as well [12]. Providing an environment supportive to the nursing staff, which accounts for time constraints and workload in small-scale living nursing homes is critical.

The built environment can play a significant role in supporting nursing staff in integrating resident engagement into their daily nursing tasks. A recent study by Lee, Chaudhury and Hung (2016) explored staff perceptions on the role of the physical environment in dementia settings. Staff felt that being close to residents such as in a small-scale living space provided familiar positive stimulation that empowered them to connect with the residents [41].

Continuing to participate in activity is vital to the quality of life of nursing home residents and nursing care should include assisting residents with this participation. In the study, this was accomplished in the nursing homes that had a supportive built environment through open, large rooms, with visual access to each other and appropriate, comfortable seating. Additionally, in the open kitchen/dining rooms, positive sensory stimulation was created; for example, when nursing staff were preparing food, the smells and sounds of cooking could be sensed throughout the home, which may encourage residents to gather. These features of small-scale living made it easier for the nurses and residents to be together in the communal areas. This is in line with a recent review showing that the physical environment can be linked with therapeutic goals for people with dementia [21]. The authors of this review indicated that certain facility characteristics such as unit size, spatial layout, or having an outdoor area can be linked with therapeutic goals such as maximizing awareness and orientation, support functional abilities, and social contact [21].

Limitations and Recommendations for Future Research

Some methodological considerations should be taken into account. First, the study had an explorative, descriptive character, including a small number of participating nursing homes, which limits the generalizability of results. Second, this study used mainly a quantitative approach for data collection on activity involvement and use of space. Collection of qualitative data for example by interviewing residents, family members or nursing staff would gain valuable information on why certain spaces were used less or more and how the environment was experienced. One limitation is that information regarding cognitive status and functioning levels across the three nursing homes is missing. Although the nursing homes have similar admission criteria, it is difficult to determine how comparable the residents across these nursing homes were. This could have affected the differences that were found in terms of the use of the physical environment. Future studies should make sure that observational data can be compared with information regarding cognition and functional status of individual residents. The OAZIS-dementia instrument used in this study has some limitations that are in line with other observational instruments to measure the physical environment. It is a relatively long instrument to fill out. Furthermore, it is beneficial if a researcher has visited the nursing a couple of times before answering all the items (which makes it more time consuming). Lastly, it remains difficult to ascertain which aspects of the environment are associated with specific outcomes for residents due to the interrelationships of the organizational, social, and physical environment [21]. Future studies should focus more on specific relationships (e.g., by manipulating a certain part of the environment).

5. Conclusions

The physical environment of small-scale, homelike nursing homes has more potential to be beneficial for people with dementia than traditional nursing homes. However, the environment is still not utilized to its full potential, which can affect the engagement in activities and social interactions of people with dementia living in a nursing home.

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References

1. Lawton, M.P.; Nahemow, L. Ecology and the aging process. In *The Psychology of Adult Development and Aging*; Eisdorfer, C., Lawton, M.P., Eds.; American Psychological Association: Washington, DC, USA, 1973; pp. 619–674.
2. Topo, P.; Kotilainen, H.; Eloniemi-Sulkava, U. Affordances of the care environment for people with dementia—An assessment study. *HERD* **2012**, *5*, 118–138. [CrossRef] [PubMed]
3. Davis, S.; Byers, S.; Nay, R.; Koch, S. Guiding design of dementia friendly environments in residential care settings: Considering the living experiences. *Dementia* **2009**, *8*, 185–203. [CrossRef]
4. Woodbridge, R.; Sullivan, M.P.; Harding, E.; Crutch, S.; Gilhooly, K.; Gilhooly, M.; Mckintyre, A.; Wilson, L. Use of the physical environment to support everyday activities for people with dementia: A systematic review. *Dementia* **2016**, *17*, 533–572. [CrossRef] [PubMed]
5. Chaudhury, H.; Hung, L.; Badger, M. The role of physical environment in supporting person-centered dining in long-term care: A review of the literature. *Am. J. Alzheimers Dis. Other Demen.* **2013**, *28*, 491–500. [CrossRef] [PubMed]

6. Fleming, R.; Crookes, P.A.; Sum, S. A review of the empirical literature on the design of physical environments for people with dementia. 2008. Available online: https://ro.uow.edu.au/cgi/viewcontent.cgi?referer=https://scholar.google.com/&httpsredir=1&article=3923&context=hbspapers (accessed on 5 September 2017).
7. Day, K.; Carreon, D.; Stump, C. The therapeutic design of environments for people with dementia: A review of the empirical research. *Gerontologist* **2000**, *40*, 397–416. [CrossRef] [PubMed]
8. Dijkstra, K.; Pieterse, M.; Pruyn, A. Physical environmental stimuli that turn healthcare facilities into healing environments through psychologically mediated effects: Systematic review. *J. Adv. Nurs.* **2006**, *56*, 166–181. [CrossRef] [PubMed]
9. Bennet, K.; Fleming, R. The Environmental Audit Tool Handbook. NSW Ministry of Health (Sydney). 2013. Available online: https://www.enablingenvironments.com.au/uploads/5/0/4/5/50459523/eat_handbook_july_13.pdf (accessed on 5 September 2017).
10. Morgan-Brown, M.; Newton, R.; Ormerod, M. Engaging life in two Irish nursing home units for people with dementia: Quantitative comparisons before and after implementing household environments. *Aging Ment. Health* **2013**, *17*, 57–65. [CrossRef] [PubMed]
11. Molony, S.L.; Evans, L.K.; Jeon, S.; Rabig, J.; Straka, L.A. Trajectories of at-homeness and health in usual care and small house nursing homes. *Gerontologist* **2011**, *51*, 504–515. [CrossRef] [PubMed]
12. Smit, D.; de Lange, J.; Willemse, B.; Pot, A.M. The relationship between small-scale care and activity involvement of residents with dementia. *Int. Psychogeriatr.* **2012**, *24*, 722–732. [CrossRef] [PubMed]
13. Smit, D.; Willemse, B.; de Lange, J.; Pot, A.M. Wellbeing-enhancing occupation and organizational and environmental contributors in long-term dementia care facilities: An explorative study. *Int. Psychogeriatr.* **2014**, *26*, 69–80. [CrossRef] [PubMed]
14. Marquardt, G.; Bueter, K.; Motzek, T. Impact of the design of the built environment on people with dementia: An evidence-based review. *Health Environ. Res. Des. J.* **2014**, *8*, 127–157. [CrossRef] [PubMed]
15. De Boer, B.; Hamers, J.P.H.; Beerens, H.C.; Zwakhalen, S.M.G.; Tan, F.E.S.; Verbeek, H. Living at the farm, innovative nursing home care for people with dementia–study protocol of an observational longitudinal study. *BMC Geriatr.* **2015**, *15*, 144. [CrossRef] [PubMed]
16. Haubenhofer, D.; Elings, M.; Hassink, J.; Hine, E.H. The development of green care in Western European countries. *Explore* **2010**, *6*, 106–111. [CrossRef] [PubMed]
17. De Bruin, S.R.; Oosting, S.J.; van der Zijpp, A.J.; Enders-Slegers, M.J.; Schols, J.M.G.A. The concept of green care farms for older people with dementia: An integrative framework. *Dementia* **2010**, *9*, 79–128. [CrossRef]
18. Verbeek, H.; van Rossum, E.; Zwakhalen, S.M.G.; Kempen, G.I.; Hamers, J.P.H. Small, homelike care environments for older people with dementia: A literature review. *Int. Psychogeriatr.* **2009**, *21*, 252–264. [CrossRef] [PubMed]
19. Slaughter, S.; Calkins, M.; Eliasziw, M.; Reimer, M. Measuring Physical and Social Environments in Nursing Homes for People with Middle to Late Stage Dementia. *J. Am. Geriatr. Socs.* **2006**, *54*, 1436–1441. [CrossRef] [PubMed]
20. Sloane, P.D.; Mitchell, C.M.; Weisman, G.; Zimmerman, S.; Foley, K.M.; Lynn, M.; Calkins, M.; Lawton, M.P.; Teresi, J.; Grant, L.; et al. The Therapeutic Environment Screening Survey for Nursing Homes (TESS-NH) An Observational Instrument for Assessing the Physical Environment of Institutional Settings for Persons With Dementia. *J. Gerontol. Ser. B.* **2002**, *57*, S69–S78. [CrossRef]
21. Chaudhury, H.; Cooke, H.A.; Cowie, H.; Razaghi, L. The Influence of the Physical Environment on Residents With Dementia in Long-Term Care Settings: A Review of the Empirical Literature. *Gerontologist* **2018**, *58*, e325–e337. [CrossRef] [PubMed]
22. Elf, M.; Nordin, S.; Wijk, H.; Mckee, K.J. A systematic review of the psychometric properties of instruments for assessing the quality of the physical environment in healthcare. *J. Adv. Nurs.* **2017**, *73*, 2796–2816. [CrossRef] [PubMed]
23. Verbeek, H.; Zwakhalen, S.M.G.; Van Rossum, E.; Ambergen, T.; Kempen, G.I.J.M.; Hamers, J.P.H. Dementia Care Redesigned: Effects of Small-Scale Living Facilities on Residents, Their Family Caregivers, and Staff. *J. Am. Med. Dir. Assoc.* **2010**, *11*, 662–670. [CrossRef] [PubMed]
24. Reimer, M.A.; Slaughter, S.; Donaldson, C.; Currie, G.; Eliasziw, M. Special Care Facility Compared with Traditional Environments for Dementia Care: A Longitudinal Study of Quality of Life. *J. Am. Geriatr. Soc.* **2004**, *52*, 1085–1092. [CrossRef] [PubMed]

25. De Boer, B.; Hamers, J.P.H.; Zwakhalen, S.M.G.; Tan, F.E.S.; Beerens, H.C.; Verbeek, H. Green care farms as innovative nursing homes, promoting activities and social interaction for people with dementia. *J. Am. Med. Dir. Assoc.* **2017**, *18*, 40–46. [CrossRef] [PubMed]
26. College Bouw Zorginstellingen. *Kwaliteit van de Fysieke Zorgomgeving*; College Bouw Zorginstellingen: Utrecht, The Netherlands, 2008; Available online: https://modernedementiezorg.nl/upl/invloed_van_omgeving/084505_kwaliteit_fystieke_zorgomgeving.pdf (accessed on 5 September 2017).
27. Maltby, J. Environmental Audit: Theory and Practices. *Manag. Audit. J.* **1995**, *10*, 15–26. [CrossRef]
28. De Boer, B.; Beerens, H.C.; Zwakhalen, S.M.G.; Tan, F.E.S.; Hamers, J.P.H.; Verbeek, H. Daily lives of residents with dementia in nursing homes: Development of the Maastricht electronic daily life observation tool. *Int. Psychogeriatr.* **2016**, *28*, 1333–1343. [CrossRef] [PubMed]
29. Lawton, M.P. Competence, environmental press, and the adaptations of older people. In *Aging and the Environment: Theoretical Approaches*; Windley, P.G., Byerts, T.O., Eds.; Springer: New York, NY, USA, 1982; pp. 33–59.
30. Smit, D.; de Lange, J.; Willemse, B.; Twisk, J.; Pot, A.M. Activity involvement and quality of life of people at different stages of dementia in long term care facilities. *Aging Ment. Health* **2016**, *20*, 100–109. [CrossRef] [PubMed]
31. Bortnick, K.N. An Ecological Framework to Support Small-Scale Shared Housing for Persons with Neurocognitive Disorders of the Alzheimer's and Related Types: A Literature Review. *Hong Kong J. Occup. Ther.* **2017**, *29*, 26–38. [CrossRef] [PubMed]
32. Brownie, S.; Nancarrow, S. Effects of person-centered care on residents and staff in aged-care facilities: A systematic review. *Clin. Inter. Aging* **2013**, *8*, 1. [CrossRef] [PubMed]
33. Geboy, L. Linking Person-Centered Care and the Physical Environment: Design Principles for Elder and Dementia Care Staff. *Alzheimer's Care Today* **2009**, *10*, 228–231.
34. Iwarsson, S. A long-term perspective on person–environment fit and ADL dependence among older Swedish adults. *Gerontologist* **2005**, *45*, 327–336. [CrossRef] [PubMed]
35. Beerens, H.C.; de Boer, B.; Zwakhalen, S.M.G.; Tan, F.E.S.; Ruwaard, D.; Hamers, J.P.H.; Verbeek, H. The association between aspects of daily life and quality of life of people with dementia living in long-term care facilities: A momentary assessment study. *Int. Psychogeriatr.* **2016**, *28*, 1323–1331. [CrossRef] [PubMed]
36. Ashburner, C.; Meyer, J.; Johnson, B.; Smith, C. Using action research to address loss of personhood in a continuing care setting. *Illn. Crisis Loss* **2004**, *12*, 23–37. [CrossRef]
37. Lee, K.H.; Boltz, M.; Lee, H.; Algase, D.L. Does Social Interaction Matter Psychological Well-Being in Persons With Dementia? *Am. J. Alzheimers Dis. Other Demen.* **2017**, *32*, 207–212. [CrossRef] [PubMed]
38. Morgan-Brown, M.; Brangan, J. Capturing Interactive Occupation and Social Engagement in a Residential Dementia and Mental Health Setting Using Quantitative and Narrative Data. *Geriatrics* **2016**, *1*, 15. [CrossRef]
39. Sink, K.M.; Holden, K.F.; Yaffe, K. Pharmacological treatment of neuropsychiatric symptoms of dementia: A review of the evidence. *JAMA* **2005**, *293*, 596–608. [CrossRef] [PubMed]
40. Pulsford, D.; Rushforth, D.; Connor, I. Woodlands therapy: An ethnographic analysis of a small group therapeutic activity for people with moderate or severe dementia. *J. Adv. Nurs.* **2000**, *32*, 650–657. [CrossRef] [PubMed]
41. Lee, S.Y.; Chaudhury, H.; Hung, L. Exploring staff perceptions on the role of physical environment in dementia care setting. *Dementia* **2016**, *15*, 743–755. [CrossRef] [PubMed]

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Two-Year Use of Care Robot Zora in Dutch Nursing Homes: An Evaluation Study [†]

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Abstract: The use of the Zora robot was monitored and evaluated in 14 nursing care organizations (15 locations). The Zora robot, a Não robot with software, is designed as a social robot and used for pleasure and entertainment or to stimulate the physical activities of clients in residential care. In the first year, the aim was to monitor and evaluate how the care robot is used in daily practice. In the second year, the focus was on evaluating whether the use of Zora by care professionals can be extended to more groups and other type of clients. Interviews, questionnaires and observations were used as instruments to reveal the progress in the use of the robot and to reveal the facilitators and barriers. Care professionals experienced several barriers in the use of the robot (e.g., start-up time and software failures). The opportunity they had to discuss their experience during project team meetings was seen as a facilitator in the project. Furthermore, they mentioned that the Zora robot had a positive influence on clients as it created added value for the care professionals in having fun at work.

Keywords: long-term care facilities; older adults; gerontechnology

1. Introduction

These days, life without technology is unthinkable and more and more care organizations incorporate technology in daily care routines. Technology implemented in care organizations comprises video conferencing not only for telecare and teleconsultations but also for the use of robots. There are different types of robots in healthcare, for example service robots and social robots [1]. Service robots mostly serve as an aid for elderly or disabled people. Social robots are developed for social interaction with elderly people, for example, to improve their health and psychological well-being. Different social robots are already available on the market for the elderly [2]. Research shows that the use of social robots in the care of people with dementia has intriguing possibilities, addressing support issues in caring for people with dementia [3]. In healthcare, robots are used for rehabilitation therapy or to assist persons in their daily activities. Furthermore, robots are now also used for social activities and entertainment. One example of such a social robot is PARO. The PARO seal robot is used for the social support for older adults [4]. It is known that the PARO seal robot, when offered to persons with dementia in nursing homes, will lead to engagement. Several other studies show that the PARO robot [5,6] has a positive influence on older persons with dementia.

This paper reports on the use of the Zora robot (Figure 1) also as a social robot in nursing homes. Zora is an acronym made up of the first letters of the Dutch words for care, elderly, rehabilitation and animation. Zora is a humanoid robot of 57 cm in height, with functional sensors for seeing and hearing. Zora is a Não robot with hardware developed by Softbank Robotics and with software made by a Belgium company (Zorabots). In this paper, the robot is referred to as Zora. Zora is used for rehabilitation practice (see Figure 2), social activities and entertainment. Não robots are also used for children with autism, and they contribute to the development of those children [7]. A recent study on understanding older people's use of technology showed that performance expectancy, effort expectancy, and perceived privacy and security are direct predictors of older people's intentions to use technology innovations such as videoconferencing [8]. Another recent study showed that for the implementation of eHealth in homes for the elderly, the preconditions must be clear and, therefore, more qualitative research is needed to reveal the perspectives of older people on technology and to investigate their motives for considering technology [9]. In the Netherlands, the use of care robots by professionals in care for the elderly increased from 3% in 2016 to 8% in 2017 [10].

Figure 1. A picture of the care robot Zora with a tablet for control.

Figure 2. A demonstration of the robot Zora (student physiotherapy).

The technology innovation stage and the extent of take-up in society can be illustrated by the pyramid of technology which distinguishes between the technology stages of envisioned, operational, applied, accepted, vital, invisible and naturalized [11]; see also Figure 3. Envisioned means just having an idea for a technological innovation, while operational means this idea has moved into something that does work. Applied and accepted mean that the technology works in practice and is accepted by users. Vital, invisible and naturalized apply to a technology innovation which is part of daily life (mobile phone, electricity or cooking, for instance). In this pyramid of technology, the Zora robot is still in the pioneer phase, namely between the operational and applied stages.

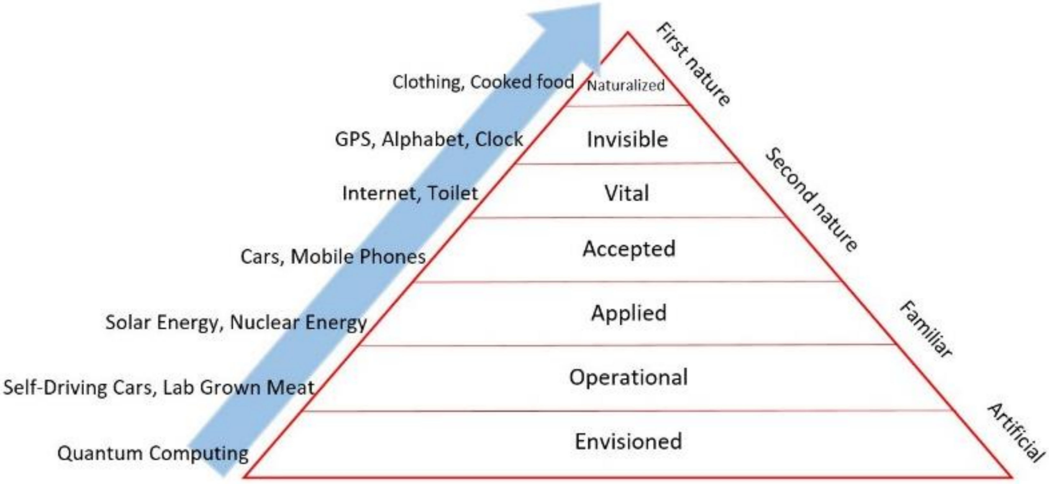


Figure 3. The pyramid of technology.

Fourteen care organizations in the Netherlands formulated the ambition to use the social robot Zora in daily (residential) care for older persons with a long-term care demand, and therefore, the project “Care innovation with Zora” was started. The project is supported by IVVU (Institutions for Nursing and Care in Utrecht), a regional association for long-term care facilities in the Utrecht region, The Netherlands.

The project objective is to innovate nursing home care by introducing robot technology to care professionals and making them acquainted with the Zora robot up to the level of acceptance. Furthermore, the project was initiated to get a better insight into what technology can mean for daily practice and to investigate the facilitators and barriers. The main research questions were how to apply the use of the Zora robot in residential care and what is the perspective of care professionals regarding the acceptance of the robot. Therefore, this study investigated to which extent professionals and clients engage with the Zora robot and/or accept the robot. In addition, we investigated the facilitators and barriers in using the Zora robot to formulate recommendations in order to move away from the pioneer phase towards the acceptance stage of this technology innovation.

2. Materials and Methods

2.1. Design

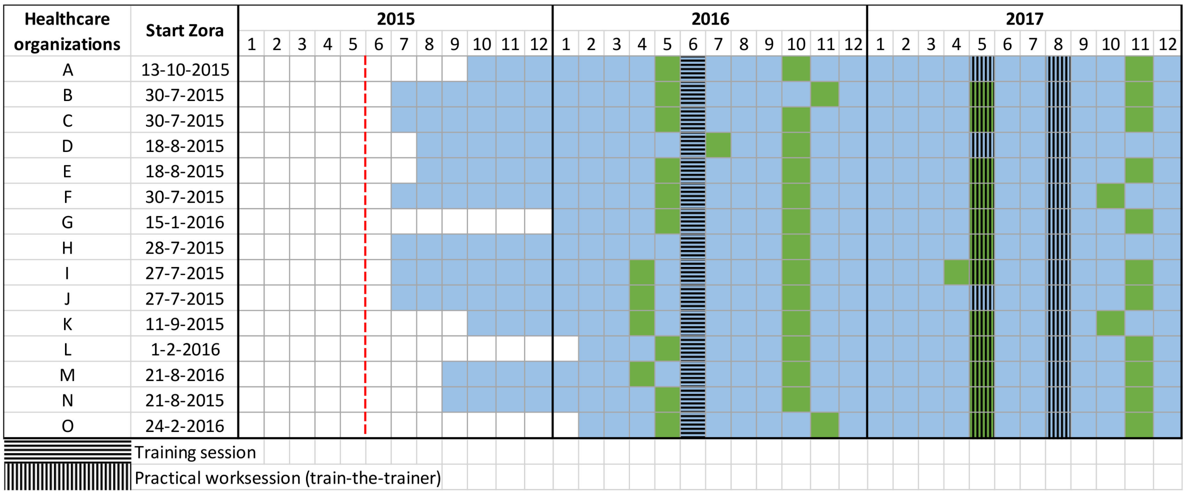
This practice-based study used a mixed-method design. Quantitative data were collected in relation to mood and involvement with the Zora robot while qualitative data included observations and interviews. The following questions were leading:

- For which client groups is Zora used?
- Is the robot used in a group setting and/or in an individual setting?
- How many departments and/or locations of the organizations did work with Zora?
- Which type of care professionals uses Zora?

2.2. Locations and Process

The use of the Zora robot was investigated on 15 locations in the Utrecht region. The project was initiated and started in 2015 by the association of care-organizations in the Utrecht region (IVVU). Students and research staff visited the care organizations in spring and autumn of 2016 and spring and late autumn in 2017. The starting times of the 14 care-organizations (15 locations) are given in

Figure 4, since this varied per location. The Não robot with software from Zorabots, referred to as Zora in this paper, was purchased from Zorabots. All fifteen locations received the Zora robot and were allowed to choose to use Zora for any purpose in care. The basic functionalities of the robot include walking, sitting, talking, moving and dancing, in other words, social activities and entertainment. Care professionals could use the robot for entertainment and rehabilitation.

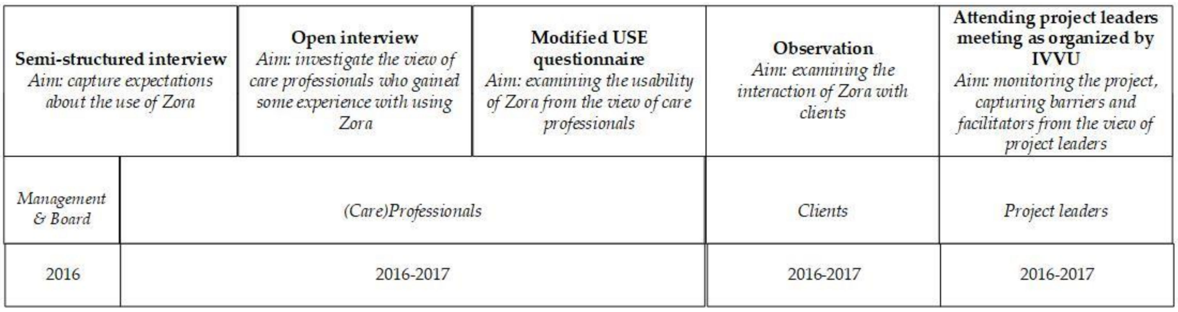


Healthcare organizations	Start Zora	2015												2016												2017											
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
A	13-10-2015										🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟩	▤	🟦	🟦	🟦	🟩	🟦	🟦	🟦	🟦	🟦	🟦	▥	🟦	🟦	▥	🟦	🟦	🟩	🟦
B	30-7-2015							🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟩	▤	🟦	🟦	🟦	🟦	🟩	🟦	🟦	🟦	🟦	🟦	🟩▥	🟦	🟦	▥	🟦	🟦	🟩	🟦
C	30-7-2015							🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟩	▤	🟦	🟦	🟦	🟩	🟦	🟦	🟦	🟦	🟦	🟦	🟩▥	🟦	🟦	▥	🟦	🟦	🟩	🟦
D	18-8-2015								🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	▤	🟩	🟦	🟦	🟩	🟦	🟦	🟦	🟦	🟦	🟦	▥	🟦	🟦	▥	🟦	🟦	🟦	🟦
E	18-8-2015								🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟩	▤	🟦	🟦	🟦	🟩	🟦	🟦	🟦	🟦	🟦	🟦	🟩▥	🟦	🟦	▥	🟦	🟦	🟩	🟦
F	30-7-2015							🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟩	▤	🟦	🟦	🟦	🟩	🟦	🟦	🟦	🟦	🟦	🟦	🟩▥	🟦	🟦	▥	🟦	🟩	🟦	🟦
G	15-1-2016													🟦	🟦	🟦	🟦	🟩	▤	🟦	🟦	🟦	🟩	🟦	🟦	🟦	🟦	🟦	🟦	🟩▥	🟦	🟦	▥	🟦	🟦	🟩	🟦
H	28-7-2015							🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	▤	🟦	🟦	🟦	🟩	🟦	🟦	🟦	🟦	🟦	🟦	🟩▥	🟦	🟦	▥	🟦	🟦	🟦	🟦
I	27-7-2015							🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟩	🟦	▤	🟦	🟦	🟦	🟩	🟦	🟦	🟦	🟦	🟦	🟩	🟩▥	🟦	🟦	▥	🟦	🟦	🟩	🟦
J	27-7-2015							🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟩	🟦	▤	🟦	🟦	🟦	🟩	🟦	🟦	🟦	🟦	🟦	🟦	▥	🟦	🟦	▥	🟦	🟦	🟩	🟦
K	11-9-2015										🟦	🟦	🟦	🟦	🟦	🟦	🟩	🟦	▤	🟦	🟦	🟦	🟩	🟦	🟦	🟦	🟦	🟦	🟦	🟩▥	🟦	🟦	▥	🟦	🟩	🟦	🟦
L	1-2-2016														🟦	🟦	🟦	🟩	▤	🟦	🟦	🟦	🟩	🟦	🟦	🟦	🟦	🟦	🟦	🟩▥	🟦	🟦	▥	🟦	🟦	🟩	🟦
M	21-8-2016									🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟩	🟦	▤	🟦	🟦	🟦	🟩	🟦	🟦	🟦	🟦	🟦	🟦	🟩▥	🟦	🟦	▥	🟦	🟦	🟩	🟦
N	21-8-2015									🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟩	▤	🟦	🟦	🟦	🟩	🟦	🟦	🟦	🟦	🟦	🟦	🟩▥	🟦	🟦	▥	🟦	🟦	🟩	🟦
O	24-2-2016														🟦	🟦	🟦	🟩	▤	🟦	🟦	🟦	🟦	🟩	🟦	🟦	🟦	🟦	🟦	🟩▥	🟦	🟦	▥	🟦	🟦	🟩	🟦

▤ Training session
▥ Practical worksession (train-the-trainer)

Figure 4. The monitoring and evaluation scheme of the project from the start in 2015. The first year of monitoring and evaluation was 2016, and 2017 was the second year. The field trial period of each location is indicated in blue. The measurement moments (observations and questionnaires) are illustrated in green. The start of the IVVU project is indicated by the red dotted line.

To monitor the project and to capture the facilitators and barriers of each subproject on location, the research staff attended the central meetings for project leaders organized by IVVU, which were held every six to eight weeks. The project leaders within each of the participating care organizations visited these meetings. At these meetings, notes were taken, categorized and systematized via open coding. This was done by marking the notes explaining the views and opinions of the project leaders about the use of Zora. In addition, an axial coding process was executed to rearrange the codes and to develop themes which indicate the facilitators and barriers in the use of Zora in daily practice. An overview of all the instruments used can be found in Figure 5.



<table>
<tr><td colspan="2">Semi-structured interview
<i>Aim: capture expectations about the use of Zora</i></td><td>Open interview
<i>Aim: investigate the view of care professionals who gained some experience with using Zora</i></td><td>Modified USE questionnaire
<i>Aim: examining the usability of Zora from the view of care professionals</i></td><td>Observation
<i>Aim: examining the interaction of Zora with clients</i></td><td>Attending project leaders meeting as organized by IVVU
<i>Aim: monitoring the project, capturing barriers and facilitators from the view of project leaders</i></td></tr>
<tr><td><i>Management & Board</i></td><td colspan="3"><i>(Care)Professionals</i></td><td><i>Clients</i></td><td><i>Project leaders</i></td></tr>
<tr><td>2016</td><td colspan="3">2016-2017</td><td>2016-2017</td><td>2016-2017</td></tr>
</table>

Figure 5. An overview of the methods used and the aims during the two-year research.

2.2.1. Semi-Structured Interviews

The semi-structured interviews used were to capture the expectations of board members and care professionals on the added value of Zora. These interviews were also executed to identify the facilitators and barriers prior to the use of Zora on a daily basis. The semi-structured interviews were based on the 7A theory for implementation [12]. The questions asked were about the awareness, availability, accessibility, affordability, acceptability, appropriateness and adequacy of

Zora. The questions were "When and in what way did you hear about Zora?", "What made you decide to start with the project?", "How does the use of the robot fit with the strategy, and is it aligned with your policy for daily care and the client's lifestyle?", "Did you work with a business plan?", "How do you want to create awareness about the use of Zora in care?", "What is the expected added value of using Zora?" and "Do you also work with other organizations with respect to the use of Zora?" All the interviews were recorded after permission was given. The Management and Board (*N* = 15) and professional carers (*N* = 20) were interviewed. The analysis of the phrases in the text was carried out with the open coding method followed by axial coding. The codes used were in analogy with the topics in the 7A theory [12], and the codes used were such as awareness, use in daily practice, willingness/eagerness to use, acceptance, technical/software issues, experiences with Zora, skills and functions of Zora.

2.2.2. Open Interviews

Open interviews were conducted to investigate the view of care professionals who gained some experience with using Zora about the added value of Zora and to reveal the barriers and/or facilitators for using the Zora robot in nursing homes after having gained experience with the use of Zora. To examine the actual use of Zora in practice, students visited the organizations for at least one day or up to four days to monitor how the organizations worked with Zora throughout the day. The variation in number of days was due to the availability and willingness of the project leader and the organization to cooperate. Students were only welcomed in 12 care organizations. Organizations were also given the opportunity to ask students for support with the use of Zora in daily practice; students had been trained in using the robot. Via this easy approachable contact with professionals, the facilitators and barriers could be revealed. In addition, the functionalities of how Zora could be improved from the perspective of daily practice was investigated.

2.2.3. Modified Use Questionnaire

A modification of the Usefulness, Satisfaction, Ease of Use (USE) questionnaire from Lund (2001) [13] was used. The internal validity was reached via discussions with students and staff in a think-aloud session about which questions needed to be added or replaced. Adjustments were made for the context of the use of the Zora robot, and the topics that were added concerned the effects Zora might have on clients and about the staff's work satisfaction. The questionnaire included the following dimensions: usability, ease of use, ease of learning, satisfaction, effects and work experience. Staff could also add remarks. The participants who filled out the USE questionnaire during the different research periods were all staff who worked with Zora. The participants had different ages, gender, education(al) (levels), functions and experiences with Zora (Table 1). There were participants whose position, for example, was activity counsellor, nurse, trainee, policy maker, physiotherapist or volunteer. Some of them had worked with Zora for a couple of hours; others worked with Zora on a regular basis of once a week or more. The majority of the staff received training in working with Zora. The students monitored the use of Zora in 13 organizations by using the modified USE questionnaire.

Table 1. An overview of the professionals' characteristics in the two research years.

Year	Age (Year) (Range (Mean))	Work Experience in Care (Years) (Range (Mean))	Gender	Received Training in Use Zora? (Yes/No)
2016 (*N* = 44)	16–57 (36)	0–30 (11)	77% female	35 Yes; 9 No
2017 (*N* = 18)	20–62 (43)	1–43 (16)	83% female	13 Yes; 5 No

2.2.4. Observations

Furthermore, activities with Zora were monitored via an observation method in accordance with Groenewoud et al. (2017) [14]. The validation of this method was set within their project. Students conducted more than 150 observation sessions during the development of games for people with dementia. With this method, the interaction of older people with a technology innovation was rated on mood and involvement. In each care organization, at least one group activity with Zora was observed. The observations were executed by students who had been instructed on how to conduct the observations. Students were trained to keep a neutral attitude towards clients and staff and also taught how to work in accordance with the protocol and how to use the observation form (see Supplement A). Two students were assigned to each observation, so both could observe half of the group. The group's activities included the participation of six to ten clients. During the observations, clients' moods and their involvement with Zora were scored from 15 min before the start of the activity, during the activity and at least 15 min after the activity with the Zora robot. Each student observed a maximum of four clients. All clients were older adults with a high intense care demand, similar to people with psychogeriatric problems. The scale scores mood range from −5 to +5 for very negative emotions (e.g., sad, afraid) to happy and joyful (e.g., laughing/relaxed facial expression and posture) respectively. The scale for involvement is from −1, scored for turning inwards (e.g., eyes closed or looking at the ground), to +5, scored for highly involved (e.g., concentrated on the activity, no distractions) [14]. The average scores were used to calculate the extent of mood and involvement of an individual client. Activities with Zora were conducted by care professionals and/or occasionally by volunteers or trainees. In addition, clients and professionals were questioned about their experience with Zora. Questions such as "Would you like to do the activity again?" and "What did you dislike about the activity with Zora?" were asked. An example of the observation on mood is given in Figure 6, and one for involvement is given in Figure 7 (both with 6 clients). The Y-axis gives the average score per client during one session on mood (Figure 6) or involvement (Figure 7) for each client. The X-axis reflects the time of the observation given in blocks of 5 min, starting, prior, during and after the activity with Zora. Each colored bar reflects one individual (client).

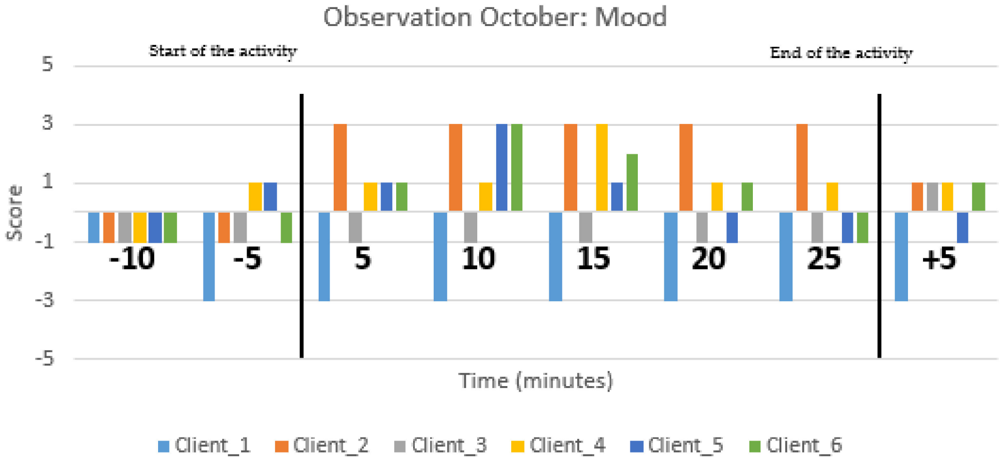


Figure 6. An observation score on mood during a group activity with the Zora robot in which six clients participated. All clients are from a psychogeriatric ward. Each colored bar represents one client. On the X-axis, the time prior to an activity (−10 and −5), the time during the activity (0–25) and after the activity (+5) are given. On the Y-axis, the mood score (−5 to +5) is given. The black vertical lines mark the start and end of the group activity with Zora.

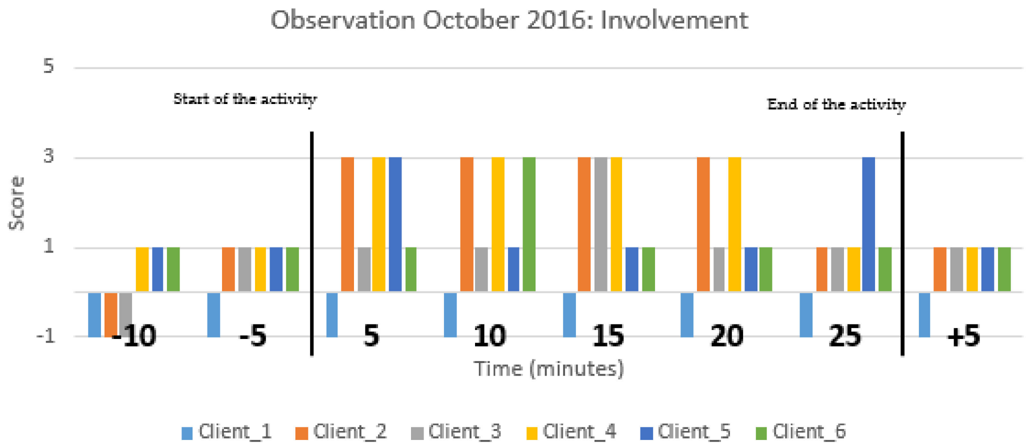


Figure 7. An observation score on involvement during a group activity with the Zora robot in which six clients participated. All clients are from a psychogeriatric ward. Each colored bar represents one client. On the X-axis, the time prior to an activity (−10 and −5), the time during the activity (0–25) and the time after the activity (+5) are given. On the Y-axis, the involvement score (−1 to + 5) is given. The black vertical lines mark the start and end of the group activity with Zora.

Ethical considerations: Ethical approval was given via the client and employees councils. All participating care organizations informed their employees and clients councils, and all received approval from their client councils to execute the project. The topic is not covered for review by the Medical Research Involving Human Subjects Act (http://www.ccmo-online.nl). Data from clients and professionals are protected in the cloud of the university only and are anonymized. Clients and professionals participated on a voluntary basis and were free to stop with the project/activity at any moment.

3. Results

The views of the Management and Board, followed by the views of the professional carers and the findings of the client observations are presented at the end of this section.

3.1. Management and Board

In total, fourteen board members and one member from the management staff were interviewed about their expectations regarding Zora.

Most of the board members and management staff first heard about Zora through the IVVU.

The view of the Management and Board is that participating in this project pioneer phase is aligned with the mission and vision of the care organizations. A quote given by one of the board members is "Zora fits in with the vision of the organization, in which we consider the well-being of our clients."

Furthermore, board members felt that the project offered the possibility to gain experience with technology in care. One of the quotes is "We want to anticipate the future."

Board members think that staff could explore and gain more experience in understanding the use of robots in daily care practice. A quote: "We want our employees to be exposed to technology innovations in healthcare."

They also envisioned that the project will enhance the view of staff on technological innovations in a positive way and stimulate the curiosity of professionals.

During the project, it became clear that it is necessary to improve the ICT (Information and Communications Technology)infrastructure in the care organization in order to contribute to the optimal functioning of Zora. That is why in the short-term Wi-Fi access in the buildings was improved. In addition, an implementation for further improvements of the ICT infrastructure was placed on the agenda.

Board members also expected that a snowball effect will occur in sharing knowledge between professionals about using social robots in general and more specifically about hints and tips for using Zora.

The expectation is that in the long run, working with Zora will be part of the daily routine.

At the start of the project, the care organizations did not collaborate with other organizations which are not part of the IVVU project. A quote: "There is no collaboration at this moment, but in the future, this would be possible when the use of Zora increases."

3.2. Professional Carers

3.2.1. Professional Carers' Views on Using Zora in Care

Based on the work satisfaction questions in the modified USE questionnaire, seventeen professionals working on the wards gave their views on how they experienced working with Zora. A third of the professionals stated that there is no collaboration for using Zora and that they don't experience support from colleagues. They did not know that they were allowed to choose to work with Zora (it was not mandatory). Two thirds of the professionals experienced more fun at work due to the fact that they were able to work with Zora. Almost all professionals (79%) indicated that they were happy when they worked with Zora. Most professionals felt that they received enough time to learn how to work with Zora. The support given was sufficient and aligned with their needs to use Zora. Almost every professional believed that clients are content when Zora is used; that is why they believe it is good to use Zora.

3.2.2. Facilitators and Barriers Mentioned

The following were seen as facilitators: the project leader's meetings, doing the project together, instruction training given by Zorabots and the availability of their Helpdesk by phone or email. Project leaders' meetings are planned for all persons from in the care organizations who use Zora, to receive support and to exchange knowledge and experiences. The Helpdesk responded, in general, within two days. In some care organizations, the Wi-Fi connection was not sufficient and was considered as a barrier. An optimal connection is necessary to use Zora properly and to update Zora remotely. Although Zorabots is constantly improving Zora, many new software versions were launched in a short period. In addition, starting Zora takes more time than expected by the professionals. A care professional stated, "The long start-up time is disappointing". For them, it was frustrating when Zora failed to start immediately. The battery life of Zora was also seen as too short according to the organizations. In 2016, Zorabots still had to develop a virtual composer to make it easier to create your own activities/compositions. This may improve the exchange of compositions between the care organizations. The care organizations mentioned that Zora's listening proficiency and speech skills were poor (speech is unintelligible, and the responses of elderly clients are misunderstood, leading to incorrect responses). A care professional said, "Zora has a tinny voice, and the language was unclear." This is seen as a barrier: The professionals experienced many software failures with Zora; see also Table 2 for a summary of the facilitators and barriers mentioned with regards to working with Zora.

Table 2. A summary of the facilitators and barriers regarding using Zora in 2016.

Facilitators Mentioned	Barriers Mentioned
• Project leader's meetings • Doing the project together/participation in the association of care-organizations in the Utrecht region (IVVU) project (peer support) • Instruction training by Zorabots • Availability of the helpdesk (phone/email) • Clients liked Zora's activities. • Zora stimulates people to move. • Zora provides reactions from clients. • Preprogrammed dances and games are funny for the clients, and clients are actively involved. • Preprogrammed music makes residents reminisce.	• Wi-Fi connection • Too complicated to program activities on Zora • Software updates of Zora composer • Start-up time • Battery life • Missing the virtual composer (a way to make programs without a connection with Zora) • Speech intelligibility and the interpretation by Zora of responses • Software failures (at the start of the project) • Experiencing time pressure • Few preprogrammed activities available • Communicating through Zora is difficult because you have to type the words on the composer at the same time (when you want to have a smooth conversation, you have to type very fast and without errors.).

The USE questionnaire ($N = 19$) supported the facilitators mentioned, for example, the ease of learning scores were high and also, the effect of Zora on the clients gets high scores, both >5 on a scale of 7. The ease of use and satisfaction about Zora score were lower, both scored <4 on a scale of 7. Table 3 shows the scores for 2016 and 2017; the scores of 2016 are based on a more than three months period of use.

Table 3. The scores of the modified Usefulness, Satisfaction, Ease of Use (USE) questionnaire, scored on a seven point Likert scale (except work experience five point scale). Given is the Mean (M) and Standard Deviation (SD).

Scores of the Modified USE Questionnaire	2016 ($N = 19$)	2017 ($N = 18$)
Usefulness (M ± SD)	2.94 ± 0.99	2.46 ± 0.94
Ease of use (M ± SD)	3.58 ± 1.00	3.02 ± 1.17
Ease of learning (M ± SD)	4.99 ± 1.04	4.81 ± 1.15
Satisfaction (M ± SD)	3.89 ± 1.51	3.04 ± 1.38
Effect of Zora on clients (M ± SD)	4.54 ± 1.31	3.71 ± 1.29
Work experience (M ± SD)	2.90 ± 0.38	2.89 ± 0.28

3.2.3. Professionals' Views on the Added Value for Clients

The professionals' view is that Zora stimulates some clients, leading to spontaneous participation. According to these professionals, Zora also has a positive effect on clients and it is highly valued. With some clients who were agitated or withdrawn, the use of Zora in a one-to-one situation gave positive results in the sense that a client who had not spoken for a while started to speak to Zora during an activity. For clients in day care and/ or with somatic problems, Zora lost credibility when having technical malfunctions. This group is more aware than residents with psychogeriatric problems that the robot is an instrument. At the same time, Zora may have added value to this group, in rehabilitation, for example.

3.2.4. Practical and Implementation Questions

In spring 2017, students visited most of the care organizations to retrieve information about the implementation issues. Issues raised by the (care) professionals were about software updates and QR codes (Quick Response codes). For most of the organizations, it is hard to update the Zora software. Running software updates is important because Zorabots is continuously improving the robot. In 2017, Zorabots introduced control via QR codes. It became clear that Zora had some issues with reading the codes. Printing the QR codes on different kinds of paper or with another format solved the problems to a large extent. Students made folders on the composer containing the QR codes of all the programs in order to make it easier for care professionals to use the QR codes.

In 2017, Zora was used more often than in 2016. In this experimental phase, the use of Zora went from ad hoc to a more structural use in 2017. Most of the organizations ($N = 13$) used Zora once or twice a week. Almost all users of Zora used the robot for movement activities while Zora was often used for cognitive training and music in combination with singing in groups sessions.

The work experience of the professionals in relation to Zora is similar to that of 2016. The findings from the USE questionnaires revealed that the professionals still experience more fun at work and that they are contented when they work with the robot. Furthermore, professionals' opinions are that clients are content when Zora is used. One professional said, "Clients do enjoy it when Zora is used."

As can be seen in Table 3, the topics of the USE questionnaire in 2017 scored a bit lower than in 2016, while professionals, for example, indicated in interviews that the ease of use increased due to the introduction of the QR codes for the control of Zora.

3.2.5. Facilitators and Failures Mentioned after One Year Use of Zora

The appearance of Zora has a positive effect on the clients. According to the professionals, the positive effect Zora has on clients is one of the success factors of the care robot, especially with the activities of dance, singing and games. The control pad, added by Zorabots, with the QR codes added, increased the ease of use of Zora. It makes it easier for professionals to work with Zora.

In 2017, Zorabots developed a virtual composer, as requested by the care organizations in 2016, to enhance the usability. The project leaders of the different care organizations believed that there could be other possibilities for the use of the virtual composer, namely to improve the exchange of compositions between the different care organizations in the project.

The most frequently mentioned (≥ 5) problems after one year of using were care professionals indicated that the comprehensibility was poor (users do not always understand the speech of the robot), the reliability (sometimes the robot is not working as expected), the listening proficiency is poor (the voice of the clients is not always audible for the robot), the starting time is still too long, the usability improved but not according to the expectations of care professionals and the stability is low (the robot falls unexpectedly when moving). A quote from one of the professionals: "Our clients have better hearing than Zora."

Problems that have been (mostly) solved by Zorabots or by care professionals since 2016 were the network connection (Wi-Fi) improved, a virtual composer was developed that enhanced the usability, fewer software failures were experienced due to several software updates, more preprogrammed activities were available via the new software and the battery life was prolonged.

3.3. Clients

3.3.1. Observations of the Activities

In the research period, 39 activities were observed with 245 clients. Figure 6 shows the mood of six clients, and Figure 7 shows the time on the involvement of six clients of a psychogeriatric ward. It is clear that not all clients were engaged during the ZORA activities. The involvement status of client 1 prior to, during and after the activity with Zora stayed the same, while the others were more involved, indicating a positive influence of Zora. In Figure 6, client 2 becomes more content when the activity with Zora starts, and after the activity, the mood score becomes lower. Figures 6 and 7 are the results of one observation during the same activity.

From 2016 onward, a slight increase was seen in the numbers of locations that worked with Zora, and more client groups were involved. More than 15 locations can be seen because Zora can be used on more than one ward (Figure 8). Group activities to stimulate the physical activities of sedentary older adults ranged from singing together to playing old traditional games (Figure 9). Zora is also used in a one-to-one setting.

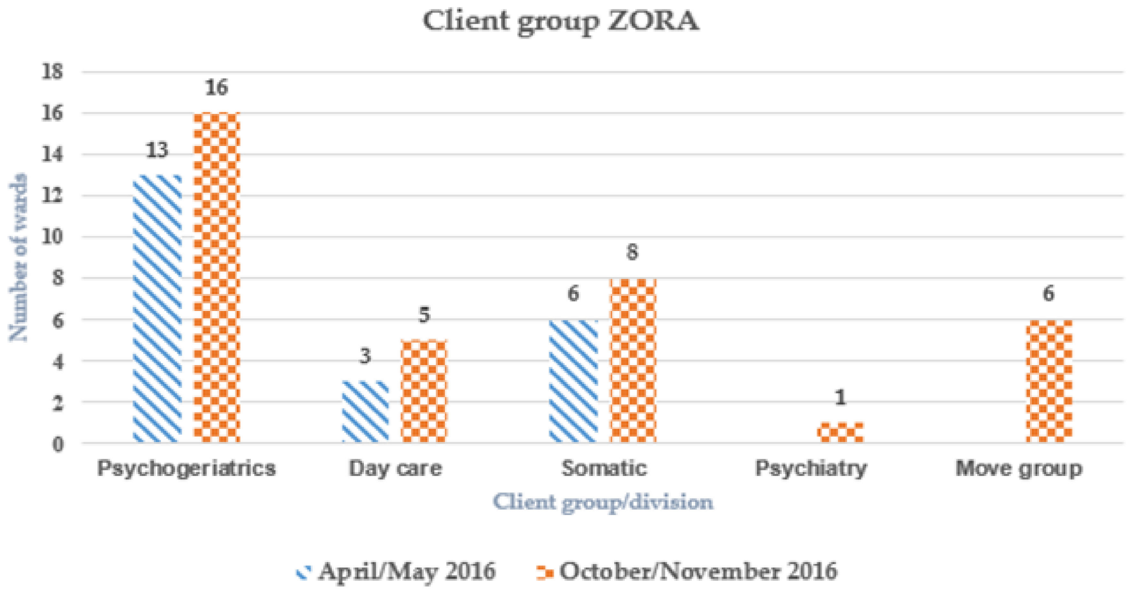


Figure 8. The client groups using Zora given per type of ward (2016): The "Move group" comprises clients who can do exercises to music.

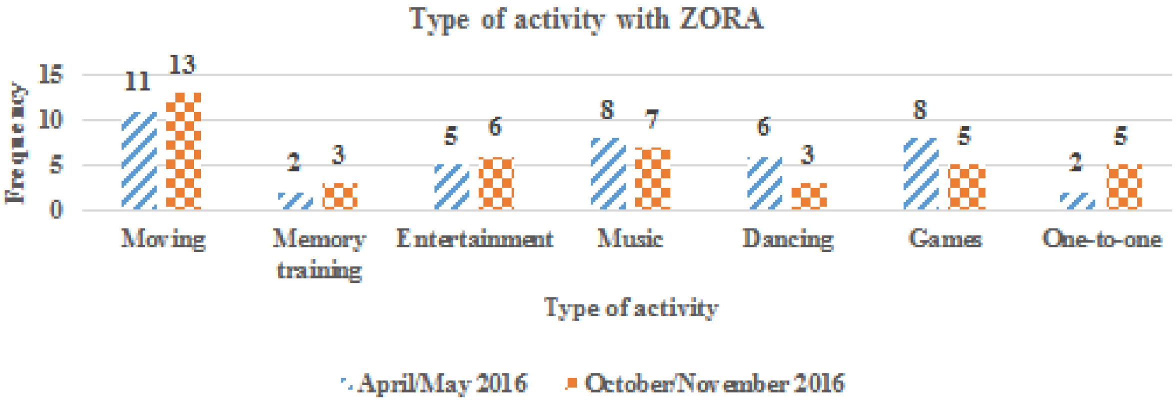


Figure 9. The number of locations where the different types of activities with Zora were given (2016).

3.3.2. Using Zora in Care Organizations

One of the goals after one year of use was to use Zora in more and different types of client groups. An estimate was made of the number of wards and locations based on 13 organizations. After one year of the introduction of Zora, Zora is used in approximately 59 locations/departments, so 37% of the total of 160 locations.

Zora is used in five different types of client groups, namely psychogeriatrics, day care, somatics, psychiatry and move groups. Move groups include groups with clients doing exercises to music. This is different from the music group in which music used is entertainment for listening to music and/or singing. All the locations examined used Zora for people with dementia (see Figure 8).

Zora is often used in group settings, for moving (rehabilitation), memory training (quiz), entertainment (stories), music (singing together), dancing (demo dances) or games (bingo). However, it is also possible to use the robot in a one-to-one setting. A quote about the one-to-one setting: "Especially in the one-to-one situation, Zora definitely gives added value for the clients." Professionals used this possibility to provoke interactions and emotions and to stimulate clients. Zora was also used occasionally in the case of restlessness. Eleven of the thirteen organizations used Zora in a one-to-one situation. This was not easy to establish for the care professionals due to the fact that it's time-intensive and that they have to type the words to communicate through Zora, but they mentioned that meaningful moments can be created, especially when using Zora for clients with dementia.

4. Discussion

The Zora project is in a pioneer phase in terms of the pyramid of technology innovation [11]. Looking at the pyramid of technology innovation, the use of Zora moved between the envisioned phase and the applied phase. The iterations between the operational phase and the applied phase are relevant in order to move towards a phase of acceptance. The acceptance of a new technology will occur when this innovation has reached full utilization. Full utilization not only addresses the use of the technology as instructed but also means that professionals a) are aware of the purpose of the innovation, b) are trained and competent to use the technology and c) are able to use the technology aligned with the context of the client situation and d) that the costs do not exceed the costs of normal, standard care. More focus on training could help the process toward full utilization. Zorabots advises users to follow a Zora training before using the robot, but this was not always the case. However, two project leader meetings were used to practise and to share experiences with each other, aligned with the "train the trainer" principle. Most of the end users who completed the questionnaire ($N = 18$) had training, but still, five professionals worked with Zora without any training at all.

Also, a more methodical approach by using the Normalization Process Theory of May and Finch (2009) could be used. This theory focuses on the implementation and evaluation of a complex intervention, new theories and business processes in healthcare [15]. The theory describes that it is important to focus on what people should do, not on the attitude. To reach the methodical approach, it is probably necessary to focus on collaboration and exchange but also on training, for example, by using the "train the trainer" principle. Furthermore, the iterations made the staff and management realize that they are part of the further development of the technology innovation and that they all act as co-designers of the Zora software. This means that the board and managers have to be careful in managing the expectations of the use of Zora in daily practice. The Management and Board became aware of the fact that the project with the care robot is a development project; this is apparent from the fact that almost every organization continued the project with Zora in 2017 without additional financial support given (subsidies).

While participating in the project, professionals realized that things can work out differently from what was than expected. Therefore, they needed to monitor the use of Zora carefully. During the spring of 2016, professionals experienced more difficulties than in autumn. They had negative experiences because of technical and software related issues; in autumn, they had enough experience to start with Zora. The spring and autumn trainings in 2016 were highly appreciated, as was the software update in summer. Professionals were less aware of the fact that a group activity with Zora has to be planned by themselves and that time to start with an activity has to be set aside. The findings in this study are comparable with the findings in a Finnish study about the impact of the Robot in Finnish Elderly Care [16]. They concluded that clients' reactions differ, and care professionals should know the clients well to anticipate their reaction. The Finnish study also concluded that care professionals need time to familiarize themselves and to experiment with Zora. Furthermore, they concluded that clients are positive about Zora. However, in our study, the Zora robot did not engage all clients as can be seen in Figure 7.

The relative decrease in scores of the USE questionnaire when comparing 2017 with 2016 can be explained by the fact that the care professionals stated that improvements of Zora take longer than they expected. They see the potential, but time after time, the problems frustrates them. This is probably the reason why they are less positive about Zora in 2017. Some of the quotes are "When Zora works correctly, it is a nice tool to use.", "Zora may contribute to the quality of care if it becomes more reliable." and "I feel that we are not much further with Zora than a year ago."

Prior to the visit of the organizations in 2016, all the care organizations were requested to provide their internal project proposal for using Zora at their own location. Each organization wrote a proposal about how they intend to use Zora, including a description of their project organizations, planning and strategy. The proposals of all the organizations were requested in order to examine whether their objectives are feasible. Unfortunately, not all the organizations provided their internal proposal. This could point to a lack of vision or interest in the implementation of Zora for daily practice on the wards.

In case of another social robot namely the KASPAR robot, used for children with autism spectrum disorder, professionals indicated that on an organizational or management level, vision needs to be developed and deployed on how to implement and use the KASPAR robot [17]. This indicates the relevancy of having a solid project proposal which should be authorized by the Management and Board. Moreover, in that particular study, training was only limited to instructions about the technological components and did not incorporate a social interaction (developing skills and feelings) component as recommended by Huijnen [17].

In our study, professionals had to explore which client group activities Zora can be used for optimally and what the optimal conditions are. At the end of this project, Zora was used successful in one-to-one situations and for movement activities during rehabilitation therapy. The monitoring in 2017 confirmed that the use of Zora is most successful in psychogeriatric departments. From May to November 2016, professionals gained more experience in composing a program for an activity using the preprogrammed activities available on the Zora composer. Professionals became more experienced in scheduling activities because they took into account the necessary preparation time for an activity with Zora. The professionals indicated that the number of preprogrammed activities should be higher, as they felt that composing a group activity themselves was too complicated. The online composer launched in 2017 could probably help professionals compose more specific programs because then, there is an opportunity to conduct activities without a connection with Zora and there is an option to share the conducted programs with all project leaders.

To gain more knowledge about which client groups the Zora care robot could be deployed effectively for, a more systematic way of implementation and evaluation of Zora activities is required. This current study could not answer the question "Does the Zora robot have an influence in the care organization?" because the use of Zora in the organizations was limited to one or two locations in each care organization.

In the elderly care setting, Zora has been welcomed and the clients appreciate Zora [18], but Zora is also used in other settings, for example for children with (physical or mental) disabilities. The research of Van den Heuvel, Lexis and De Witte (2017) concludes that the deployment of Zora seems to be promising in situations where clients need to learn movements again and also promising with (cognitive skills) communication and social interaction [19]. The Não humanoid robot, with software other than Zora, also has a positive influence on children with autism; it contributes to their involvement and achievement of goals in school activities [7].

4.1. Limitations

The quantitative data from the observations in spring and autumn of 2016 were not comparable because observations were not scored by the students in a comparable manner. In spring, students observed one activity at each location, and in autumn, two activities were observed. While in spring, each individual student observed a certain number of clients, in autumn, some of the students observed all the clients. Unfortunately, the observation method was not carried out consistently in accordance with the instructions. This is inherent in applied research in a practice-based setting when working with students. Different remarks were given in the observation forms as to how the students had experienced the observation. The following statements were made:

- "I was able to observe well, had a good view of the clients and was not distracted.",
- "My presence did not affect clients.",

- “My presence influenced clients; they looked at me all the time.”,
- “I participated in the activity to motivate clients to participate.” and
- “I was able to observe, but there was some distraction by people passing by.”

Another limitation was that each organization was able to set up its own project plan. The result was that some of the organizations gave professionals time allocated to Zora activities whilst others did not. This is one of the characteristics of a field trial with multiple cases. In future studies, the monitoring and evaluation should be executed in a more controlled situation. That would result in a more comprehensible comparison of the use of the Zora care robot in daily practice.

The willingness of the care organizations was very important in this research to get the information needed. Sometimes organizations were less willing; this affected the results.

4.2. Practical Implications

Working with a social robot like Zora is still in an experimental phase. Professionals have to be aware that things will not work perfectly immediately. Communication with staff and clients about this is crucial. Participating in such a project means acting as codesigners to enhance the technology innovation performance. In this phase, the Zora care robot showed added value when used in a rehabilitation setting to stimulate the movements of the clients while having fun. At the same, clients with psychogeriatric disorders might also benefit from the Zora activities, especially those where the Zora robot is used in one-to-one situations.

The students suggested some possible improvements based on their experiences and background. The suggestions they gave are practical and technical in nature. These suggestions have not been examined further.

- Think about how Zora can be used in the future for other activities.
- Use the function “word spotting” so Zora may respond (“listen”) better.
- Think about other ways of charging Zora, for example, with contactless charging; organizations will be able to use Zora for longer periods, for example, when they use Zora on a sheet with charging sensors, the robot can be charged while Zora is dancing.
- Use Artificial Intelligence Markup Language (AIML) to make it easier to have conversations. AIML works with programming patterns/scripts.

5. Conclusions

According to the professionals, the Zora robot can have a positive influence on the clients and staff. All the organizations see the potential of Zora and see possibilities for alternative ways of applying Zora in daily practice. All the care organizations are still willing to continue using robot Zora so as to offer clients alternative ways for pleasure and entertainment and rehabilitation sessions.

The results of this study are based on a single field trial, and therefore, any generalization should be treated with caution.

Supplementary Materials: The following are available online at http://www.mdpi.com/2227-9032/7/1/31/s1, Supplement A: Observation scheme: Mood and Involvement. This scheme is used during the observations at the care organizations.

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References

1. Maisonnier, B.; Gelin, R.; Koudelkova Delimoges, P. Humanoid robots for elderly autonomy. *Gerontechnology* **2014**, *13*, 77–78. [CrossRef]
2. Kachouie, R.; Sedighadeli, S.; Khosla, R.; Chu, M.T. Socially assistive robots in elderly care: A mixed-method systematic literature review. *Int. J. Hum. Comput. Interact.* **2014**, *30*, 369–393. [CrossRef]
3. Mordoch, E.; Osterreicher, A.; Guse, L.; Roger, K.; Thompson, G. Use of social commitment robots in the care of elderly people with dementia: A literature review. *Maturitas* **2013**, *74*, 14–20. [CrossRef] [PubMed]
4. Sabanovic, S.; Bennett, C.C.; Chang, W.-L.; Huber, L. PARO robot affects diverse interaction modalities in group sensory therapy for older adults with dementia. In Proceedings of the 2013 IEEE International Conference Rehabilitation Robotics (ICORR), Seattle, WA, USA, 24–26 June 2013.
5. Yu, R.; Hui, E.; Lee, J.; Poon, D.; Ng, A.; Sit, K.; Ip, K.; Yeung, F.; Wong, M.; Shibata, T.; et al. Use of a therapeutic, socially assistive pet robot (PARO) in improving mood and stimulating social interaction and communication for people with dementia: Study protocol for a randomized controlled trial. *JMIR Res. Protoc.* **2015**, *4*, e45. [CrossRef] [PubMed]
6. Bemelmans, R.; Gelderblom, G.J.; Jonker, P.; de Witte, L. Effectiveness of robot Paro in intramural psychogeriatric care: A multicenter quasi-experimental study. *J. Am. Med. Direct. Assoc.* **2015**, *16*, 946–950. [CrossRef] [PubMed]
7. Desideri, L.; Negrini, M.; Malavasi, M.; Tanzini, D.; Rouame, A.; Cutrone, M.C.; Bonifacci, P.; Hoogerwerf, E.J. Using a humanoid robot as a complement to interventions for children with autism spectrum disorder: A pilot study. *Adv. Neurodev. Disord.* **2018**, *2*, 273–285. [CrossRef]
8. Van Houwelingen, C.T.; Ettema, R.G.; Antonietti, M.G.; Kort, H.S. Understanding older people's readiness for receiving telehealth: Mixed-method study. *J. Med. Internet Res.* **2018**, *20*, e123. [CrossRef] [PubMed]
9. Peek, S.T.; Luijkx, K.G.; Rijnaard, M.D.; Nieboer, M.E.; van der Voort, C.S.; Aarts, S.; van Hoof, J.; Vrijhoef, H.J.; Wouters, E.J. Older adults' reasons for using technology while aging in place. *Gerontology* **2015**, *62*, 226–237. [CrossRef] [PubMed]
10. Nictiz; NIVEL. eHealth-monitor 2017: Kies bewust voor eHealth. 2017. Available online: https://bit.ly/2GlOVn6 (accessed on 21 November 2018).
11. Van Mensvoort, K.M. *Pyramid of Technology: How Technology Becomes Nature in Seven Steps*; Eindhoven University Lectures; Eindhoven University of Technology: Eindhoven, The Netherlands, 2013; Volume 3, Available online: https://bit.ly/2sSfSJS (accessed on 21 November 2018).
12. Krout, J. An overview of older rural populations and community-based services. In *Providing Community-Based Services to the Rural Elderly*; Krout, J., Ed.; SAGE Publications, Inc.: Thousand Oaks, CA, USA, 1994; pp. 3–19.
13. Lund, A.M. Measuring usability with the USE Questionnaire12. *Usability Interface* **2001**, *8*, 3–6.
14. Groenewoud, H.; De Lange, J.; Schikhof, Y.; Astell, A.; Joddrell, P.; Goumans, M. People with dementia playing casual games on a tablet. *Gerontechnology* **2017**, *16*, 37–47. [CrossRef]
15. May, C.; Finch, T. Implementing, embedding, and integrating practices: An outline of normalization process theory. *Sociology* **2009**, *43*, 535–554. [CrossRef]
16. Melkas, H.; Hennala, L.; Pekkarinen, S.; Kyrki, V. Human impact assessment of robot implementation in Finnish elderly care. In Proceedings of the International Conference on Serviceology, Tokyo, Japan, 6 September 2016; pp. 6–8.
17. Huijnen, C.A. A Touching Connection: Robot Mediated Interventions for Children with Autism Spectrum Disorder. Doctoral Dissertation, Maastricht University, Maastricht, The Netherlands, 2018.
18. Waardigheid en trots. Verpleeghuiszorg 2025. 2016. (In Dutch). Available online: https://bit.ly/2pQXzD4 (accessed on 21 November 2018).
19. Van den Heuvel, R.; Lexis, M.; De Witte, L. Introducing ZORA to children with severe physical disabilities. Presented at the AAATE 2017, Sheffield, UK, 12–15 September 2017; pp. 510–516. [CrossRef]

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A Review of Age Friendly Virtual Assistive Technologies and their Effect on Daily Living for Carers and Dependent Adults

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Abstract: Many barriers exist in the lives of older adult's, including health, transport, housing, isolation, disability and access to technology. The appropriate integration of technology within age-friendly communities continues to offer possible solutions to these barriers and challenges. Older adults and disabled people continue to be affected and marginalized due to lack of access to the digital world. Working collaboratively with planners, policy makers and developers, social and living spaces in the future will ensure that residents are equipped to live in an era that continues to be led by, and is dependent upon, access to technology. This review paper uniquely draws together the small volume of literature from the fields of gerontology, gerontechnology, human computer interaction (HCI), and disability. This paper examines the national and international age-friendly frameworks regarding older adults who are carers of dependent people with disabilities.

Keywords: ICT; Age in Place; Disability; Smart Technology; Intergenerational Relationships; Connected Health

1. Introduction

The age friendly movement commenced in 2007 when the World Health Organization (WHO) set out its global plan and framework [1] for Age-Friendly Cities. The WHO defines age-friendly as "*policies, services, setting and structure support and able people to age actively*" [1] (p. 5). This programme brought together 33 cities across 22 countries to identify and ascertain what key elements within the urban environment facilitated and supported active and healthy ageing (AHA) [2]. The WHO Global Network of Age-Friendly Cities was established for four reasons:

(1) To link participating cities to WHO and to each other;
(2) To facilitate the exchange of information and best practices;
(3) To foster interventions that are appropriate, sustainable and cost-effective for improving the lives of older people; and
(4) To provide technical support and training [2].

To date, the global population stands at nearly 7.6 billion people, with 60% of world's population residing in Asia, 17% in Africa, 10% in Europe, and 9% in Latin America and the Caribbean. China and India continue to be the most populous countries, with 19 and 18% respectively [3]. The growth of the population is increasing at a rate of 1.10 per cent per year, slower than the last decade at 1.24 per cent per year. By 2030, the United Nations (UN) estimate the global population will reach 8.6 billion and increase to 9.8 billion by 2050. The global population is estimated to rise to 11.2 billon people by 2100 [3].

The WHO Global Network of Age-Friendly Cities builds on the WHO active ageing framework. Fitzgerald and Caro [4] reported the WHO definition of 'active ageing' as "*the process of optimizing opportunities for health, participation, and security in order to enhance quality of life as people age. It applies to both individuals and population groups*" (p. 12) [5]. More recently, the WHO has replaced the previous policy [5] with the term and notion of 'Healthy Ageing' [6]. The WHO 'Healthy Ageing' policy has been set as a goal to achieve between 2015 and 2030 [6]. The WHO defines Healthy Ageing as "*the process of developing and maintaining the functional ability that enables wellbeing in older age*" [6]. Under this policy, the needs and abilities of an individual are measured through the following criteria:

- Meet their basic needs,
- To learn, grow and make decisions,
- To be mobile,
- To build and maintain relationships, and
- To contribute to society [6].

There are several points which one should consider under this definition, including: the *intrinsic capacity* associated with the mental and physical abilities of an individual (i.e., walking, thinking, seeing and hearing). These can be affected by a disease, injury and age-related conditions. *Environment* includes several factors, including the home, community and society, interwoven in conjunction with relationships, attitudes, values and policies. Health and social care provisions and systems should ideally be interconnected, in a bid to support individuals' *intrinsic capacity* [6]. There are two primary considerations noted by the WHO and their Healthy Ageing framework:

(1) **Diversity:** There is no typical older person. Some 80-year olds have levels of physical and mental capacity that compare favourably with 30-year olds. Others of the same age may require extensive care and support for basic activities like dressing and eating. Policy should be framed to improve the functional ability of all older people, whether they are robust, care-dependent or in between [6].

(2) **Inequity:** A large proportion (approximately 75%) of the diversity in capacity and circumstance observed in older age is the result of the cumulative impact of advantage and disadvantage across people's lives. Importantly, the relationships we have with our environments are shaped by factors such as the family we were born into, our sex, our ethnicity, level of education and financial resources [6].

This paper examines the national and international age-friendly frameworks with respect to older adults who are carers for people with disabilities. Within its overview of existing age-friendly frameworks and contemporary evidence, an overview of state-of-the-art technologies is presented, followed by recommendations for expanding this work.

2. Background Literature

2.1. Age-Friendly Communities

Since the turn of the millennium, there have been several age-friendly initiatives building on the WHO Global Age-friendly framework [1]. A review conducted by Steels [7] provides a synopsis of global age-friendly cities and frameworks [2,8–12], illustrating their key features. Fitzgerald and Caro [4] presented several features and elements which they deemed necessary to meet the minimum requirements of an age-friendly city or community. These features include pre-conditions that must be in place before any age-friendly initiative can commence. The preconditions include: the density of population, climate, weather, topographical features (communities residing on hills such as the favelas in Brazil), social and civic organisations, health and social care provision [4]. Within diverse communities, ensuring residents have a variety of mobility options is crucial. This includes ensuring the availability of public transport connections, accessible places to walk, and community transport services (e.g., dial a ride). Within these communities, the requirements of outdoor spaces and buildings to facilitate and enable residents to successfully age in place is central to the success of the environment. Early consultations between residents, planners and developers to identify key challenges and potential barriers are crucial to the achievement of all of the above aims. Barriers and challenges may not be identified, challenged and amended without consultations between the residents, planners and developers. Moreover, community activities require that residents respectfully build up their relationships with one another in conjunction with their friends, family and support networks, ensuring residents are respectful of each other [4]. Several approaches such as focus groups, face-to-face meetings, interviews (e.g., one-to-one or community) or surveys can be conducted to identify needs and requirements from residents. It is important to ensure that all interested parties have the opportunity to communicate and share their expectations and concerns.

Buffel [13] has conducted co-researching and co-production activities as part of the Manchester Age-Friendly strategy (MAS) [2]. A significant element in the success of MAS is the enablement of actors to share their experiences and learn from each other about the needs and requirements of their communities. The concept of an 'Age-Friendly Business' has enabled businesses in the community to make alterations to facilitate ease of access or service by residents [4]. Such alterations or changes include: assisted devices to open doors, increasing the font size on menus, and changing the height and access to toilet dispensers [4]. Already, across America and Ireland businesses have undertaken alterations to provide residents with ease of access to the premises or services. Consequently, many businesses increased their income as a result of word-of-mouth approval in the community [4].

In the UK, the city of Manchester was recognized by the WHO as an age-friendly city-region, chosen as part of the age-friendly initiative programme [14]. McGarry and colleagues [2] provide an overview of the two frameworks and approaches set out by the WHO and MAS [15].

The WHO age-friendly strategy includes eight domains of interest: (1) Outdoor spaces and buildings; (2) housing; (3) transportation; (4) social participation; (5) respect and social inclusion; (6) civic participation and employment; (7) communications and information and (8) community support and health services. Primarily, the MAS 2020 age-friendly strategy [15] focuses on six of the eight domains outlined by the WHO and includes: (1) lifetime neighbourhoods (environment, community safety, housing, transport); (2) cross-cutting themes: improving engagement, improving relationships; (3) cross-cutting themes: promoting equality; (4) income and employment; (5) culture and learning, and (6) healthy ageing, care and support services [2].

To date, age-friendly initiatives have primarily focused on the needs and requirements of existing ageing populations. However, there is little consideration and discussion surrounding the needs of mid-older adults (<~45 years old) who are carers of children/young people and dependent adults with disabilities. Furthermore, what are the implications, based on the national and international age-friendly strategies associated to successfully age in place?

The aim of this paper is to review age-friendly virtual assistants and their effect on carers and dependent adults in contemporary society.

2.2. Methods

This paper will be underpinned by identity theory posited by Burke & Stets [16]. The notion of identity theory posits persons residing in society the opportunity to reserve a stable environment, irrespective of any slight inconsistencies. This is succeeded by the change in peoples' actions, which in turn results in the perceptions of persons aligned with the standard or ideal self [16], while the balance within one's environment shifts based on the deviation or non-verification of a person's identity; this results in a person's modification of their behaviour.

For those parents, guardians and carers who are residing in disability friendly communities and age-friendly environments, they have the opportunity to continue to live alongside their dependent child. This, in turn, has the potential to alleviate stress, social isolation, loneliness, and promote independence for both carers and dependent adults. Giving dependent adults the opportunity to live semi-independently or fully-independently alongside their parents, guardians and carers will contribute to the creation of and dissemination of good practice.

Age-friendly cities can provide harmonious, supportive, inclusive living and social environments regardless of age, race, gender or disability through face-to-face communications, created and supported by technology. Through a myriad of activities, age-friendly cities can help to identify, and tackle problems experienced by the residents, while providing immediate and on-going support for both the carer and the dependent adult. Conversely, by encouraging the opportunities for social encounters and by building upon the existing age-friendly frameworks, there are potential benefits and improved social cohesion for all residents in the wider community.

2.3. Digital Exclusion

Automation and accessibility of goods and services (e.g., banking, shopping, health care appointments) are increasing, which is resulting in limited access by some populations. According to the UK Government "*Digital inclusion, or rather, reducing digital exclusion, is about making sure that people have the capability to use the internet to do things that benefit them day to day*" [sic] [17]. Moreover, in the UK Government Digital Inclusion Strategy 2014 policy paper, Francis Maude, Minister for the Cabinet Office, stated, "*We need to equip the whole country with the skills, motivation and trust to go online, be digitally capable and to make the most of the internet*" [17].

A worrying phenomenon relates to the continuation of digital exclusion relating to the "vulnerable and disadvantaged groups in society" [17]. The policy identified five groups within society that are most likely to be digitally excluded:

(1) Those in social housing,
(2) Those on lower wages, or unemployed,
(3) Those with disabilities,
(4) Older people, and
(5) Young people. Only 27% of young people who are offline are in full-time employment [17].

Within existing debates surrounding digital cities, there are vulnerable members of society who are marginalized and penalized because of limited access to and understanding of the digital world. This in turn, has the potential to be a detrimental factor relating to their health and independence.

The digital divide is still an ongoing topic of discussion, which results in many communities, and individuals not being able to access rudimentary technologies such as a computer and/or access the Internet [18–22]. Ferguson and Damodoran [23] reported how the digital divide primarily focuses on the 'haves' and the 'have nots.' However, it also relates to three points that differentiate those who associated with the digital divide. First, connectivity: this relates to appropriate access to equipment. Second, capability: ensuring everyone has the skills and knowledge to conduct tasks and to retrieve relevant information. Finally, content: the perception of relevant content and the *"motivation from the 'pull' of compelling functionality"* (p. 5) [23].

Within the digital divide, digital participation is important for all citizens, be it those who are vulnerable, or who are slow adopters, from the older/elderly person to the wealthiest of individuals. It is important to understand the motivations of digital participation to understand what the barriers are to using technology, and to ensure access and availability is met. Ferguson and Damodoran [24] stated:

> "[...] *widespread digital participation can only come about through the confident and successful take up by older people and others in the digital world and the way that services relevant to their needs are designed and presented*". (p. 5)

The authors believe that by collaborating and communicating with communities at both grassroots networks and with national organisations, there are opportunities to learn and understand the barriers to and enablers of technology faced by older adults and slow adopters. Currently, there is a growth of work in the domains of the digital divide and older adults' engagement. However, there is a paucity of work surrounding those individuals known as 'slow adopters.' This cohort of society are individuals or communities who are not just older people, but who are mid-older and younger people, who may live in social housing; they are people who are unemployed or who are employed on precarious contracts or receive low incomes. They are individuals with disabilities, who reside in different communities both culturally (e.g., traveller) and geographically (e.g., rural), or who are homeless and are moving between towns and cities, or who are moving around different areas within one place, or young people who are not in employment, education or training (NEETs). All of these categories of citizens may have no direct or limited access to public funds [24]. For some citizens, their level of literacy, numeracy and digital literacy skills pose additional barriers to their digital participation.

In January 2019, the NHS (National Health Service) Digital announced the commencement of a project focusing on the use of digital technologies by homeless community outreach workers in Hastings, UK [25]. The project collaborates with several partners including NHS England, NHS Digital, Good Things Foundation and The Seaview project. The aim is to use digital technologies to ensure a suitable approach is conducted by and between support workers/organisations and the homeless community. Physical locations such as libraries can provide public access to rough sleepers who wish to search for specific information (e.g., health and wellbeing centres) on the Internet. However, little work has focused on the barriers and enablers to technology faced by individuals of the homeless communities. Additional issues and challenges can hinder technology use by rough sleepers and include the varying types of data plans, access to charging points for a mobile/smartphone, and possible exclusion from accessing public Wi-Fi. Furthermore, many mobile phone plans require a data contract and bank account, which too could be problematic for rough sleepers who do not have access to this type of information or accounts. There are many reasons why slow adopters and older adults have barriers to adopting and using technology in their lives. This can include embarrassment around their lack of technical knowledge and skills, and the design of technologies, while there could be limited opportunities for learning outside of the workplace [24]. By understanding the needs of marginalized and disadvantaged communities, support and guidance can be offered to ensure individuals within these respective communities can become digital citizens. The UK Government [17] has outlined its digital strategy, although, when it was outlined three years earlier, Adam Hillmore stated:

> *"We should not consider increasing online presence among older people on its own; it is easier to bring people together as a community and to make using the internet part of that"*. (p. 5) [24]

Taking a grassroots approach, as suggested in the quote above should safeguard all voices are heard within respective communities. Ferguson and Damodoran noted that the position of local governments is ideally situated within their communities to take the lead and to facilitate a 'user-driven' approach [24]. Local government is the ideal actor to take the lead role within communities and towns regarding digital participation. Given that local governments own public space and buildings such as libraries, they are ideally placed to input into schools and partnerships. Taking on this role, local governments can encourage their respective networks and partners to become active members across their communities. This, in turn, may link to different initiatives that can also benefit from local government assisting with key issues [26]. Furthermore, understanding the exact needs and requirements of marginalized communities is facilitated by employing a co-design/creation approach rather than a top-down process. Seven needs have been reported by Ferguson and Damodoran [23] based on specific user characteristics:

(1) Readily available,
(2) Trusted and sustained,
(3) Delivered in familiar, welcoming and local venues,
(4) Embedded in social activities and personal interests,
(5) Free of time pressure and assessments,
(6) Inclusive of problem-solving/trouble-shooting, and

(7) Offering impartial advices and 'try before you buy' [23,27].

Furthermore, Ferguson and Damodoran argued:

> *"The UK Government Digital Strategy (launched 1 March 2017) states that it seeks to simultaneously implement strategies intended to address connectivity issues (with the aim of completing the roll-out of 4G and superfast broadband by 2020) and capability issues (e.g., creating the Digital Training and Support Framework)"*. (p. 6) [26]

Nonetheless, there are concerns that still need to be addressed for rural and marginalized communities, and for those individuals who are slow adopters and older adults. The latter is equally important, because, for many people, they learn how to use technology in the workplace. For those people who have retired and were not exposed to technology, this too will result in limited and low digital participation [26]. Moreover, Ferguson and Damodoran [26], note how evidence indicates *"basic skills training has reached most of those for whom it is appropriate"* (p. 6). However, while basic skills training may benefit some people in society, for those who are slow adopters, it is likely that they have not had the opportunity [26].

Indeed, for many people using technologies to access the digital world, it is an integral part of their daily lives and "*not using the internet is different from 'digital exclusion.' Some non-users have made an informed and reasoned choice to be offline*" (p. 1) [28]. While access to the digital world is available in both public and social spaces, one requires a digital device (i.e., a computer, laptop, smartphone or tablet) to access the Internet, which in turn leads onto other digital worlds. Moreover, the Centre for Ageing Better notes, "*As opposed to digital inclusion operating as a standalone intervention, digital support should be embedded within the delivery model of a range of local community and public services wherever feasible and appropriate*" [28]. With on-going austerity and cuts to public services, it is of paramount importance that local and national governments do not marginalize and penalize vulnerable members of society further.

Mouland, Richardson and Damodoran [28] stated "*Even for those who are engaged with existing technologies, the pace at which technology develops places significant demands on us to learn new behaviors and skills. Those who were raised in a digital world will still hit these obstacles over time and find new technologies harder to adopt—particularly after leaving the workforce*" (p. 6) [28].

3. Technology Solutions

Phenomenal technology developments have occurred over the last twenty years in the field of enabling industries (i.e., video games, smartphone and small, medium enterprises (SME)) the opportunity to design, develop and enhance solutions to reach a broad spectrum of users in society.

In the proceeding section, the authors will review different technologies, ICTs and contemporary research projects aimed to facilitate and enhance users' accessibility and ease of use, to support successful ageing in place through active and healthy ageing (AHA).

3.1. Overview of Virtual Assistants

In recent years, we have seen the development of what is been coined as 'personal assistants' or 'virtual assistants,' designed in the form of 'speakers' that can be placed around the house and respond to a voice(s), which in turn executes the command(s). The most commonly known devices are smart speakers/personal assistants such as the Amazon Echo or Alexa [29,30]. There are other devices with similar capabilities known as Google Home and Google Home Mini. Contemporary research has suggested these 'personal assistants' can offer older adults the ability to maintain living independently, and possibly support ageing in place. Indeed, according to the National Institute for Health Research (NIHR), "*A number of studies have explored integrated monitoring and response systems to check the health, wellbeing and safety of older people living at home. Some of these are focused on particular groups, like those with dementia. They range from systems using sensors, alarms or wearable technology to cameras, smart televisions and service robots*" [31] (p. 3).

Therefore, the functionality of these virtual or personal assistants can provide a user with a wealth of information (e.g., weather reports, checking events in a calendar), coupled with the ability to control their heating and lighting on or off via three automation and third-party apps.

Additional features available through the virtual assistants offer users the opportunity to control what music they listen to (via streaming services), set and manage alarms, order food (e.g., Domino's or Pizza Hut) and set reminders (e.g., for medication) [17–23,32–41]. Homes which have 'home automation' virtual assistants have the capacity to interact and connect with several manufacturers, including Philips Hue and Nest [39–41].

Some existing users of Alexa say they feel a strong bond with their virtual assistant and perceive their devices as a member of the family [30,41]. The notion of using Alexa and similar devices or virtual assistants within the home can offer the users or residents a multitude of opportunities to engage and receive information. Whether you are an older adult, a carer or a dependent adult, there are opportunities to age in place by connecting with these types of devices through the primary interaction of voice recognition.

Early adoption of new technology is key. For many people in society, learning how to use a new piece of technology can be worrisome or a steep learning curve [42]. Nevertheless, for some people it is crucial that the technical infrastructure allows several devices to seamlessly operate together, in order to deliver an automated, self-monitoring smart home [43–46].

Li and colleagues [44] proposed the notion of neighbourhoods being connected via wireless sensors, which, if triggered through deviant activity, can be recorded via surveillance cameras, which in turn would inform all residents connected on the smart system. This follows the original conception of the 'Neighbourhood Watch' scheme across the UK, where residents involved in the scheme reported any suspicious behaviour or crime to the police. A 'smart, connected,' age-friendly and disabled-friendly community gives residents the potential to detect problems and protect one another.

3.2. Integrating Virtual Assistants into the Lives of Carers and People with Disabilities

While research concerning virtual assistants is still in its infancy, these devices have great potential for people with a multitude of disabilities. For example, Hampshire County Council trialled the Amazon Echo to help both the elderly and disabled [47,48] people in their communities. Similarly, Virgin Trains have integrated Alexa to assist disabled passengers [49] with their communication and interactions. Several factors affect dependent adults (e.g., physical, cognitive, speech and visual impairments). These include low self-esteem and confidence and limited social networks, which in turn increase their risk of loneliness, poor health and wellbeing. In some instances, one's disability may fluctuate throughout one's life, and may deteriorate over time. Therefore, the use of virtual assistants (Amazon Echo, Alexa, Google Home and Google Home mini) can offer dependent adult's additional options to communicating with friends and family members, more so than only participating in dialogue when a specific answer is needed.

Devices including Amazon Echo, Alexa, Google Home and Google Home mini provide individuals with disabilities the opportunity to communicate with the device and respond to commands. One example of a disability that may affect an individual's communication (i.e., speech and language) is autism spectrum disorder (ASD). Many individuals who have been diagnosed with ASD require an intervention focusing on the "*aspects involved in producing or understanding speech and language*" [50]. The use of these devices may initially cause frustration for the individual, given the initial inability of the device(s) to decipher speech. However, one of the benefits of virtual assistants is the potential to help improve speech.

An example of this is demonstrated in the written account of Megan D, who reflected on her six-year-old, disabled son, and who used the virtual assistant Alexa. Megan D noted how her son communicates and connects with people through a series of questions that fall into his areas of interest. Regardless of whether the son has asked these questions earlier on in the day or in previous days, the use of Alexa is the primary way for the son to connect and communicate [51]. Since purchasing the

Alexa device, Megan D has observed changes in her son. Typically, through repetition of questions, Megan D's son regularly engages in conversations with the Alexa device. However, it is the virtual assistant's capacity to answer the son's repetitive questions on demand that has improved the quality of life of Megan D and her son. Furthermore, the ability to recognize different voices and language patterns makes this type of virtual assistant an ideal companion for many individuals with ASD.

The use of virtual assistants can be beneficial to individuals who have been diagnosed with a neuro-degenerative condition such as multiple sclerosis (MS). Hampshire County Council, in conjunction with NHS Digital, have launched a scheme which explores the integration of the Alexa device into adult service care plans. For example, Claire Williams, who has been diagnosed with MS, was one of the recipients of these virtual assistants. Williams notes "*I can do loads of things for myself now which when I was first diagnosed with MS seven years ago, I didn't think I'd be able to do.*" Furthermore, Williams has reported positive improvements within her life due to the integration and use of the Alexa virtual assistant. Williams has used the device for many things, including turning on the lights, playing music, reading books and adding items to the shopping list, which is on her husband's phone [52].

Likewise, Bogost shares his experiences of using Alexa with his 82-year-old father, who is legally blind and has been since the age of 18. Bogost notes how the virtual assistant offers a "*hands-free operation for able-bodied folk and new accessibility for those with limited mobility or dexterity*" [53]. Furthermore, Bogost [53] recognises his father's willingness to embrace the new technology, for example, using it playfully by asking the virtual assistant a series of questions he knows it cannot answer.

While we have focused on the use and installation of virtual assistants in the home and an age-friendly environment, there are further opportunities for bringing ageing and disability together. These opportunities do not just safeguard against social disconnectedness, reduce isolation, and improve communication, but also ensure physical and cognitive fitness can be maintained, therefore demonstrating how ICT can help an AHA be achieved. There have been several key pieces of research that have integrated technology investigating both physical and cognitive activities. In the following section, we provide an overview of contemporary research that has the potential to offer older adults, carers and dependent adults the opportunity to engage and interact with the technologies aimed at enhancing AHA and intergenerational relationships.

3.3. Overview of Exergames

The iStoppFalls (ISF) European Union (EU) Project [54] was an international, multi-centre study, which included a single-blind, two-group randomized control trial (RCT) involving 160 community-dwelling older adults aged 65 years and over [55]. ISF aimed to design and develop information, communication and technology (ICT) based systems using physical activity to reduce the risk of falling by adults aged 65 years and over. Additionally, strength and balance exercises were conducted via user interaction and engagement with three purpose-built exergames. Gschwind and colleagues [55–57] describe the ISF ICT-based system, which was comprised of several types of technologies (Figures 1 and 2). The ISF system offered users a diverse range of interactive approaches (Figure 3), including gesture, a remote control, speech and a tablet device. Participants randomized to the intervention group (IG) had access to the ISF system through several menu options (Figure 4). These included: fitness training, reviewing user performance, meeting point (for example, virtual meeting place for all users), falls and health prevention.

Three purpose-built exergames were designed, developed and implemented into the ISF system. Marston and colleagues [57,58] provide an extensive overview of the purpose-built exergames: the Bumble Bee Park, Hills 'n' Skills and The Bistro exergames (Figure 5). Each exergame incorporated strength and balance exercises from the Otago programme [58], while additional Otago exercises (Figure 6) were integrated into the system under the 'training programme' option. Therefore, users were able to continue building their strength and balance in conjunction with the exergames.

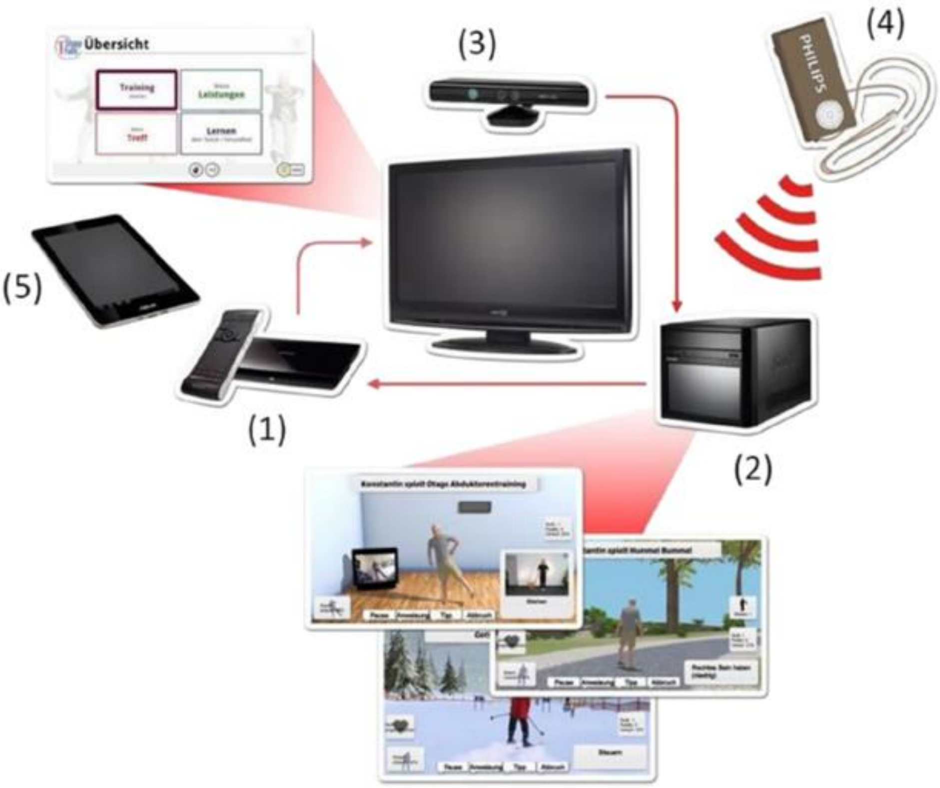

Figure 1. The different technologies integrated into the iStoppFalls ICT-based system. (Permission granted by the Dr Rainer. Wieching—PI, [57].) (**1**) Set top box (iTV), (**2**) mini-PC (exergame), (**3**) Kinect (gesture/voice), (**4**) Senior Mobility Monitor, (**5**) tablet (diary, control).

1) Remote Control

2) Gesture

3) Voice

4) Tablet

Figure 2. The different modes of interaction available to users of the iStoppFalls ICT-based system. (Permission granted by the Dr Rainer Wieching—PI, [57]). (**1**) Remote control, (**2**) gesture, (**3**) voice or (**4**) tablet.

Figure 3. The different menu options available to users in the iStoppFalls ICT-based system. (Permission granted by the Dr Rainer Wieching—PI, [57]). (1). Page header. (2) Training: The area of training. The user can exercise or determine their risk of falling. (3) Performance: The user can view their feedback and results. (4) Meeting Point: The user can communicate with other users who use the system. (5) Falls & Health: The area of learning, educational material and information on fall risks in everyday life, and how to reduce this risk. (6) Gesture and Voice Recognition: Two buttons to activate the gesture and/or voice control. (7) Change User: The user can either log out of the program or start with a different user account. (8) Help: The user can find help in this section for the most common problems and how to use the system.

Figure 4. The three purpose-built exergames ((**a**) Hills 'n' Skills, (**b**) The Bistro and (**c**) Bumble Bee Park) integrated into the iStoppFalls ICT-based system. (Permission granted by the Dr Rainer Wieching—PI, [57]).

Fall risk assessment was integrated into the ICT-based system, which enabled users to be initially assessed and included a physical assessment using the purpose-built software, the Microsoft Kinect console and the Senior Mobility Monitor (SMM) developed by Philips Netherlands [55,57]. Four physical assessments were conducted between the user and the integrated sensors which in turn enabled interaction via the user's television. The assessments included several balance tests: comfortable-bipedal, semi-tandem, near-tandem and the tandem stance [55–57]. Participants were required to undertake the balance assessments twice for a maximum of 30 s each, leading with their preferred foot. Participants were instructed not to change their preference (foot) in between stances and to keep their eyes open. Reaction time was integrated and assessed in the ICT system through hand and foot reaction times for each respective participant. This was calculated by hitting the green button (when highlighted) on the table or on the floor of the virtual environment [55].

The ISF RCT concluded that the ICT-based system did reduce the physiological fall risks of older adults aged 65 years and over that were living in their own home. Participants assigned to the intervention group showed greater adherence and an improvement in postural sway, step reaction and executive function [56].

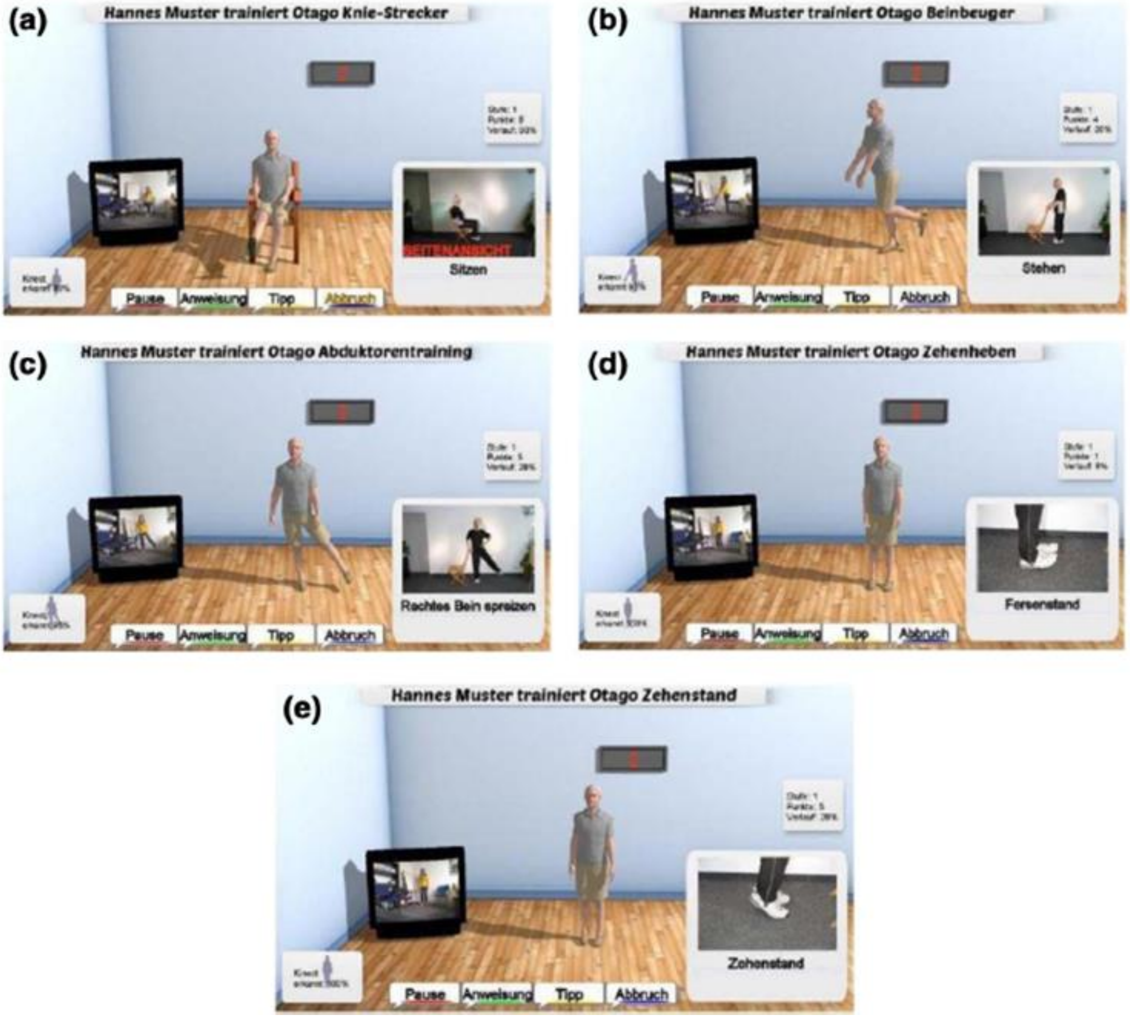

Figure 5. The different Otago exercises integrated into the iStoppFalls ICT-based system. (Permission granted by the Dr Rainer Wieching—PI, [57]). (**a**) Knee extension, (**b**) knee flexion, (**c**) leg abduction, (**d**) toe raises, (**e**) calf raises. There is a demonstration via the icon on the bottom right hand side of the screen. On the right side of the screen, the users are able to see themselves on the television screen. The four buttons at the bottom of the screen (pause, instructions, tips, and abort) can be selected by the users to execute the command.

To understand the usability, user experience and acceptance of technologies within the ISF purpose-built system, Vaziri and colleagues [59] deployed the System Usability Scale (SUS) [60], the Physical Activity Enjoyment Scale (PACES) [61] and the Dynamic Acceptance Model for the Re-evaluation of Technologies (DART) [62], coupled with interviews and observations of participants. The results showed the ISF ICT-based system to have an overall score of 62 out of 100, indicating good usability, with most users enjoying the ISF exergames. The PACES measure and the DART measure displayed user acceptance of the ISF system to be acceptable.

3.4. MobiAssist Project

The MobiAssist project (2015–2018) proceeded the iStoppFalls Project and aimed to explore the social impacts of the ICT-based suite of exergames aimed at people with dementia and their caregivers. Over a period of eight months, researchers used a co-design approach, while observing the daily lives of informal and professional caregivers of 14 people who had been diagnosed with dementia [63,64]. Conducting a co-design approach enabled the research team to gain insights into the daily routines of the participants' and their caregivers, coupled with biographical backgrounds, memories, social environment and recording their experiences, attitudes and practices of using technology [64].

Figure 6. An overview of the MobiAssist ICT-based system and the technological components. (Permission granted by David. Unbehaun [63,64]).

Participants were aged between 72–89.6 years, comprising six females and eight males [65]. The contents of the MobiAssist system include several digital technologies, software and purpose built exergames (Figure 6) [63,64]. The MobiAssist ICT-based system contains exercises and exergames enabling users' performance to be measured and aims to "*counteract the progression of dementia and to help people with dementia to remain as autonomous as possible*" [64].

The MobiAssist project includes a series of strength and balance training exercises (Figure 7) from the Otago Exercise Program (OEP) [66], similar to the ISF ICT-based system [63,64]. The strength training exercises from the OEP enable users to strengthen their upper and lower limb muscles, using knee extensions, knee bends, sideways leg raises, toe-stands, the elbow bends and front raise aimed at the shoulder muscles [63,66]. The exergames aim to enhance and improve the balance and coordination of the participants [64]. Figure 8 left displays a visual representation of some of the games that are implemented into the MobiAssist project.

A brief description of some of the games include: the 'Apple game,' which requires participants to collect virtual apples from a tree and place them into a basket; the 'Mole game,' which requires the participants to hit moles when they pop up from the ground at intermittent times. Participants' engaging with the 'Mole game,' requires the user to move sideways and move forward (take steps) to hit the mole [64]. An additional game (Figure 8, left) is the 'Wheel of Fortune,' which requires the participants to raise their hands and spin the wheel. This game is aimed at problem solving and cognitive tasks such as letter games, mental arithmetic, classification and completion of rhymes, verses and poems or remembering music titles [64]. The second game, displayed in Figure 8, right, is based on folk music, and, while the participant marches on the spot, the music continues to play. However, if the participant stops marching on the spot, the music gradually fades out. If the participant wants to continue listening to the music, they have to restart marching on the spot [64].

MobiAssist project reported several limitations, including the different settings and system issues experienced by participants. For example, there were issues surrounding the Kinect recognition by participants, relatives or caregivers who were standing too close to the camera. There was an in/exclusion criterion to assist with the recruitment of participants and their support network(s). In order to ensure coherent recruitment, process a mediator (care institution) was involved in the recruitment procedure between the respective participants and the research team. Furthermore, conducting interviews with participants who had been diagnosed with dementia was difficult at times, in particular engaging with the MobiAssist ICT-based system. Therefore, participants were limited in their ability to provide the research team with "*meaningful and informative answers, largely because of the deterioration of their cognitive and communicative resources and capabilities*" [64].

Figure 7. Integrated assessments in the MobiAssist ICT-based System. (Permission granted by David. Unbehaun) [65].

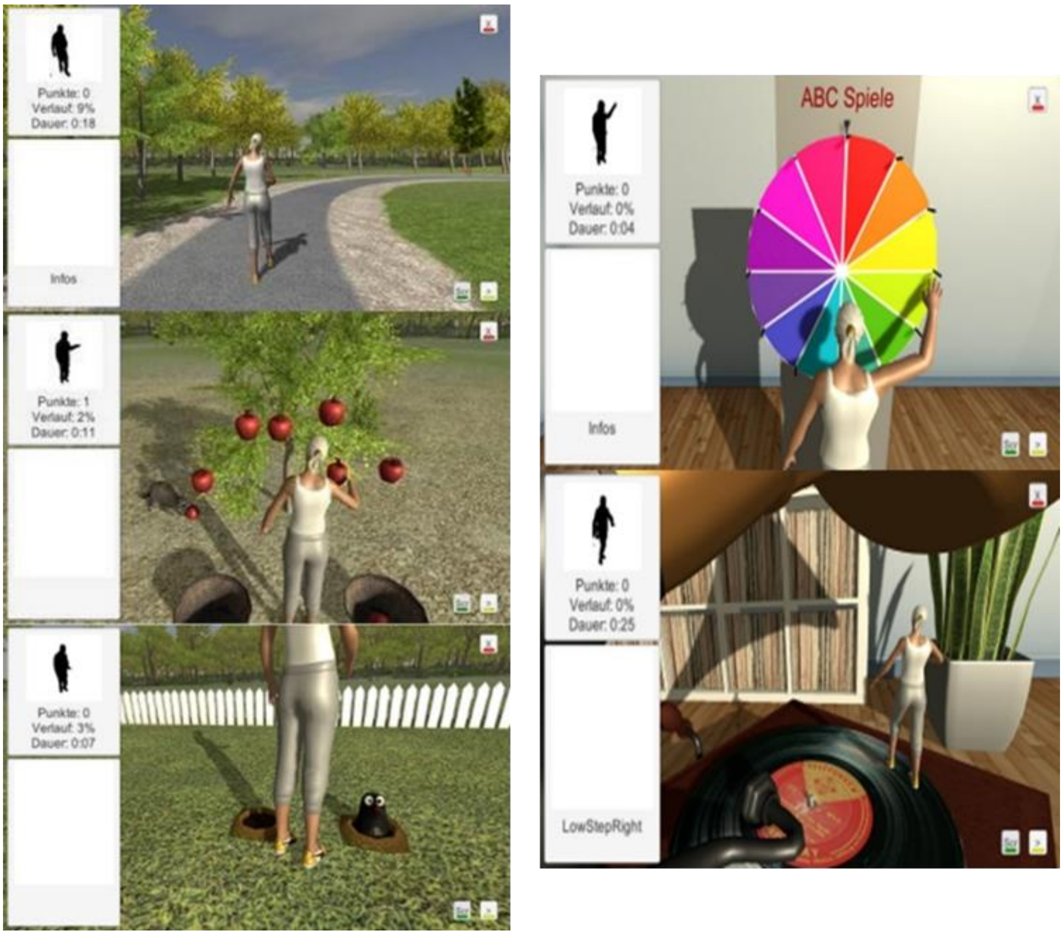

Figure 8. (**Left**) displays the strength and balance Park, Apple and Mole exergames. (**Right**) displays the Wheel of Fortune and Music/walking on the spot exergames. (Permission granted by David. Unbehaun) [64].

Both the iStoppFalls and MobiAssist ICT-based systems have the potential to offer carers and dependent adults the opportunity to engage and socially connect with friends, family members and with each other. The technology infrastructure will be a key concern (e.g., cost of Internet connection) for some people, highlighting the very essence of the digital divide. The MobiAssist project shows that there is potential to enhance social interaction and increase empowerment using serious games, and simultaneously build intergenerational relationships between the carer and the individual. For example, the research team concluded that the MobiAssist system has a positive trend to "*support workflows and thus improve institutionalized quality of care*" [64].

Within an age-friendly environment, older carers and disabled people can connect and share experiences with one another. The technology solutions discussed in the previous section offer users across different age cohorts the motivation and opportunity to interact with both young and older cohorts. This, in turn, has the potential to reduce the risk of social isolation and enhance social connectedness, offering enhanced engagement, communication and ensuring the AHA mandate is achieved.

Conversely, within the home environment and/or community, the notion of ageing-in-place can in some instances require assistance from younger adults of the family or community. Thus, integrating an intergenerational approach within an age-friendly environment has many positive benefits from the perspectives of both younger and older generations. These benefits include learning and sharing knowledge and experiences, caring opportunities for those who have fallen due to short, medium- and long-term illness, enhancing and build upon one's social skills, and enhancing social connectedness, which in turn will result in a decrease of social isolation. Steels [7] examines the Generations of Hope Community (GHC) [65], a non-profit organisation and social welfare agency, which created a program located in Illinois, U.S., "*where children adopted from foster care can find permanent homes and develop intergenerational relationships in a specially designed community*" [67] (p. 48).

Hope Meadows is a neighbourhood located two hours outside of Chicago. It became the first community planned by GHC and aimed "*to improve the service delivery and policies of the child welfare system; it ended up helping not only foster and adopted children but senior citizens as well.*" (p.18) [68].

Marc Freedman stated, "*The story of Hope Meadows offers not only a vision for how we can help take care of some of the most vulnerable young people in the society—foster children who essentially have nowhere else to turn—but how we can create neighborhoods that enrich the lives of all ages.*" (2001) [67].

At GHC, there are at least three generations residing in the environment—older adults, families and young people, facilitating a capacity to ensure care and support is available for the residents. By integrating an intergenerational approach into the environment, it can offer different generations of residents living within this type of environment an opportunity to undertake caring responsibilities, whereby the younger residents (e.g., children/teenagers) can understand the ethos of giving and receiving care in the future [68]. Through this social cohesion, each generation facilitates and teaches the others the different complexities, issues, needs and requirements which are significant to them, while learning from one another.

The approach undertaken at GHC enables older adults "*who do not want retirement to mean the end of their productive years, who want it to mean something more than a pension, health care, and a roof over their heads*" [68] (p. 51).

This concept facilitates a myriad of individuals and families to live together in one community, serving a purpose for all residents. Utilizing the theoretical approach of identity theory purported by Burke and Stets [16] in the age-friendly home and framework, it offers the residents the opportunity to take on the role of carer. In particular, Hope Meadows facilitates older residents to re-establish identities and roles previously held in society and their respective communities. For some older residents in Hope Meadows, they have the opportunity to feel needed and/or useful through the eyes of the parents of young children as a knowledgeable friend or community member. In some instances, for the older residents, having the younger residents in the community who may need assistance or care will provide the older person a sense of purpose. This notion also offers co-residents the opportunity to share knowledge and experiences, thus resulting in a learned environment; thus, intergenerational relationships are encouraged and fostered through the differing roles and identities forming and reforming within this age-friendly community.

4. Discussion

This paper has presented an initial overview of the different types of virtual assistant currently available on the market and how these devices can be integrated into existing age-friendly framework(s), coupled with the integration of technology, which to date has not been a focal point of contemporary age-friendly initiatives. This paper sets the scene for initial discussion combining two popular societal domains that are worth exploring further. This review paper uniquely draws together the small volume of literature from the fields of gerontology, gerontechnology, human computer interaction (HCI) and disability. Furthermore, evidence of worldwide ageing populations and the phenomenal developments of technology, in conjunction with the needs of local and national governments, means that alternative solutions are required to address the concerns of citizens ageing-in-place, be it from the standpoint of an older person or a parent/guardian of a dependent person. This paper contributes to—and is at the intersection of—the fields of gerontology, HCI and disability. Consequently, it offers insights into further discussions in the age-friendly and technology [69] domains.

In the context of older and dependent adults, contemporary evidence illustrates a myriad of opportunities for developers, researchers, health and social care practitioners, older carers and their young dependent children/adults so they can live together, in an environment that is familiar, safe and adaptable to the varying and changing needs of both.

Despite an increase in evidence, there is still a lack of understanding of the barriers and enablers to the take-up of technology by older adults, their support networks and healthcare practitioners. Given the nature of preventative healthcare technology and the potential influences it has in day-to-day activities, there is the self-perception and assumption that technology is not suitable for carers, marginalized and vulnerable communities, dependent adults and children, commonly based on their identification as being frail and/or lacking experience/understanding. Therefore, there is a need to improve understanding of the importance of planning and prevention at an early stage. Moreover, we need to demonstrate and highlight the benefits of technology in one's life, family environment and across communities, who may, in turn, want to use technology to enhance their intergenerational experiences and relationships. The intergenerational exchange of knowledge and experiences can be shared and passed on to younger people. At the same time younger people can facilitate a sense of meaning and purpose for older adults. These shared experiences and community involvement can offer and identify specific meanings to all residents, who may have several identities and roles within the family, community, local area and community groups [16]. Burke and Stets [16] purport that a person's myriad identities are interconnected through their respective behaviour(s), feelings, judgements and sentiments, which are influenced and integrated through identity and society. Identity is associated with one's role in society or community—this could be through their profession, being a member of a community group (e.g., church, organisation) or network. Each identity has its own characteristics and expectations associated with the respective identity, resulting in one's expectations being integral in the transformation of powerful stereotypes [16].

The authors have discussed the use of virtual/personal assistants such as Alexa, Echo and Google Home. This type of technology offers users across society a variety of options and support in their day-to-day tasks. For example, a British man who has cerebral palsy uses his virtual assistant to ensure he is able to get in and out of bed safely [70]. Connecting the virtual assistant to a light bulb in the bedroom and speaking the correct commands (i.e., switch light on/off) can offer a person enhanced safety (reducing the risk of falling) and independence. This type of support or assistance ensures a user who suffers from a disability, chronic health or life-limited condition the dignity, power and control over his or her own life. While it is still necessary for carers and support networks to assist individuals with deliberating conditions, virtual and personal assistants seem to offer users greater control.

Ferguson and Damodoran [23,24,26] have discussed and highlighted the needs and requirements of grassroots networks surrounding the issues and concerns of the digital divide, while offering and proposing solutions to local and national governments. Several recommendations include taking a 'user pull' approach rather than a top-down approach, to enhance and offer greater opportunities to communities and marginalized communities. The suggested 'user pull' approach encompasses 15 characteristics, including individuals who are community-based and trusted, drop-in sessions, user centred practice enabling individuals to choose and set their own learning pathways, no demands or assessments placed on the individual(s), and peer-to-peer learning. While fostering this type of physical space, additional benefits are offered to users, including flexibility, which in turn enables users to try new technologies without experiencing pressure from others (for example, sales/retail assistants). Furthermore, by offering a safe, approachable, flexible and peer-to-peer learning space, users' fears and anxieties regarding learning new technologies are reduced. Similarly, this type of physical space is paramount for individuals in the homeless community who wish to seek health information and advice [25].

Using and engaging with a virtual assistant may facilitate the dependent adult to have an identity and role within their environment, where previously this may not have been the case or may have been very limited. From the standpoint of the carer, this may provide a greater sense of freedom, knowing this virtual assistant has the capabilities to offer their dependent adult or child more confidence to conduct different activities. Moreover, the use and deployment of smart home devices, wearable devices and communication tools such as virtual assistants can offer ageing carers and dependent adults the option to monitor their daily activities, their wellbeing and their quality of life. Additionally, this form of technology can offer inter-generational support, resulting in the perception of the role and identity of a person to be positive, an authority figure role within the family, peer group(s) or community group(s) as a tech-savvy dyad [16]. However, little is known about the use and impact of technologies and the positive benefits of deploying virtual assistants into the lives of ageing carers and dependent adults on a day-to-day basis. This is also the case with the age-friendly framework, and in ascertaining whether one or both actors can age-in-place in their respective communities when faced with the barriers and enablers of being digitally connected or disconnected.

5. Recommendations and Thoughts

Future work should incorporate technology being tested and used in real-life settings, with dependent adults, their carers and support networks. Additional investigations should seek to include health practitioners to examine their perspectives and impact of virtual assistants within their role(s) and identity within the community.

Concomitantly, the cost-effectiveness of virtual assistants and associated technologies needs to be explored and taken in to account. This would not solely relate to purchasing of technology, but also the integration of technology into new construction projects (e.g., housing) and infrastructure [17,28]. Contemporary research and policy briefings show few or no evidence-based recommendations associated with the cost of installing the Internet, and this should be evaluated for both short-term and long-term adherence, focusing on a cost–benefit analysis to ascertain whether the cost implications outweigh the benefits of integrating the technology into the lives of older adults. For some actors, there is a perception that a piece of technology is a luxury or an unnecessary bill, which in turn may outweigh the benefits and take-up. For users on a low income, whose income may already be stretched, the added necessity of an Internet bill may not be an incentive or motivation to invest, regardless of the potential benefits.

Greater exploration is needed to examine the barriers and enablers of technology associated with existing carers and people diagnosed with diverse disabilities. This work has the potential to ascertain the impact that such technology has or may have on successful ageing and ageing-in-place. Therefore, conducting this examination would reveal myriad perceptions and impacts associated with technology, home automation and the issues associated with this integration and use.

Across the healthcare sector, services are aiming to be more cost-effective, and technology has the potential to offer alternative solutions (e.g., Skype consultations/appointments). However, the paucity of evidence from the standpoint of the health practitioner demonstrates the need for this area to be explored. Coupled with health provisions, it is necessary to ensure local and national policymakers are informed of contemporary evidence to safeguard and ensure that community and national infrastructure is available to deliver digital solutions to all members of society. It is particularly important for networks and communities at a grassroots level to have an input and voice. Previously, policy briefings have been given at the Northern Irish Assembly [71,72] in Belfast that demonstrate how contemporary research can be used to inform policymakers and community actors who can make a difference at the local government level, and who represent their respective communities.

In the context of age-friendly environments, the GHC Hope Meadows environment illustrates the positivity and benefits of intergenerational residents residing in one environment. Therefore, the use and deployment of smart home devices, wearable devices, and communication tools offer residents in this type of environment or their respective digital eco-system the option to monitor their health and wellbeing, their daily activities, and also that of their neighbours.

Contemporary evidence and work surrounding age-friendly frameworks has made great strides [69], yet, there is still a paucity of work on understanding of the impact technology can have on the physical space of a home, shared community or outdoor space. Future work should consider exploring the age-friendly agenda in conjunction with technology, taking on board the suggestions posed by Ferguson and Damodoran [23,24,26] to take a 'user pull' approach, furthering previous initiatives and ensuring local governments can support volunteers through the provision of physical space, advice and need in order to support those who are vulnerable, slow adopters or who are homeless.

6. Conclusions

This review paper is significant because it draws on the work from the fields of gerontology, HCI and age-friendly framework(s). Based on the evidence, there is a paucity of current debates focusing attention on the power technology can have within and across age-friendly cities and communities. This is particularly the case for those individuals who are carers in later life to dependent adults.

Furthermore, this paper brings together a myriad of domains to discuss contemporary issues surrounding individuals and communities of the 21st century society. While there are phenomenal technological developments occurring through artificial intelligence (AI), interaction (e.g., gesture, voice) and engagement, it cannot be ignored that there are still concerns surrounding access and digital participation.

To alleviate and close the gap of the digital divide requires substantial work relating to and focusing on communication and co-production from all directions of society. This would require groups including local and national governments, education providers, charities, architects, construction, families, and generational cohorts and businesses to collaborate together and move this agenda forward. Circulating strategies are not productive when the needs of the most vulnerable or marginalized communities are not met. Ensuring the infrastructure of a city/town or country is accessible to those wealthiest as well as those who are in marginalized communities is key. Exploring and identifying issues surrounding infrastructure could be useful, such as offering free Wi-Fi on public transport (e.g., train service), and public spaces which in turn allow individuals such as rough sleepers to access an Internet connection while also facilitating them to search specific information (e.g., health). The UK has experienced 10 years of austerity, witnessed across varying regions up and down the country, that has left the neediest and most vulnerable in extremely difficult circumstances. Businesses—be they large or small—have a social responsibility to assist and support local and national initiatives and communities. This too is the responsibility of county councils and government(s).

All proposed recommendations and future proposals should work towards the culmination of industry, community networks, health practitioners, families, and policymakers to learn and share knowledge, experience, and share 'lessons learned.' More importantly, all actors playing a role and part in decision making need to listen to the voices of those directly affected, while also identifying the needs of the people at all socio-economic levels of society.

The work presented in this paper contributes to the fields of gerontology, gerontechnology, (HCI) and disability, based on the debates associated with the integration of new technologies into the home and/or physical space used by citizens in society with/out a myriad of disabilities.

There is the potential for virtual/personal assistants to positively impact the lives of carers of dependent adults, children and adults with chronic health and neuro-degenerative conditions. Conducting a co-production approach with a multitude of actors has the potential to move age-friendly framework(s) forward. Taking this kind of approach will ensure all voices are heard, especially the voices of those who will be residing in these environments or cities, by those actors who will primarily be responsible for making the final decision(s).

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References

1. WHO. *Global Age-Friendly Cities: A Guide*; WHO: Geneva, Switzerland, 2007.
2. McGarry, P.; Morris, J. A great place to grow older: A case study of how Manchester is developing an age-friendly city. *Work. Older People* **2011**, *15*, 38–46. [CrossRef]
3. United Nations. *World Population Prospects: The 2017 Revision, Key Findings and Advance Tables*; ESA/P/WP/248; United Nations: New York, NY, USA, 2017.
4. Fitzgerald, K.G.; Caro, F.G. An Overview of Age-Friendly Cities and Communities Around the World. *J. Aging Soc. Policy* **2014**, *26*, 1–18. [CrossRef] [PubMed]
5. WHO. *Active Ageing A Policy Framework*; WHO: Geneva, Switzerland, 2002.
6. WHO. What is Healthy Ageing? Available online: http://www.who.int/ageing/healthy-ageing/en/ (accessed on 4 December 2018).
7. Steels, S. Key characteristics of age-friendly cities and communities: A review. *Cities* **2015**, *47*, 45–52. [CrossRef]
8. Menec, V.H.; Means, R.; Keating, N.; Parkhurst, G.; Eales, J. Conceptualizing age-friendly communities. *Can. J. Aging* **2011**, *30*, 479–493. [CrossRef] [PubMed]
9. Greenfield, E.A.; Oberlink, M.; Scharlach, A.E.; Neal, M.B.; Stafford, P.B. Age-friendly community initiatives: Conceptual issues and key questions. *Gerontologist* **2015**, *55*, 191–198. [CrossRef]
10. The Ministry of Social Development. *Positive Ageing Indicators 2007*; The Ministry of Social Development: Wellington, New Zealand, 2009.
11. Health Canada. *Healthy Aging in Canada: A New Vision, A Vital Investment From Evidence to Action*; Health Canada: Ottawa, ON, Canada, 2006.
12. Feldman, P.H.; Oberlink, M.R. The AdvantAge Initiative:Developing Community Indicators to Promote the Health and Well-Being of Older People. *Fam. Commun. Heal.* **2003**, *26*, 268–274. [CrossRef]
13. Buffel, T. Social research and co-production with older people: Developing age-friendly communities. *J. Aging Stud.* **2018**, *44*, 52–60. [CrossRef]
14. Greater Mancester Combined Authority, 'Greater Manchester Becomes UK's First Age-Friendly City-Region. 2018. Available online: https://www.greatermanchester-ca.gov.uk/what-we-do/ageing/age-friendly-greater-manchester/ (accessed on 14 March 2019).
15. Manchester City Council. *Manchester: A Great Place to Grow Older 2010–2020*; Manchester City Council: Manchester, UK, 2009.
16. Burke, P.; Stets, J. *Identity Theory*; Oxford University Press: Oxford, UK, 2009.
17. G. D. Service. Government Digital Inclusion Strategy. Available online: https://www.gov.uk/government/publications/government-digital-inclusion-strategy/government-digital-inclusion-strategy (accessed on 7 February 2019).
18. Berry, R. *Older people and the Internet: Towards a "System Map" of Digital Exclusion*; The International Longevity Centre-UK: London, UK, 2011; pp. 1–18.
19. Eszter, H.; Hinnant, A. Differences in Young Adults ' Use of the Internet. *Commun. Res.* **2008**, *35*, 602–621.
20. Morris, A.; Goodman, J.; Brading, H. Internet use and non-use: Views of older users. *Univers. Access Inf. Soc.* **2007**, *6*, 43–57. [CrossRef]
21. Friemel, T.N. The digital divide has grown old: Determinants of a digital divide among seniors. *New Media Soc.* **2016**, *18*, 313–331. [CrossRef]
22. Dewan, S.; Riggins, F.J. The Digital Divide: Current and Future Research Directions. *J. Assoc. Inf. Syst.* **2005**, *6*, 298–337.
23. Ferguson, M.; Damodaran, L. *Digital by Choice: Bridging the Digital Divide. Part 2 of 3: User-Pull—Embracing Users' Needs*; Socitm: Northampton, UK, 2018.
24. Ferguson, M.; Damodaran, L. *Digital by Choice: Bridging the Digital Divide. Part 1 of 3: Why Digital Participation Matters*; Socitm: Northampton, UK, 2018.
25. NHS. Digital. Digital Inclusion Project Brings Healthcare Technology to the Homeless. 2019. Available online: https://digital.nhs.uk/news-and-events/latest-news/digital-inclusion-project-brings-healthcare-technology-to-the-homeless?fbclid=IwAR2EC1D7LgfZ5EYPtuO0VOSdVwKEwkkGaMiva-BeCESbqRmJYb-qysGqsWI (accessed on 7 February 2019).

26. Ferguson, M.; Damodaran, L. *Digital by Choice: Bridging the Digital Divide. Part 3 of 3: Why Digital Participation Matters*; Socitm: Northampton, UK, 2018.
27. Monograph, K.T.E. Taming the Dragon; Making Technology Work for Us. Available online: http://kt-equal.org.uk/uploads/monograph%20taming%20the%20dragon%20final.pdf (accessed on 7 February 2019).
28. Mouland, J.; Richardson, J.; Damadoran, L. *The Digital Age: New Approaches to Supporting People in Later Life Get Online*; Centre for Ageing Better: London, UK, 2018.
29. Kaundinya, A.S.; Atreyas, N.S.P.; Srinivas, S.; Kehav, V.; Kumar, N.M.R. Voice Enabled Home Automation Using Amazon Echo. *Int. Res. J. Eng. Technol.* **2017**, *4*, 682–684.
30. Purington, A.; Taft, J.G.; Sannon, S.; Bazarova, N.N.; Taylor, S.H. "Alexa is my new BFF": Social roles, user satisfaction, and personification of the Amazon Echo. In Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems, Denver, CO, USA, 6–11 May 2017; ACM: New York, NY, USA, 2017; pp. 2853–2859. [CrossRef]
31. National Institute for Health Research. HELP AT HOME Use of Assistive Technology for Older People. Available online: https://www.dc.nihr.ac.uk/themed-reviews/research-on-assistive-technology.htm (accessed on 7 February 2019).
32. Taylor, M.; Priest, D. The Complete List of Alexa Commands so far. *cnet*. 2018. Available online: https://www.cnet.com/how-to/amazon-echo-the-complete-list-of-alexa-commands/ (accessed on 7 December 2018).
33. Lui, C. Amazon Opens First-Ever Alexa Smart Home Retail Space in Canada. *retial insider*. 2018. Available online: https://www.retail-insider.com/retail-insider/2018/11/amazon-canada-opens-first-ever-pop-up-retail-space (accessed on 7 December 2018).
34. James, K. Amazon Echo Update Adds Pandora, iTunes, and Spotify Voice Control. *zdnet.com*. 2015. Available online: https://www.zdnet.com/article/amazon-echo-update-adds-pandora-itunes-and-spotify-voice-control/ (accessed on 7 December 2018).
35. Donnelly, G. Amazon Alexa Will Come Built-In to All New Homes From Lennar. *Fortune.com*. 2018. Available online: http://fortune.com/2018/05/09/amazon-alexa-lennar/ (accessed on 7 December 2018).
36. Kharpal, A. Amazon Launches its AI-Powered Speaker Echo in Europe. *CNBC*. 2016. Available online: https://www.cnbc.com/2016/09/14/amazon-echo-launched-in-uk-and-germany.html (accessed on 7 December 2018).
37. Goode, L. Is There an Echo in Here? All the Hardware Amazon Announced. *Wired*. 2018. Available online: https://www.wired.com/story/amazon-echo-hardware-2018/ (accessed on 7 December 2018).
38. Wong, R. How to Use Artificial Intelligence to Order Pizza. *Mashable.com*. 2017. Available online: https://mashable.com/2017/02/07/how-to-order-pizza-with-amazon-alexa-google-home/?europe=true#zgUly9iQ6sq8 (accessed on 7 December 2018).
39. Steele, B. Amazon Echo Controls Belkin WeMo and Philips Hue with Your Voice. *Endgadget*. 2015. Available online: https://www.engadget.com/2015/04/08/amazon-echo-controls-philips-hue-belkin-wemo/?guccounter=1 (accessed on 14 March 2019).
40. Tofel, K. Amazon Echo can Now Control Wink Smart Home Products. *zdnet.com2*. 2015. Available online: https://www.zdnet.com/article/amazon-echo-can-now-control-wink-smart-home-products/ (accessed on 7 December 2018).
41. Green, P. Alexa, Where Have You Been All My Life? *New York Times*. 2017. Available online: https://www.nytimes.com/2017/07/11/style/alexa-amazon-echo.html (accessed on 7 December 2018).
42. Amazon Alexa. Why Connect Your Devices to Alexa? *Amazon*. Available online: https://developer.amazon.com/alexa/connected-devices (accessed on 7 December 2018).
43. Risteska Stojkoska, B.L.; Trivodaliev, K.V. A review of Internet of Things for smart home: Challenges and solutions. *J. Clean. Prod.* **2017**, *140*, 1454–1464. [CrossRef]
44. Li, X.; Lu, R.; Liang, X.; Shen, X.; Chen, J.; Lin, X. Smart community: An internet of things application. *IEEE Commun. Mag.* **2011**, *49*, 68–75. [CrossRef]
45. Chiuchisan, I.; Geman, O. An Approach of a Decision Support and Home Monitoring System for Patients with Neurological Disorders using Internet of Things Concepts Faculty of Electrical Engineering and Computer Science. *WSEAS Trans. Syst.* **2014**, *13*, 457–459.
46. Ray, P.P. IoT: An Architectural Framework for Monitoring Health of Elderly People. In Proceedings of the 2014 International Conference on Science Engineering and Management Research (ICSEMR), Chennai, India, 7–29 November 2014; pp. 3–5.

47. BBC News. Amazon Echo Trial to Help Elderly and Disabled People. 2018. Available online: https://www.bbc.co.uk/news/av/uk-politics-43869120/amazon-echo-trial-to-help-elderly-and-disabled-people (accessed on 6 March 2019).
48. Hampshire County Council. Hampshire County Council: Pushing the Boundaries by Using Amazon Echo. 2018. Available online: https://www.local.gov.uk/hampshire-county-council-pushing-boundaries-using-amazon-echo (accessed on 6 March 2019).
49. Peskett, J. Virgin Launches New Alexa Initiative to Assist Disabled Passengers. *Accessibility Mobility Professional*. 2019. Available online: https://www.accessandmobilityprofessional.com/virgin-launches-new-alexa-initiative-to-assist-disabled-passengers/ (accessed on 6 March 2019).
50. Gordon, B. Speech and Language Problems In Asd. 2007. Available online: https://iancommunity.org/cs/articles/speech_and_language_problems (accessed on 6 March 2019).
51. Mighty, T. How Amazon's Alexa Is Helping My Son with a Disability. 2017. Available online: https://themighty.com/2017/11/amazon-alexa-helping-child-disability/ (accessed on 31 January 2019).
52. Pilmoor, E. Available online: https://www.portsmouth.co.uk/news/health/amazon-alexa-has-changed-my-life-says-titchfield-ms-sufferer-1-8500812 (accessed on 9 March 2019).
53. Bogost, I. Alexa Is a Revelation for the Blind Legally Blind since Age 18, My Father Missed out on the First Digital Revolution. Available online: https://www.theatlantic.com/magazine/archive/2018/05/what-alexa-taught-my-father/556874/ (accessed on 13 March 2019).
54. iStoppFalls. 2011. Available online: http://www.istoppfalls.eu/cms/front_content.php (accessed on 4 March 2019).
55. Gschwind, Y.J.; Eichberg, S.; Marston, H.R.; de Rosario, H.; Aal, K.; Ejupi, A.; Kroll, M.; Drobics, M.; Annegarn, J.; Wieching, R.; et al. ICT-based system to predict and prevent falls (iStoppFalls): Study protocol for an international multicenter randomized controlled trial. *BMC Geriatr.* **2014**, *14*. [CrossRef]
56. Gschwind, Y.J.; Eichberg, S.; Ejupi, A.; de Rosario, H.; Kroll, M.; Marston, H.; Drobics, M.; Annegarn, J.; Wieching, R.; Lord, S.R.; et al. ICT-based system to predict and prevent falls (iStoppFalls): Results from an international multicenter randomized controlled trial. *Eur. Rev. Aging Phys. Act.* **2015**, *12*. [CrossRef]
57. Marston, H.R.; Woodbury, A.; Kroll, M.; Fink, D.; Eichberg, S.; Gschwind, Y.J.; Delbaere, K. The design of a purpose-built exergame for fall prediction and prevention for older people. *Eur. Rev. Aging Phys. Act.* **2015**, *12*, 1–12. [CrossRef]
58. Marston, H.R.; Kroll, M.; Fink, D.; Eichberg, S. Digital Game Aesthetics of the iStoppFalls Exergame. In *Proceedings of the 4th Conference on Gaming and Playful Interaction in Healthcare. Games for Health 2014*; Schouten, B., Fedtke, S., Schijven, M., Vosmeer, M., Gekker, A., Eds.; Springer: Wiesbaden, Germany, 2014; pp. 89–100.
59. Vaziri, D.D.; Aal, K.; Ogonowski, C.; Von Rekowski, T.; Kroll, M.; Marston, H.R.; De Rosario, H.; Poveda, R.; Gschwind, Y.; Delbaere, K.; et al. Exploring user experience and technology acceptance for a fall prevention system: Results from a randomized clinical trial and a living lab. *Eur. Rev. Aging Phys. Act.* **2016**, *13*. [CrossRef]
60. Brooke, J. SUS—A quick and dirty usability scale. In *Usability Evaluation in Industry*; Jordan, P.W., Thomas, B., Weerdmeester, B.A., McClelland, A.L., Eds.; Taylor & Francis: London, UK, 1996; pp. 1–7.
61. Mullen, S.P.; Olson, E.A.; Phillips, S.M.; Szabo, A.N.; Wójcicki, T.R.; Mailey, E.L.; Gothe, N.P.; Fanning, J.T.; Kramer, A.F.; McAuley, E. Measuring enjoyment of physical activity in older adults: Invariance of the physical activity enjoyment scale (paces) across groups and time. *Int. J. Behav. Nutr. Phys. Act.* **2011**, *8*. [CrossRef]
62. Amberg, M.; Fischer, S.; Schröder, M. An Evaluation Framework for the Acceptance of Web-Based Aptitude Tests. *Pdfs.Semanticscholar. Org.* **2005**, *8*, 151–158.
63. Unbehaun, D.; Vaziri, D.D.; Aal, K.; Wieching, R.; Tolmie, P.; Wulf, V. Exploring the Potential of Exergames to affect the Social and Daily Life of People with Dementia and their Caregivers. In Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems, Montreal, QC, Canada, 21–26 April 2018; ACM: New York, NY, USA, 2018; pp. 62–77. [CrossRef]
64. Unbehaun, D.; Vaziri, D.D.; Aal, K.; Li, Q.; Wieching, R.; Wulf, V. Video-game based Exergames for People with Dementia and Their Caregivers. In Proceedings of the 2018 ACM Conference on Supporting Groupwork, Sanibel Island, FL, USA, 7–10 January 2018; ACM: New York, NY, USA, 2018; pp. 401–405. [CrossRef]
65. Generations of Hope. 2007. Available online: http://ghdc.generationsofhope.org/ (accessed on 4 December 2018).

66. Campbell, A.J.; Robertson, M.C. *Otago Exercise Programme to Prevent Falls in Older Adults: A Homebased, Individually Tailored Strength and Balance Retraining Programme*; ACC: Mumbai, India, 2003.
67. Eheart, B.K.; Power, M.B.; Hopping, D.E. Intergenerational Programming for Foster-Adoptive Families. *J. Intergener. Relatsh.* **2003**, *1*, 17–28. [CrossRef]
68. Eheart, B.K.; Hopping, D.; Power, M.B.; Mitchell, E.T.; Racine, D. Generations of Hope Communities: An intergenerational neighborhood model of support and service. *Child. Youth Serv. Rev.* **2009**, *31*, 47–52. [CrossRef]
69. van Hoof, J.; Kazak, J.K.; Perek-Białas, K.M.; Peek, S.T.M. The challenges of urban ageing: Making cities age-friendly in Europe. *Int. J. Environ. Res. Public Health* **2018**, *15*, 1–17. [CrossRef] [PubMed]
70. Mathieson, S. "I feel in Control of My Life": Alexa's New Role in Public Service. *The Guardian*, 7 February 2019.
71. Marston, H.R.; Freeman, S.; Genoe, R.; Kulcyzki, C.; Musselwhite, C. *The Cohesiveness of Technology in Later Life: Findings from the Technology In Later Life (TILL) Project Knowledge Exchange Seminar Series 2017–2018*; Stormont: Belfast, UK, 2018.
72. Waights, V.; Bamidis, P.; Almeida, R. Technologies for care—The imperative for upskilling carers. In *Knowledge Exchange Seminar Series 2017–18*; Stormont: Belfast, UK, 2018.

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Making Homes More Dementia-Friendly through the Use of Aids and Adaptations

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Abstract: The majority of people with dementia live in their own homes, often supported by a family member. While this is the preferred option for most, they often face multiple challenges due to a deterioration in their physical and cognitive abilities. This paper reports on a pilot study that aimed to explore the impacts of aids and adaptations on the wellbeing of people with dementia and their families living at home. Quantitative data were collected using established measures of wellbeing at baseline, 3 months and 9 months. In-depth case studies were carried out with a sample of participants. Findings from the pilot suggest that relatively inexpensive aids can contribute towards the maintenance of wellbeing for people with dementia in domestic settings. The project also increased the skills and confidence of professionals involved in the project and strengthened partnerships between the collaborating organisations across health, housing and social care. Providing aids that can help people with dementia to remain living at home with a good quality of life, often with the support of a family member, is an important element in the development of age-friendly communities.

Keywords: dementia-friendly environments; aids and adaptations; loneliness; domestic settings

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1. Introduction

The profile of ageing is changing. In 2017, the global population over the age of 60 numbered 962 million, rising from 382 million in 1980. The number of adults over the age of 80 has tripled and older adults are set to outnumber young people under 10 years old by 2030 [1]. In the UK, health and social care services are supporting increasing numbers of people over the age of 65. This trend is set to continue in coming years, with over half of local authorities expecting to see 25% of their population to be over the age of 65 by 2036 [2]. Ninety-six percent of older people live in mainstream, un-adapted housing as owner occupiers [3]. However, this is a population which is paving the way for change. The growing number of older people represent an influential body who voice higher expectations for living in communities which are more responsive to their needs and 'age-friendly', yet 'the places in which older people experience ageing have often proved to be hostile and challenging environments' [4]. One response to population ageing at international and national levels is the development of age-friendly communities, based on the premise that 'physical and social environments are key determinants of whether people can remain healthy, independent and autonomous long into their old age' [5].

Ageing is often accompanied by challenges to physical and cognitive wellbeing. In recent years the UK government has prioritised an agenda to support people to live well with dementia [6], including an aspiration for communities to become dementia-friendly [7]. There are currently an estimated 850,000 people living with dementia in the UK, a figure which is projected to increase to over 1 million by 2025 [8]. This picture is replicated globally where the number of people living with dementia is estimated to be in the region of 36 million, doubling by 2030 and projected to be more than tripled by 2050 [9]. Dementia is a complex and multi-faceted condition which impacts each individual differently, resulting in a range of symptoms which can limit a person's ability to function independently. Memory loss is a common symptom of dementia, but the condition brings other challenges, such as compromised visual and spatial awareness, difficulty with object recognition, challenges in seeing colour and colour contrast, greater need for increased light levels and challenges with orientation to space and time.

For people with long-term degenerative conditions such as dementia, living well in their own homes can be a challenge and moving to long-term care is often seen as the only option. However, the projected increase in this population places substantial financial burdens on society, so that the traditional expectation of supporting people in long-term residential settings is no longer viable. Additionally, with greater diversity within the housing and care markets, residential care is now just one option alongside a range of models including sheltered housing, extra care housing and remaining in one's own home with additional support.

There is growing evidence to suggest the importance of the physical environment in enabling older people to attain their full potential [10], sometimes known as 'ageing in place'. This is also recognised within established theoretical approaches such as the environmental press model, which focuses on the fit between the environment and an individual's physical and cognitive capacities [11]. Eighty-five percent of people in the UK say they would prefer to remain living in their own homes if they received a diagnosis of dementia [12]. An estimated two thirds of people with dementia live in their own homes, and of this population one third live alone and one third live in housing with care [8]. This brings with it additional difficulties including a greater risk of social isolation and loneliness. Research conducted in the UK by the Alzheimer's Society found that 62% of people with dementia who live alone felt lonely, compared to 38% of all people with dementia [13].

For people living with dementia, the symptoms they experience can have a significant impact on their confidence and ability to continue to lead an independent and full life, yet remaining in a familiar environment with the right assistance can often be beneficial. Based on data from the English Housing Survey [14], there are at least 475,000 households in England lived in by adults aged over 65 with a disability or long-term limiting illness, many of whom report that they lack the home adaptations they need [15].

There is good evidence that minor aids and adaptations can improve a range of outcomes for older people and help them remain at home for longer. In addition to increased levels of confidence and autonomy, aids and adaptations can reduce hospital admissions for avoidable conditions such as falls and urinary tract infections, which remain some of the most common reasons for hospital admissions among the elderly [16]. However, there is little evidence in relation to the value of aids for people living with dementia in their own homes [15]. This paper adds to the body of knowledge in understanding the importance of aids and adaptations in the home from a UK perspective. It demonstrates that for people with dementia at the early stages of their journey, minor aids and adaptations can have significant benefit for helping to improve quality of life and supporting living well at home.

'People with a dementia have the right to live life … as they did before their diagnosis … to live in their home, in the neighbourhood they know and perhaps surrounded by friends and caring neighbours' [17].

2. Materials and Methods

A study providing aids and adaptations to people living with dementia in their own homes was piloted in Worcestershire, a county in the West Midlands region of the UK, for a 12 month period during 2017–2018. Worcestershire has approximately 588,000 residents with 3.9% having a diagnosis of dementia, a figure which is slightly lower than the national average. Known as the Dementia Dwelling Grant (DDG), the pilot study built on an existing service through which people with a dementia diagnosis were allocated a dementia advisor (DA). Assessment for the DDG was carried out by the DAs, an approach that it was hoped would minimise disruption and anxiety for the people living with dementia and their families. While dementia is associated with older age, it was felt that the potential benefits of the DDG should be made available to anyone referred to the DA service, regardless of their age. The DDG was not means-tested and was available to people with a clinical diagnosis of dementia who were living at home.

The DDG pilot did not provide a monetary grant but instead offered a range of small-scale aids and home adaptations that were believed to benefit people living with dementia, and that were not available through other programs. Where necessary, these were delivered and installed by the established handyperson service. The list of aids and adaptations was informed by research and best practice in dementia-friendly design. It included items for use around the home including key locators and clocks, and those for specific areas, such as touch bedside lights and bath mats.

A research team at the University of Worcester was commissioned to carry out an evaluation of the pilot, with the broad aim of exploring the impacts of the aids and adaptations that were provided on the wellbeing of recipients. Two paper-based forms were developed by the research team in consultation with the local authority administering the project, to capture information from people living with dementia who consented to participate in the study. The first, an assessment form, captured basic demographic data as well as information on which aids and adaptations were to be provided with the grant. The second form comprised a series of validated measures to assess aspects of the grant recipients' health and wellbeing. This form was completed as part of the baseline assessment and repeated after three and nine months to capture the impact of the DDG intervention over time. The measures were taken from the UK Office for National Statistics 'People, Population and Community' (UKPPC) survey [18] and the Short Warwick Edinburgh Mental Wellbeing Scale (SWEMWBS) [19]. General wellbeing was measured using four questions that assess quality of life on a scale from 0 (not at all) to 10 (completely). The SWEMWBS tool asks respondents to describe their experience over the past two weeks in relation to seven statements on a five-point scale from 'none of the time' to 'all of the time'. In addition to the individual statements, composite SWEMWBS scores can be generated on a scale from 7 to 35, with higher scores indicating greater mental wellbeing.

The information captured by the assessment form was analysed to provide descriptive statistics about the evaluation participants, while the validated measures in the evaluation form were analysed according to the relevant process for each individual measure. Where possible, findings were compared between baseline, 3 month follow up and 9 month follow up to investigate the longer-term experiences and impacts of the aids and adaptations for intervention participants. The results were analysed to see if any significant changes had taken place between the different time points, and any significance will be highlighted in the results. In the absence of a control group, comparator data were obtained from the UK Office of National Statistics to enable the DDG information to be viewed within a wider context.

In addition, a purposeful sample of 15–20% of grant recipients who had completed a three-month evaluation were chosen as case studies. The sample aimed to mirror the wider group of DDG recipients by including participants with a variety of dementia diagnoses, ages, living situations, and types of aids required. The case studies used semi-structured interviews conducted in a person's home to explore which aids and adaptations had been of most benefit, and if any additional aids or adaptations would be useful and might be made available and included in future grants. Finally, towards the end of the pilot, research interviews were carried out with key project stakeholders to discuss how the project was developed and implemented and to explore the main benefits, facilitators and barriers. The interviews with grant recipients and project stakeholders were transcribed and analysed for key themes.

3. Results

3.1. Participants and Interventions

In this pilot project, 510 people were assessed for the DDG by the dementia advisors. Of these, 382 (75%) received a DDG, with 101 (26%) of these consenting to be part of the full evaluation. The majority of referrals (60%) came from the Early Intervention Dementia Service, with 14% unknown, and 13% from the Community Mental Health Team. The remainder were from families, self-referral and family doctors. The age range of those receiving a DDG was 36 to 98 years with an average (mean) of 80 years old. Fifty-five percent were female and 97% were White British. This profile closely reflects the local population. Sixty-two percent of DDG recipients were married, with the majority of the remainder being widowed.

Although those consenting to be evaluation participants were slightly younger than those who did not give consent (mean age 78 compared to 81), their overall demographics were very similar to the whole group of DDG recipients. Among the evaluation participants, Alzheimer's disease was the most common dementia diagnosis (40%) followed by vascular dementia (22%) and mixed dementia (21%). Fifty-four percent had at least one other medical condition, with arthritis, diabetes, mobility issues, frailty and heart conditions being the most common. Ninety-five percent had at least one carer, with 80% living with their carer. This person was most commonly a partner or spouse, followed by a son or daughter. Eighty-six percent of the evaluation cohort were owner occupiers, with 64% living in a house and 23% in a bungalow.

Ages of the 13 case study participants ranged from 55 to 92 years, with an average of 80. Nine were female and four were male. Five had Alzheimer's disease, four had mixed dementia, two had vascular dementia, one had Lewy-bodies and one had fronto-temporal dementia. Ten case study participants lived with their spouse with three recipients living alone supported by carers or family.

All individuals in the evaluation cohort requested at least one item; 12 items were the maximum requested by an individual. The five most popular items requested were a dementia clock (two types were offered: a day/night clock and a digital 12/24 h clock), noticeboard/white board, touch-activated beside light, key locator and memo minder. The average number of items required by customers was five (four different types of item) at a cost of £138. This cost does not include additional costs, such as the time of a dementia advisor to undertake the assessment or the time of the handyperson to deliver and install items.

3.2. The Wellbeing of Participants

General wellbeing was measured at baseline, at 3 months and at 9 months as shown in Table 1. Comparator data from the UKPPC survey [19] show slightly lower levels of general wellbeing for DDG participants at baseline than for the wider population in relation to items 1 to 3. Scores for item 4 indicate levels of anxiety that are considerably higher than those for the wider population.

Table 1. General wellbeing scores for intervention participants and the UK population. Percentages for items 1, 2 and 3 refer to respondents who scored 9 or 10 on a scale from 0 (not at all) to 10 (completely). Percentages for item 4 refer to respondents who scored 1 or 2 on the same scale. DDG: Dementia Dwelling Grant.

Wellbeing Question	**DDG Data**		**UK Comparator Data**	
	%	**Mean**	**%**	**Mean**
1. Overall, how satisfied are you with your life nowadays?	25.0	7.1	30.2	7.7
2. Overall, to what extent do you feel the things you do in your life are worthwhile?	26.5	7.1	35.6	7.9
3. Overall, how happy did you feel yesterday?	27.5	7.2	34.9	7.5
4. Overall, how anxious did you feel yesterday?	32.5	4.4	39.9	2.9

Two further items taken from the UKPPC survey were used to measure satisfaction with health and satisfaction with accommodation, using a seven-point scale from 'completely dissatisfied' to 'completely satisfied'. The findings shown in Table 2 indicate higher levels of satisfaction with their health and accommodation for those receiving the intervention than for the wider UK population.

The final measure of general wellbeing asked participants to answer the question 'How often do you feel lonely' on a five-point scale from 'often/always' to 'never'. A high proportion (14.8%) responded 'often/always' compared with 4.1% of the wider UK population.

Mental wellbeing was measured using SWEMWBS [19]. Responses were largely positive for each item as shown in Figure 1, with the majority of respondents selecting at least 'some of the time'. Composite SWEMWBS scores were generated for the 77 participants who responded to at least five of the seven items and so would have a valid score. This gave a mean score of 23.6 for the DDG group compared with 24.6 for the wider population.

Table 2. Satisfaction scores for intervention participants and the UK population. Percentages for each question refer to respondents indicating any level of satisfaction on the scale.

Satisfaction Question	DDG Data %	UK Comparator Data %
5. How satisfied are you with your general health?	60.2	49.6
6. How satisfied are you with your accommodation?	99.0	89.9

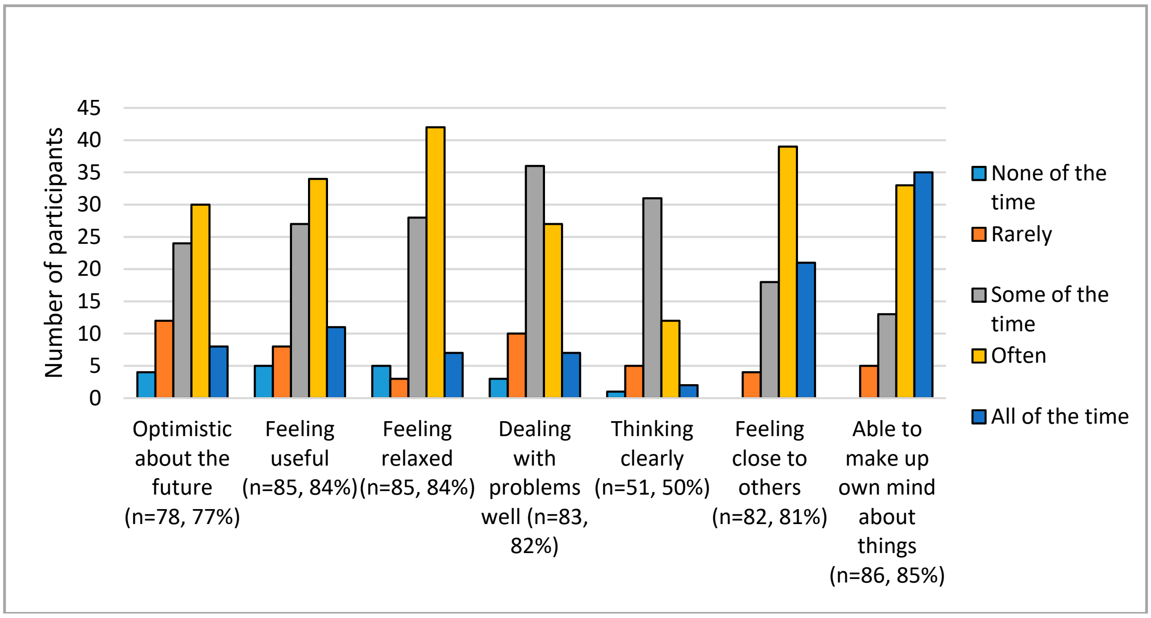

Figure 1. Baseline participant scores for mental wellbeing based on the Short Warwick Edinburgh Mental Wellbeing Scale.

Due to the timings of the baseline assessments and the ongoing nature of referrals to the DA service, it was only possible to carry out 80 of the 3 month follow up assessments during the evaluation, with 73 participants still living at home and being able to complete the assessment process. Mean scores for satisfaction with life, feeling worthwhile and happiness had improved slightly for the 73 participants, while remaining lower than the national average. Similarly, anxiety levels decreased for the participants but were still substantially higher than the wider population. At three months there was little or no change in 'satisfaction with health' and 'satisfaction with accommodation' compared to baseline. There was also no significant change in the composite SWEMWBS scores, although they had declined slightly. However, there was a reduction in levels of loneliness, with 10.6% of respondents reporting that they felt lonely 'often' or 'always' compared with 14.9% at baseline. This improvement was not statistically significant.

Nine-month assessments were completed with 36 participants, with the reduction in numbers again being closely linked to the timing of the baseline assessment in relation to the lifetime of the study. In terms of general wellbeing, there was a slight decline in the mean response for 'satisfaction with life' and 'feeling worthwhile' between baseline and 9 months, and a slight improvement for 'anxiety', while 'happiness' was unchanged, as shown in Table 3. The reduction in loneliness that was seen at 3 months continued at 9 months, with fewer participants reporting that they were lonely 'often', 'always' or 'some of the time'.

Table 3. Mean general wellbeing scores for intervention participants at baseline, 3 months and 9 months.

Wellbeing Question	Baseline v 9 Month			3 Month v 9 Month		
	No. Participants Responding at Both Time Points	Mean (out of 10)		No. Participants Responding at Both Time Points	Mean (out of 10)	
		Baseline	9 Month		3 Month	9 Month
1. Overall, how satisfied are you with your life nowadays?	28	7.0	6.4	24	7.2	6.6
2. Overall, to what extent do you feel the things you do in your life are worthwhile?	16	7.6	7.4	13	7.1	7.0
3. Overall, how happy did you feel yesterday?	18	6.8	6.8	11	6.5	6.9
4. Overall, how anxious did you feel yesterday?	16	5.6	5.4	7	4.0	5.3

Overall there was a slight decline in terms of composite wellbeing scores from baseline to 9 months. Participants also reported greater satisfaction with their accommodation, with 94% being 'completely satisfied' at nine months compared with 71% at baseline. Levels of satisfaction with health and accommodation remained higher than the UK average at 9 months. The data only allowed calculation of a composite SWEMWBS score for ten participants at the 9 month follow up. For these, the average score increased marginally from the 3 month figure, while remaining slightly below the UK average. As for the 3 month assessments, no statistically significant changes were seen at the 9 month follow up.

3.3. Case Study Themes

While participants were on the whole very pleased with the aids they had received, they appeared to have had little involvement in choosing them. Most had products chosen for them either by the dementia advisor or by their spouse. The items reported as being of most use were whiteboards, lights/lamps and clocks. Whiteboards were most commonly fitted in the kitchen area and used to remind participants about appointments and events, although some were kept in the lounge to remind them of immediate tasks. One participant described how she used the whiteboard to plan her week and maximise her independence:

> "I write everything on there. I put everything that we are going to do through the week. I write it all down so that I don't have to keep saying 'what are we doing' all the time. When we have done something, I immediately rub it off because I know that's done. And it makes me think as well, I like that." (Marjorie).

Her husband added that initially she was writing everything haphazardly on the board and it became confusing for her. He divided the board into days of the week and found that this provided an excellent way to enable Marjorie to note, and anticipate, events for the forthcoming week.

Several participants found lights and touch lamps to be the most beneficial aids. Some had chosen battery operated as opposed to plug in lights; some had chosen motion sensitive lights whereas others could be switched on and off manually. The lights appear to have helped with orientation, preventing injury and maintaining continence:

> "The best thing for me is the light, we've got it on top of the landing and it comes on by movement so in the middle of the night when either of us goes to the loo, it comes on.

> We sleep with our bedroom door open and I've only got to move my blanket and it comes on." (Peggy).

> "Before we had them, I meant to switch on the switch by the door, but I missed it and I cut my finger all down there because there was no light." (Joan).

Several participants were provided with multiple aids through the grant program. For example, Nancy and her daughter who was her main carer had chosen a GPS tracker, a large button telephone, a memo-minder, a touch lamp, a red toilet seat, a white board, a key locator and new signage. She particularly liked the big button telephone, which allows speed dialling by using large buttons at the top of the display:

> "We haven't put pictures on it . . . we have just put (son's name) press to call and (daughter's name) press to call. I think it's good to put 'press to call' rather than just a photograph because if it's just a face you don't know that's going to call."

> However, Nancy viewed the new signage as intrusive and unnecessary:

> "No, I don't like that . . . because I don't need a blooming thing like that . . . I just go out of there and into there."

Other participants also described the limitations of specific aids that were provided. For example, Florence's husband talked about the memo-minder that was fitted adjacent to the front door and played a message to remind his wife to close the door properly or to take her keys if she left the house. He felt that the device was 'too sensitive' and had become a nuisance:

> "I've recorded various messages. The one at the moment says 'Florence, don't forget to close the door properly' because sometimes she doesn't latch it properly and lock it, 'and if you go out, don't forget your key'. Now that's been on but it did get on our nerves a bit so what we've started to do is for me to only switch it on when I go out and I don't go out that often, just one night a week when I play squash, and I like to switch it on then but sometimes I forget and that's the disadvantage of that method . . . it's easy to go out and forget to switch it on. It could be useful but if you open the door to anyone it goes off."

Other problems that were reported included someone who found it difficult to understand the digital clock when it was set to 24 h time mode. They had been unable to find out how to change the function and settings of the clock.

3.4. Stakeholder Perspectives

Stakeholders identified a wide range of benefits arising from the DDG pilot. For example, the aids provided were thought to offer crucial support after a diagnosis of dementia, as well as a way to promote continued independence:

> "You've got to keep them using it, you've got to keep them stimulated. And some of this equipment does just that, they can tell their own time, they can tell what time of the day and night it is you know? They can see where they're going, they can look in a drawer, and know that it's the right one, because it's got a label on. Okay it's got a label on, but so what? At least it means that they're not going into the wrong drawer, becoming frustrated, and then giving up."

The benefits for family carers of someone living at home with dementia were perceived to be equally important:

> "I think if we can benefit the carer and make life better, easier for the carer as well, to be able to care for that person, and stay well themselves, then yeah, absolutely, I don't think we should distinguish between the two, as such."

Additional benefits were thought to arise from the highly collaborative nature of the pilot, putting the partners in a good position to deliver future initiatives:

> "Partnership working as well, has been really beneficial between obviously, the University, but also with Worcester City Council, and with Care and Repair (the local home improvement service), and our knowledge, as well, has increased in terms of what people need and want, to be able to manage their dementia, to be able to live at home as well."

Finally, there were seen to be substantial benefits for some of the professionals involved in implementing the grant, in terms of their skills and confidence levels:

> "The more they (handyperson staff) went into people, they'd always visited people with dementia, 'cause they had mobility issues as well, but they actually hadn't thought about it from the dementia person's point of view, whereas actually fitting equipment and showing people how to work it, they got more of a feel for it, and their experience, and they became obviously more sensitive to the issues, and could also raise other issues that they were worried about."

The flexibility that was allowed in terms of the list of aids and adaptations on offer was seen as an important feature of the grant:

> "I think, as a regular list, this one is fine, then we just say to people, if there's something outside the box, you let us know, and we will review, and if it's okay, and comes from a reputable source, we'll probably buy it, to be honest with you."

Similarly, the lack of means-testing was viewed by all stakeholders interviewed as a key factor in the success of the pilot, largely due to the additional burden that means-testing would place on people with dementia and their families:

> "And yes, it means that we get stuff to people quicker, and they benefit from it quicker as well. It doesn't matter whether you've got the money or not, if you haven't got the capacity, and you've got a carer who's stretched to the limit, they really aren't going to go out and source these things, and bother with them. So, they will go without them. And, at that point in time, that person then will deteriorate and lose their independence, and I think, for the small cost that it is, because it's not a massive amount of cost, means-testing would be too much trouble, in reality."

4. Discussion

Findings from the pilot study reported in this paper suggest that relatively inexpensive aids were associated with increased overall wellbeing for people living with dementia in their own homes three months after receiving them. This should be considered in the context of an intervention group who were living with dementia and whose quality of life might be expected to be deteriorate over a period of nine months. Levels of wellbeing for pilot study participants were lower than that for the wider population, particularly in relation to loneliness, which again is not unexpected given the widely reported challenges of living with dementia. However, it was more difficult to account for the fact that levels of satisfaction with both health and accommodation were higher at baseline for participants than for the wider population.

Of particular note is the reduction in levels of loneliness amongst the people using the aids, which has been recognised as an important issue for older people generally [4] and those living with dementia in particular [13]. The picture was more mixed at nine months, with a slight deterioration in satisfaction with life and feeling worthwhile but an improvement in terms of anxiety and overall mental wellbeing. This may reflect the complexities of health and wellbeing for participants. For example, levels of co-morbidity were over 50%, which indicates the high levels of frailty experienced by people living with dementia. It also raises the possibility that the benefits reported from having the aids related not just to their dementia, but also to other conditions such arthritis, diabetes and heart conditions. In addition, it is important to note that most participants received several aids, with one person having 12, which raises the possibility different aids may be having different impacts for specific individuals. While this pilot study identified specific aids as being of most value to participants (dementia clock, notice board or white board, touch beside light, key safe), more research is required to explore the impacts of such items individually and in combination. The findings also demonstrate the key role played by family carers, usually a spouse, in supporting people with dementia in their own homes. This highlights the importance of providing aids, and other services, that can protect their wellbeing and enable them to continue in their role.

The case study findings draw on the experiences of those receiving the aids to highlight the impact they had on quality of life for people with dementia and their families. For example, the use of a whiteboard for planning weekly activities and tasks brought major benefits for one person with dementia and her husband. Similarly, touch-activated bedside lights made it easier for participants to get up at night and make their way to the bathroom. However, several participants experienced challenges when using the aids provided. One family carer described having to turn off the memo minder because it had an over-sensitive activation mechanism, while one person with dementia found the 24 h clock to be confusing. One unanticipated theme that emerged from this pilot study was the benefits experienced by the professionals involved, particularly increases in knowledge and confidence for working with people with dementia.

Learning from the pilot study has informed the following key recommendations:

- It is important to maximise involvement of the person with dementia and their family in selecting the aids and equipment. This may involve walking around the house and identifying difficulties and potential solutions, e.g., dark areas in the house which may be improved with LED motion-sensitive lights. For the person with dementia, having ownership of these decisions will make it more likely that they will engage in the use of the items and understand their purpose.
- The value of future proofing should not be underestimated. There are many advantages to identifying items that could be useful in the future and which will help people retain their independence. This might include providing specific items that are not on the standard list but which grant recipients have identified as being useful.
- The scheme works most effectively with a relatively small list of 'stock' aids and adaptations. However, this can only be developed in response to feedback regarding what items are useful and popular.
- It is important to provide support beyond the provision of the aids and adaptations, for example, ensuring that recipients and their families are conversant with setting up devices such as changing 24 h digital display clocks to a 12 h setting. Additionally, it could include explaining that some items may be useful for supporting the grant recipient rather than for them to use themselves, e.g., a key safe for use by family or friends.

5. Conclusions

In conclusion, the findings from the pilot study reported in this paper indicate that relatively small and inexpensive aids and equipment can make a positive difference to the lives of people living with dementia in their own homes. The benefits spanned three main areas: promoting independence and quality of life for people with dementia and their family carers; increasing the skills and confidence of professionals involved in the project; and strengthening partnerships between the collaborating organisations across health, housing and social care. During the pilot study, five aids were reported to be the most beneficial: dementia clock, noticeboard/white board, touch-activated beside light, key locator and memo minder. While people earlier in their dementia 'journey' have the opportunity to become more familiar with the equipment, this should not prevent people with more advanced dementia from benefitting, particularly when a carer or family member can also become familiar with the items and their potential use. Providing aids that can help people with dementia to remain living at home with a good quality of life, often with the support of a family member, should be considered as an important element in the development of age-friendly communities [5]. Following the positive findings from this evaluation, the grant scheme is continuing to be offered to people with a diagnosis of dementia living at home across Worcestershire.

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References

1. United Nations. *World Population Ageing*; United Nations: New York, NY, USA, 2017.
2. Office of National Statistics. Overview of the UK Population: 2017. Available online: https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/articles/overviewoftheukpopulation/july2017 (accessed on 8 February 2019).
3. Care & Repair. Small but Significant: The Impact and Cost Benefits of Handy Person's Services. 2018. Available online: http://careandrepair-england.org.uk/wp-content/uploads/2018/07/Small-but-Significant-Handyperson-Evaluation-CRE-2018.pdf (accessed on 15 February 2019).
4. Buffel, T.; Handler, S.; Phillipson, C. *Age Friendly Cities and Communities: A Global Perspective*; Policy Press: Bristol, UK, 2018.
5. World Health Organisation. *Global Age-Friendly Cities: A Guide*; WHO: Geneva, Switzerland, 2006. Available online: https://www.who.int/ageing/publications/Global_age_friendly_cities_Guide_English.pdf (accessed on 19 February 2019).
6. Department of Health. *Living Well with Dementia: A National Dementia Strategy for England*; Department of Health: London, UK, 2009.
7. Department of Health. Prime Minister's Challenge on Dementia. 2015. Available online: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/414344/pm-dementia2020.pdf (accessed on 8 February 2019).
8. Alzheimer's Society. *Dementia UK*, 2014 ed.; Alzheimer's Society: London, UK, 2014.
9. Prince, M.; Prina, M.; Guerchet, M. *World Alzheimer Report 2013 Journey of Caring: An Analysis of Long-Term Care for Dementia*; Alzheimer's Disease International: London, UK, 2013.
10. De Boer, B.; Beerens, H.; Katterbach, M.; Viduka, M.; Willemse, B.; Verbeek, H. The Physical Environment of Nursing Homes for People with Dementia: Traditional Nursing Homes, Small-Scale Living Facilities, and Green Care Farms. *Healthcare* **2018**, *6*, 137. [CrossRef] [PubMed]
11. Topo, P.; Kotilainen, H.; Eloniemi-Sulkava, U. Affordances of the care environment for people with dementia—An assessment study. *HERD* **2012**, *5*, 118–138. [CrossRef] [PubMed]
12. Alzheimer's Society. *Fix Dementia: Home Care*; Alzheimer's Society: London, UK, 2016.
13. Alzheimer's Society. *Dementia: The Hidden Voice of Loneliness*; Alzheimer's Society: London, UK, 2013.

14. Department of Communities and Local Government. *English Housing Survey Adaptations and Accessibility Report, 2014–15*; DCLG: London, UK, 2016. Available online: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/539541/Adaptations_and_Accessibility_Report.pdf (accessed on 15 February 2019).
15. Powell, J.; Mackintosh, S.; Bird, E.; Ing, J.; Garrett, H.; Roys, M. *The Role of Home Adaptations in Improving Later Life*; Centre for Ageing Better: London, UK, 2017.
16. Marquardt, G.; Johnston, D.; Black, B.S.; Morrison, A.; Rosenblatt, A.; Lyketsos, C.G.; Samus, Q.M. A Descriptive Study of Home Modifications for People with Dementia and Barriers to Implementation. *J. Hous. Elder.* **2011**, *25*, 258–273. [CrossRef] [PubMed]
17. Bartlett, R.; Brannelly, T. *Life at Home for People with a Dementia*; Routledge: Oxford, UK, 2019.
18. UK Office for National Statistics. People, Population and Community Survey. 2017. Available online: https://www.ons.gov.uk/peoplepopulationandcommunity/wellbeing/articles/measuringnationalwellbeing/apr2017 (accessed on 21 February 2019).
19. Warwick Medical School. Short Warwick Edinburgh Mental Wellbeing Scale. 2013. Available online: https://warwick.ac.uk/fac/sci/med/research/platform/wemwbs/swemwbs_7_item.pdf (accessed on 21 February 2019).

healthcare

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Article

Citizens' Juries: When Older Adults Deliberate on the Benefits and Risks of Smart Health and Smart Homes

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Abstract: *Background*: Technology-enabled healthcare or smart health has provided a wealth of products and services to enable older people to monitor and manage their own health conditions at home, thereby maintaining independence, whilst also reducing healthcare costs. However, despite the growing ubiquity of smart health, innovations are often technically driven, and the older user does not often have input into design. The purpose of the current study was to facilitate a debate about the positive and negative perceptions and attitudes towards digital health technologies. *Methods*: We conducted citizens' juries to enable a deliberative inquiry into the benefits and risks of smart health technologies and systems. Transcriptions of group discussions were interpreted from a perspective of life-worlds versus systems-worlds. *Results*: Twenty-three participants of diverse demographics contributed to the debate. Views of older people were felt to be frequently ignored by organisations implementing systems and technologies. Participants demonstrated diverse levels of digital literacy and a range of concerns about misuse of technology. *Conclusion:* Our interpretation contrasted the life-world of experiences, hopes, and fears with the systems-world of surveillance, efficiencies, and risks. This interpretation offers new perspectives on involving older people in co-design and governance of smart health and smart homes.

Keywords: smart health; older people; co-design; digital life-world; smart cities

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1. Background

Smart cities is a public-policy term for the move towards cities with an increasingly digital infrastructure that enables the real-time monitoring and management of key services in response to changing contexts, typically within transport and traffic management, energy, water, waste, and healthcare. The latter is becoming an increasingly significant area, with "smart health" being a newly coined term to describe the emerging health paradigm enabled by such an infrastructure. According to Solanas et al [1], "Smart health (s-health) is the provision of health services by using the context-aware network and sensing infrastructure of smart cities." Indeed, with an increasing proportion of the population being over 65 years of age [2], and with continuing constraints on resources, assumptions are made that digital technology will be the solution to improve the lives of older people whilst also reducing health and care costs [2] (p.9). Indeed, being able to deliver "smart", efficient, personalised health solutions data is key to communicating with users to enableing older people (and their carers and associated health professionals) to monitor and manage their own healthcare and ultimately "age in place" [3].

Despite considerable investment in smart cities, there continues to be low public awareness of the concept. This may be due in part to an overriding emphasis on technology as opposed to engaging with citizens or users; although this focus is starting to shift, as "while citizens tend to be the implied beneficiaries of smart city projects, they are rarely consulted" [4]. Indeed, in an The Institute of Engineering and Technology report [5] in 2016, less than one in five of the general population (18%) were aware of the term "smart city" and only 6% of older people (over 65 years) were aware of the term. The latter, in particular, signals a real challenge when considering the development of healthcare solutions for older people within a smart cities context. It is, therefore, crucial to understand the potential for the involvement of this key stakeholder group, i.e., older people.

It should be said, however, that whilst "smart health" is a relatively new concept, espousing all things digital, data-driven, and connected, there exists a strong body of research relating to more traditional technology-enabled healthcare and assistive technologies (telecare, telehealth, and telemedicine) [6,7] and a wealth of systematic reviews [8]. Nevertheless, despite "people" (older adults, care-givers, healthcare professionals) being the primary focus of such research, there still exists a general lack of understanding of the real needs of such stakeholders, compounded by a further lack of awareness of underlying attitudes, perceptions, and potential barriers to acceptance and use. Indeed, much technology-enabled healthcare research continues to focus on the technical and clinical aspects as opposed to the more subjective conditions of use [9]. There is clearly a need to involve older people/citizens fully in the development of any technology-enabled or smart healthcare initiatives, and ideally at the earlier stages of policy and service development, rather than positioning them as the testers or consumers of technology in pilot or trial settings is crucial [10]. Despite work to engage patients and the public in strategic decision making about health services, there remains a lack of consensus about how such initiatives should operate and which patients should be involved [11].

Research on stakeholder views in the field of telehealth also suggests that there may be a considerable divergence of goals between older people and other stakeholders. In a discourse analysis of 68 publications and 10 knowledge-sharing events on telehealth and telecare, Reference [7] identified four separate competing discourses that tended to "talk past one another"—that is to say, that operated with different assumptions, values, and goals, with little cross-fertilisation. Significantly, they found that these separate discourses tended to map onto different stakeholders, as follows. The modernist discourse was employed by policymakers, the technology industry, and biomedical and health informatics researchers, and it conceptualises technology as the driver and older people as passive consumers. The humanist discourse of older people as active subjects was a separate, more marginalised discourse. Similarly, Peek et al. [12] investigated the aims of different stakeholder groups involved in technology for ageing in place. Whilst stakeholders may agree on aims, the different perspectives held could be problematic in choice and implementation of technology.

The divergence between the views and experience of older people who are being asked to use technology and younger adults who are more likely to be designing and making decisions about implementation of digital technology has been labelled as the "digital divide". While recognising potential generational inequalities, there is a risk that use of such language and terms such as "digital immigrant" may not be supported by evidence and risk exacerbating stereotypes and stigma [13]. We have interpreted these challenges by drawing on the theory of Communicative Action developed by Habermas [14]. Experience of our personal daily lives, for example our desire for privacy, are part of our life-world, whereas the bureaucratic system of local government and local services tend to form a network of the systems-world. Habermas described the concern of the systems-world encroaching and controlling the life-world, sometimes as a result of corporate interests; this he named colonisation of the life-world. Digital interactions and communication have the potential to form new modes of communication; thus, they have the potential to extend our life-worlds. However, systems are necessarily developed and owned by corporations (private or public); therefore, digital systems are fundamentally systems-world [15]. Taking this perspective, we can consider the negotiation or exchange which may occur, often implicitly, between the individual and the system, in terms of whether digital systems serve the purpose of the life-world or systems-world.

Partly to counter some of these concerns, co-production or co-design has been advocated as a way to enable end users to have a significant voice and to enable technologies and systems to be designed in a way that is "user-friendly" and accountable to populations (especially local communities). The concept of co-production can be applied to citizen involvement at different stages of the planning, implementation, and review of health and social care solutions [16]. Here, we explore the potential for smart health to be co-produced with older citizens in the UK.

2. Methods

We held initial engagement sessions to co-design the topics and develop personas [17,18] for the citizens' juries. We then held two citizens' juries in Nottingham, UK. People who had attended the initial engagement sessions were invited to the second citizens' jury (B), and therefore, we expected their views and opinions to have developed from the initial meeting. Whereas, for the first citizens' jury (A), we invited people who were new to the project, and thus, we expected their views may be novel or they may have less awareness of the topics.

2.1. Participants

We engaged with many different stakeholders and networks to recruit participants for the project, including; Vulnerable Adults Provider Network (Nottingham Community and Voluntary Service), Age-Friendly Nottingham Steering Group, Nottinghamshire County Council, Nottingham City Council, Self Help UK and Healthwatch Nottingham. We especially contacted organisations who could help us to reach more vulnerable older residents such as those from Black Asian and minority ethnic communities, and those with disabilities or mental health needs.

For the initial engagement meetings, we also invited staff or volunteers of organisations which engaged with older people. These stakeholders did not participate in jury sessions. In total, 34 people attended these two preparatory meetings. In total three personas were developed but only one was used to prompt discussions within the citizens' juries.

All participants of the citizens' juries filled out a consent form, demographics questionnaire and a survey designed to assess attitudinal change before and after each of the citizen's juries. In total, 23 participants took part in the citizen's juries: 9 attended Jury A (participants were new to the project) and 14 attended Jury B (participants had previously attended the initial co-design workshop of the project). The age range for both juries was 60–70. Gender was roughly even in both juries, with 4 females in Jury A (44%), and 9 females in Jury B (64%)

2.2. Materials and Procedure

The citizens' jury methodology is described in detail in several studies [19–21]. Both jury sessions took the same format over approximately 4 hours including lunch and refreshment breaks. Each session was audio-recorded for later transcription. Participants were first asked to complete a pre-session survey consisting of 9 brief multiple-choice questions which aimed to gauge the level of knowledge participants had and their existing opinions about issues of relevance. These included questions such as "How often do you use technology such as the following: mobile phone, motion sensors or alert systems?" and the possible answers: "Several times a day"; "Sometimes"; "Rarely" or "Never"; or questions such as "Who should design health technology applications for well-being?" and possible answers: "Technology developers"; "Technology consumers"; "Local government"; "All of all the above"; and "Other, please write a few words", (see Supplementary Citizens' Jury Post-session Survey for details).

Participants were then presented with a series of dilemmas and encouraged to discuss the issues that each dilemma raised (see two examples below and a summary of topics discussed is shown in Table 1). The topics for the dilemmas were developed in the preparatory meetings. Furthermore, participants were asked for their recommendations on how to address the dilemma or problem presented to them. The juries were all moderated by an experienced facilitator, an adult previously unknown to the participants and who was not presented as an authority figure. The facilitator made sure all participants had the chance to be heard, with all experiences, viewpoints, and recommendations seen as valid and respected by all members of the jury. The sessions were guided in a way that was not leading or instructive so as not to prescribe opinions. Discussions took the form of a deliberation after each dilemma was presented, around two tables of 4 to 7 participants. This allowed participants to share opinions with the emphasis being that there were no right or wrong answers.

Table 1. Table of topics and dilemmas discussed within the citizens' juries.

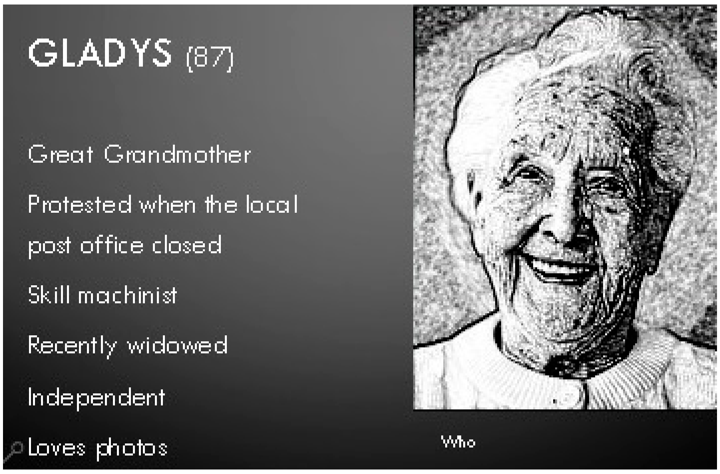
Topic	Issue or Dilemma
Smart health concept	Does the term smart health resonate or carry meaning?
Sharing of personal (medical) data	Ownership of data and continuity of care or risk of misuse?
Online systems to access health or social care	Convenient or barrier for some people?
Digital technology in the home	Reassurance for family member or invasion of privacy?
Barriers to access	Cost barrier of digital devices, lack of broadband internet connection?

Examples of the dilemmas include:

Safety monitoring versus concerns of loss of independence: Assistive technology and monitoring in the home may benefit people by offering support and to reassure people of safety. However, some people may feel that monitoring implies "keeping tabs" on them and that this may reduce privacy and independence.

Data-sharing and privacy: If someone's medical information was shared with their social worker then this may avoid duplication of the same questions. On the other hand, there was a concern for privacy; will the individual know and have control over who has access to personal data?

These dilemmas were presented to be discursive rather than prescriptive, to prompt responses and recommendations, and a persona (see Figure 1) was also created as a way to tell a story about how an individual may be affected by digital technologies and how this may affect their health.



GLADYS (87)

Great Grandmother

Protested when the local post office closed

Skill machinist

Recently widowed

Independent

Loves photos

Who

Figure 1. Persona created as a way to tell a story about how an individual may be affected by digital technologies and how this may affect their health.

This survey (see supplementary) consisted of 3 brief multiple-choice questions designed to measure attitudinal change, followed by a series of 15 statements designed to measure opinion on the issues raised; 10 statements were scored on a Likert scale from 1 (agree very little) to 10 (agree very much), and 5 were scored on a Likert scale from 1 (applies to me very little) to 10 (applies to me very much). Statements covered similar issues to those from the pre-survey including benefits/risks of health technology for society and perceptions on influencing decision making.

3. Results

3.1. Participants' Demographics (Table 2)

Table 2. Self-reported characteristics and beliefs of participants.

Total Participants (*n* = 23)		Jury A (*n* = 9)	Jury B (*n* = 14)
Gender	Female	44% (*n* = 4)	64% (*n* = 9)
	Male	56% (*n* = 5)	36% (*n* = 5)
Age	Younger than 60	0	0
	60–70	44% (*n* = 4)	50% (*n* = 7)
	70–80	44% (*n* = 4)	36% (*n* = 5)
	Older than 80	2% (*n* = 1)	14% (*n* = 2)
Religion	No religion	56% (*n* = 5)	29% (*n* = 4)
	Christian	33% (*n* = 3)	57% (*n* = 8)
	Unitarian	11% (*n* = 1)	0
	Wiccan	0	7% (*n* = 1)
	Prefer not to say	0	7% (*n* = 1)
Activity limitation	Very limited	2% (*n* = 1)	44% (*n* = 4)
	Limited	44% (*n* = 4)	0
	No	33% (*n* = 3)	50% (*n* = 7)
	Prefer not to say	2% (*n* = 1)	21% (*n* = 3)
Health	Good	22% (*n* = 2)	57% (*n* = 8)
	Fair	88% (*n* = 7)	36% (*n* = 5)
	Bad	0	7% (*n* = 1)
Ethnicity	White British	100% (*n* = 9)	72% (*n* = 10)
	White Other	0	7% (*n* = 1)
	Caribbean	0	21% (*n* = 3)

3.2. Opinion Survey: Pre-Jury and Post-Jury

This section compares responses from the pre- and post-surveys between the two groups. We were interested in whether participation within the jury led to changes in attitudes, and therefore, we invited people who were new to the project to one group, Jury A, whereas people who had attended the initial engagement meeting, and therefore had experience within the project were invited to Jury B. However, none of the survey differences between juries were significant when applying non-parametric statistic χ^2, thus, prior involvement in the project did not appear to significantly change attitudes.

3.2.1. Pre-Jury Survey

The pre-session survey revealed that at least two-thirds of the respondents in both juries use technology; the majority use technology several times a day. Additionally, a majority of people in both juries felt it was at least quite important for older people to use new technologies (93.3% of the group who had experience with the project, 66.6% of the group who were new to the project).

Most respondents in group A, who were new to the project, (85.7%) said that "Smart City Nottingham" made them feel interested about future opportunities. Whilst, in the group who had experience with the project (B), a large proportion of the respondents were split between being interested (44%) and concerned about technology (44%). In regard to the influence smart cities have over the future of healthcare of older people, responses in both group sessions were varied. A large number of the new group (A) did not know how much influence smart cities had (44.4%). Whereas in the group with experience with the project (B), the responses were mixed. This indicates that there were a range of perspectives within both groups. The range of views expressed addresses any concerns that the project may have recruited a self-selecting group; for example, people who were very critical or cynical of digital innovation.

People of different ethnicities have been described as experiencing a digital divide in a similar way to older people [22]. We have involved participants of different ethnicities and religions, as shown in Table 2, indicating that we have a mixed group of participants; however, we did not aim to analyse these intersectionalities.

A majority of both juries believed that they should have an influence in the designing of assistive technologies (77.8% and 54.5% in the new group and the group with prior experience, respectively). When asked who should design and implement health applications, a majority of respondents on both juries said that this should be a mix of technology consumers and local governments. In regard to whether the respondents thought about the ethical consequences of health technologies, at least two-thirds of both juries revealed that it is something they thought about a least a little bit.

3.2.2. Post-Jury Survey

Participants were asked to complete a survey immediately after the jury session in order to assess whether topics raised within the discussion had prompted concerns or changes in views. After the session, when asked who should be accountable if smart technologies go wrong, a majority of the group new to the project (A) answered “Other services” (55.6%) with smaller responses opting for the “Manufacturer” and the “Health Services” (Figure 2). Whilst the greatest response of the group who had experience with the project was tied between “Other services” (38.5%) and “Manufacturer” (38.5%).

When asked if the participants had learnt anything new about assistive technologies, at least two-thirds of both juries said they had learnt at least “A little” (84.6% and 66.6%, in the groups with prior experience and new to the project, respectively).

In regard to whether the participants had come up with new ideas about how to increase accessibility of smart cities for older people, a majority of respondents in both juries reported that new ideas emerged during the sessions (69.2% and 66.7% in the groups with prior experience and new to the project, respectively), whilst around a third in both juries reported no new ideas had emerged during the sessions.

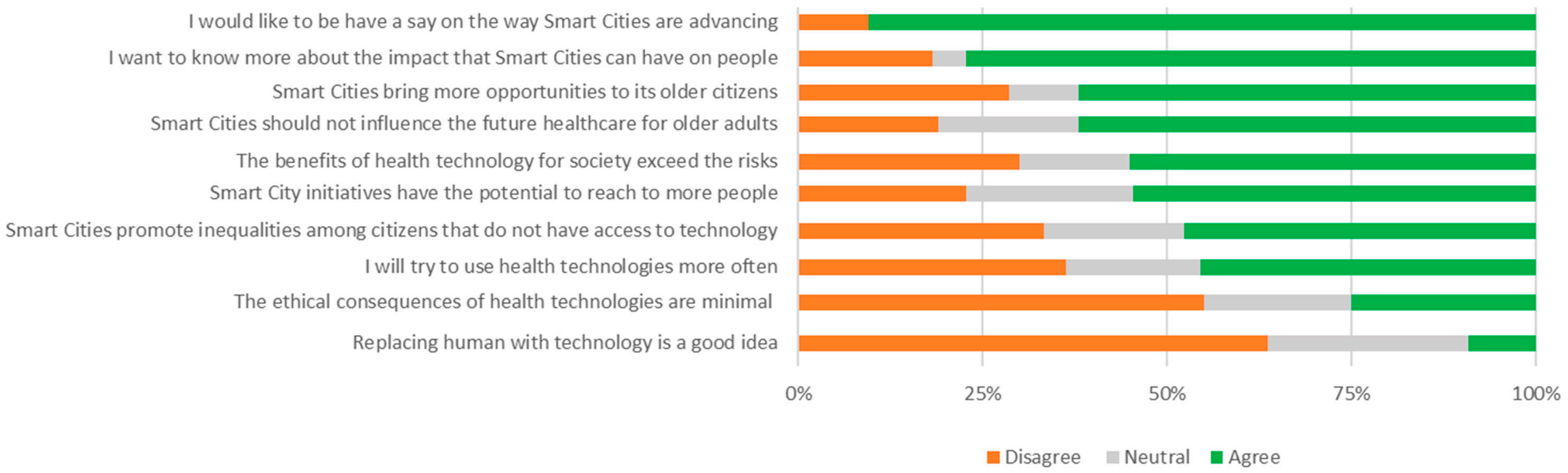


Figure 2. Post-session responses of all participants to the statements relating to issues raised in the juries. Differences between the groups were not significant for any of the statements.

3.3. Analysis of Discussion During the Citizen's Jury Sessions

The deliberations that took place at the two citizen's jury sessions were audio-recorded and analysed through exploring two perspectives. Personal experiences as well as hopes and fears about how technology may affect individuals was interpreted as reflecting the life-world. Participants discussed the potential efficiencies or improvements that the digital system could achieve; they also expressed concerns about surveillance of citizens and other risks, and these were interpreted as reflecting the systems-world. These two perspectives enabled a more nuanced interpretation, rather than a polarised interpretation of positive or negative outcomes (for the individual). Initial themes emerged from the groups of the open-space engagement session. The discussions within citizens' juries then added weight and resonance to these (see Table 3).

Table 3. Topics which emerged during workshops.

Topic Number	Personal, Life-World	Strategic, Systems-World
1	Control, privacy	Mis-trust about purpose of data collection, lack of control
2	Choice, access to information and personal efficacy	Standardisation, paternalistic
3	Continuity of care is benefit of information sharing	"Using data against you", e.g., cross-checking between agencies
4	Monitoring for safety	Surveillance and utility of data, reaching into personal domain (e.g., mobile phone)
5	Ownership	Population collective data of public sector data
6	Experience of technology in older life	Lack of adjustments for older people

3.4. Concept of Smart Health

There was much discussion about the meaning of the term "Smart Health". Our assumption was that the term relates to digital technologies that may improve or affect health and healthcare, and much of the discussion resonated with that concept. Different interpretations were that SMART was an acronym for something or that smart meant healthy living, or equivalent to good health literacy.

> " . . . it's what you eat. Now then isn't that an education process where we're talking about being smart with our health? It's nothing to do in essence we've got a gizmo on the table; it's whether or not we've got the capability to understand what in fact smart health is." (Group A, male respondent)

Whilst this quote initially appears to be discussing a different concept; it highlights a need to understand health literacy as well as digital devices. Having considered this range of concepts of the neologism "Smart Health", we will focus our interpretation on the meaning that many participants touched upon. This was very clearly described in the following quote from one participant:

> " . . . about using devices like your mobile phone, your computer, an iPad-kind-of-thing, anything digital like that. And then using like little programmes that you might call apps with some computers to help you manage your health long term of your life. So that if you've got a health condition like diabetes or something, you can manage it yourself and take control and be independent, but I would only say that as an abstract concept, not as a living position." (Group B, female respondent)

For the main part of the discussion, we interpreted views about a number of topics, and we have attempted to contrast two perspectives that were voiced by participants; views about personal experiences, or life-world, and views about the system or citizens as a whole.

3.5. Theme 1: Control and Privacy versus Mis-Trust in Purpose of Data Use

Discussion about errors and fraud were voiced as a way to demonstrate concerns about control and privacy. One participant describes the GP software system being offline, possibly due to an error, and this preventing transfer of case notes. This may be frustrating at a personal level, due to inconvenience, but it may prompt general concerns about risks of data, due to error or fraud.

> "At the moment the software at my GP place is—to use a technical term—buggered up, because I've got some other thing and they won't transfer electronically. (Group A, male respondent)

One participant had concerns about the Council using or sharing data in ways that were not in the interests of the individual. Concerns were raised about whether data was being collected in order to develop a marketable database of personal data. This indicates an awareness of the high value of personal data and also a lack of trust in the purpose of the system collecting this data.

> " ... I have a comment on the technology of this. That is, I think our approach is entirely wrong. The technology is being introduced so as to accumulate a large databank which is sellable; it's not got anything to do with our health." (Group A, male respondent)

There was discussion of governance and suggestions of additional regulation to reassure individuals. There was also an acknowledgement that there may be a diversity of views from individuals about the level of concern about sharing data.

> "I have no problem personally with sharing my data, but I do understand other people do. And it's a matter of choice. For me the solution to this would be actually regulation. So, if people abused access to your data and information that there were penalties that they would pay." (Group A, female respondent)

Concern about private multinational companies collecting medical data.

> " ... Google are now wanting to set up a website to do with smart health. They want access to your medical records, and I'm against that, some people who agree with it, that's entirely up to them, but with me my information will stop with the people who I want to have my information." (Group A, male respondent)

In this section, experience of digital technology in the personal life-world may be a feeling of invasion of privacy of data, especially if an individual's data is being used or shared in a way that was not clear or transparent. Furthermore, digital technology may enable an individual to have a greater sense of control of their GP appointment, for example, but when an error occurs, this might spark concerns about a lack of control of their personal medical data. On the other hand, the weaknesses of the systems are revealed when a computer (ICT) problem occurs, which leads to loss of control. Where the system shares data, there may be concerns as to the purpose. A concern about the systems-world is that it gathers data, almost as an inherent characteristic. Beliefs about motivation for collecting data were because large datasets are seen to be valuable or because data could be used to control or surveil the individual.

Within this theme, the life-world perspective may be described as the convenience of using online systems, for example booking appointments or sharing data with different professionals. Whereas the systems-world perspective highlights a concern that personal data is being amassed, and this may be associated with risks of accidental breach of confidentiality, or purposeful selling of data. There was also a concern that data could be shared with a motivation of controlling aspects of people's lives (maybe welfare benefits) or services. Responses to these concerns were at both the systems-world level (regulation and sanctions) and the life-world level of acknowledging that people opt-out or refuse to share their personal data.

3.6. Theme 2: Choice or Self-Efficacy versus Standardisation

Fears were voiced that with an increasing implementation of digital systems, in the future it will not be possible to opt-out or use non-digital processes. This may be interpreted as the efficiencies of standardisation of the systems-world; that bureaucracies aim for a standard process rather than flexibility to individual preferences. Participants suggested that some individuals may not want to use digital technology; which indicates that there is an expectation within modern discourse that everyone will adapt to digital technology (given time and opportunity). The views expressed questions of whether some people may not accept digital technology, and whether their views and rights should be respected. This led to an expression of concern that a group of people may have their rights infringed upon in the future, and that they will be disadvantaged if they do not accept the use of digital technology. One participant used the analogy of online shopping:

> "It's like people who buy things online now and get a better deal. But not everybody wants to do that, and not everybody should be forced to do it. So, it might be … based on individual need and the individual willingness to do it." (Group A, female respondent)

This description of buying goods online as an analogy to accessing welfare services indicates an acceptance of the discourse, in media and policy, about welfare services being conceptualised as commodities to be bought by, or given to, individuals, rather than as public goods to which citizens have a right to access. This is exemplified by the phrasing of this quote: " … manage for yourself; your health, your wellbeing over a long time" (Group B, female respondent).

The systems-world perspective is often about standardisation and efficiency of processes and services. Thus, there was a view that, in the future, older people would not have a choice, but would have to use digital technology to access health and care services.

> "I think there is a certain section of society upon which it will be imposed. They won't have any choice, mainly for cost reasons. Services can only operate if we have a system working and everyone is included in it...the point will come when they cannot be cared for adequately without this system, without wearing something on their arm. And that will come with our 87-year-old [persona]. If she hasn't taken her chance to learn basic technology when younger, when she is older and very dependent, she's so confused she doesn't know how to use it, and she hasn't a position to say no I resist any longer. It will be forced on her; she will have to accept it. So, it will be unfair, it will be undemocratic, but that is the way it is likely to go." (Group B, male respondent)

This respondent makes a clear link between the systems approach of standardising care processes and the risk that this may mean that some individuals will have to accept technology with which they do not feel comfortable. At a personal, life-world level, this indicates a constraint in choice of care or treatment, while at a systems-level this becomes about democratic choice in investment in services and technologies.

3.7. Theme 3: Data Sharing Enables Continuity of Care versus Cross-Checking between Agencies

One participant described data-sharing in a positive way; this participant is describing telehealth.

> " … if you're wearing or having some device, then the information you provide or is provided by you, or your piece of equipment, then goes back to a centre. So, it goes to your health worker, whether it's your GP, the hospital, district nurse or whatever they call them today, and that saves time, energy, money." (Group A, female respondent)

The participant implies that through sharing data between all members of the healthcare team, it will improve efficiency of communication, and hence improvement of continuity of care.

However, another participant had a very cynical view of how organisations could use personal data.

> “ . . . if you ever have a problem with [organisations] like I do, they can access your whole life near enough at the click of a mouse button. And I don’t want them to have that.” (Group A, male respondent)

This participant mentioned that he had previously had conflicts with the Council, so this may have shaped his mistrust in the digital information. This demonstrates how views about digital or smart technology are overlaid on previous relationships with institutions; these might be new technologies, but they are embedded in existing bureaucracies and systems.

These two respondents demonstrate how this interpretation may open new discourses about data use and trust in data-sharing. Whereas the first quote is about personal care and improving continuity, that is where the individual may gain benefits from opting into the system. The second quote shows how the individual is thinking about how the system works at a bureaucratic level, and what the implications might be for control of personal data. Development within smart cities should acknowledge these two discourses in order to improve governance and processes as well as communications about these with stakeholders and public.

3.8. Theme 4: Systems-World Reach into Personal Devices; Convenient Reminders or Over-Reach?

> “ . . . the appointments, notifications on the phone. Which I think is great, it’s a good idea.” (Group A, female respondent)

This participant is describing the healthcare system’s use of efficient scheduling and digital communication to reach into the domain of personal communication, the mobile phone. The participant welcomes this, presumably from a perspective of convenience and preventing forgetting the appointment. However, this may be an area of tension, where other individuals may feel that reminder notifications on their mobile phone may invade their personal space and life-world. Another participant had had phone and skype consultations with the doctor and this participant had a similar view; that this was convenient and saved the doctor’s time.

> “I very often don’t need to go down to the doctor. I’ve had one phone appointment with the doctor, but I would quite like a Skype for the next time appointment; to save me going down sometimes and to save them time.” (Group A, female respondent)

Again, receiving a phone call from the doctor at home and conducting a medical consultation over the phone could be perceived as the systems-world accessing the personal space of home, and carries the risk of communications being unsecure. People may become concerned that organisations or systems can reach into their personal space to communicate or monitor their activity.

> “ . . . Even though I’ve got a laptop, I treated myself to a [Smart TV] . . . it frightens me to death. I’ve got this thing that somebody’s watching me.” (Group B, female respondent)

For individuals with limited cognition or communication, it may be difficult to understand their view on health monitoring and use of data; and yet this may be a situation where monitoring an individual’s health status is a priority. One participant described the importance of understanding the individual’s wishes before cognitive decline.

> “I know my husband and I have talked about people having power of attorney at various time about care, about finances. People have got to make those kinds of decisions before they . . . [deteriorate].” (Group A, female)

3.9. Theme 5: Ownership versus Collecting Population-Level Data

Participants from one session mentioned ownership of health records, comparing the situation in Britain with France. Her experience in France was that individuals have ownership of their records and take them to the doctor, whereas Britain was perceived to be behind the times in not enabling people to own their records.

> " . . . why Britain is one of the few countries in Europe that people don't keep their own records. I mean I know that when I'm in France if someone goes to the doctor, they take their records with them. And I don't see why I'm not grown up enough to know what's wrong with me . . . in Britain, it's always been the doctor's always the way; that knows the answer, and you're there listening to the great God doctor." (Group A, female respondent)

This participant is indicating that the lack of access and ownership to personal health data indicates an entrenched paternalistic relationship between healthcare professionals and patients. This is a description of the systems-world, and a frustration that the personal health information cannot be owned and co-located within the life-world of the individual.

" . . . I think it is important that the individual is in charge of it." (Group A, female respondent)

Ownership of data could lead to individuals checking the validity of data and correcting errors. Another respondent indicates that they would be willing to share personal data, as long as an appropriate regulatory framework was in place, with appropriate sanctions.

> " . . . I have no problem, personally, with sharing my data, but I do understand other people do. And it's a matter of choice. For me the solution to this would be, actually, regulation. So, if people abused access to your data and information, that there were penalties that they would pay." (Group A, male respondent)

An exchange between two participants highlighted the difference between personal data for care of the individual compared to the same data being aggregated and used for population intelligence. The first participant starts by introducing the idea that information is provided by the individual, phrasing which may indicate a sense of ownership. This information then "goes back" to a centre which coordinates professional activity; this phrasing suggests a spatial distance between the personal and professional (systems) worlds. The outcome of these processes is that "your GP . . . district nurse" is notified of the issue and can respond in an efficient and timely manner, indicating a personal and convenient response. These savings may refer to the system, and the mention of money suggests efficiency for the system rather than savings for the patient (as there are no out-of-pocket fees for health professionals' time in the health service in England).

> " . . . if you're wearing or having some device, then the information you provide or is provided by you, or your piece of equipment, then goes back to a centre. So, it goes to your, so your health worker, whether it's your GP, the hospital, district nurse or whatever they call them today. And that saves time, energy, money." (Group A)

In responding to this participant, another participant takes the "indirect" perspective of the systems-world. He argues that although there has to be potential to benefit the individual patient, there also has to be a benefit for the health system; this phrasing—"has to benefit the health service"—suggests a "business case" type of argument. Personal data collected by various devices is interpreted by analysts to yield population data in order to improve decision-making for future health service planning. This latter perspective is an objective argument which also has potential to benefit the individual in the long term, and is a strong contrast to the personal benefits of arranging multi-disciplinary care in a timely way to meet the needs of an individual (person-centred care).

> "It has to be for the benefit of the patient. I fully accept that. But, also, there is an indirect benefit to the patient in that it has to benefit the health service itself. The collection of data about the community—and that will ultimately help you. It may not give you an immediate assistance, but down the line, people who are able to interpret it will know more about the population and be able to make more intelligent decisions about healthcare." (Group A, male respondent)

Taking a systems-world perspective, the participant argues that aggregated data can inform health planning. This is a complex argument and indicates a high level of knowledge and consideration by this particular participant.

3.10. Theme 6: Co-Design for Older People

Different perspectives may be characterised as "why do we have to use digital technology to access services that we had for years". This contrasts with the systems-world assumption that older people should use technology in the same way as younger people (already) do.

> "Now does in fact Gladys [persona] want somebody to call in to her who can remind her how to in fact access a part of a computer programme? I forget, and I'd spend more time trying to remember how to do it, purely and simply because I only need to do that particular problem on an infrequent period of time. So, I get frustrated." (Group A, male respondent)

With this perspective in mind, participants were keen that technology developers should involve older people into the design of products and systems.

> "But the technology companies have to employ people like Gladys [persona] and say right, we've got this thing, does it work for you? And I'm not sure the extent to which they use people like that when they're designing their products." (Group A)

Thus, at the systems-level, data might identify that a proportion of people are not accessing technologies or services delivered in a technological context; however, we need to understand how individuals interact and find meaning in digital technologies, in order to improve design to be accommodating of all older people.

4. Discussion

4.1. Key Findings

This paper compares the opinions and attitudes about smart cities and the impact on health and well-being. We held two citizens' juries, where the difference between the two juries was that one group had previously been involved in the co-design of the content of the session (B), whereas the other group were new to the project (A). The results revealed that there were no differences between the juries in existing levels of knowledge, opinions, and in attitudinal change. The pre-session survey was implemented to gauge the existing level of knowledge and opinions. Whilst the post-session survey was implemented to measure attitude change and measure opinions on the issues discussed.

The survey completed before and after the jury session can be linked to the topics discussed at the juries. Discussions revealed participants' deliberations about the benefits and risks of smart health technologies and system. During the pre-session survey, 44.4% (Jury A) and 14.3% (Jury B) of participants expressed concerns towards technology. This result highlighted the differing welcoming attitudes to smart health. Whilst discussing attitudes, participants voiced scepticism and resistance towards smart health technologies. Concerned participants expressed a preference for face-to-face support. In the post-session statements, a majority of participants did not agree it was a good idea to replace humans with technology. However, the participants did express that technologies can help reach those who live alone and aid in social interactions, mentioning benefits to health problems in older adults such as dementia. This was reflected in the over half of the participants agreeing that smart city initiatives can help reach more people.

Although a majority of participants suggested in the pre-session survey that they often use technology, in the discussion, participants made recommendations of training in technology for older adults. They also mentioned issues of the digital divide, which was expressed in rating in post-session statements. Despite identifying a digital divide, pre-session results suggest that participants do believe it is important that older adults use new technologies. Furthermore, responses to the post-session questionnaire which suggests that individuals will try and use health technologies more often, although responses were mixed. This should be an incentive on the potential of greater use of health technologies, provided technologies are accessible, simple, and affordable for the target population.

Participants recognise the importance of sharing information through health technologies and how it can potentially benefit their navigation in healthcare (such as making appointments). A majority agreed in the post-session statements that the benefits of health technologies exceed the risks. The group did, however, raise issues relating to the regulation of data sharing and their part in controlling the information. Generally, in the pre-session survey, when asked about ethical consequences, a majority of participants in both groups had some concern. This trend continued in the responses in post-session statements related to ethical consequences, where even after discussion, a majority disagreed with having minimal concern.

Qualitative analysis used a Habermasian approach of exploring perspectives on life-world and systems-world. The advantage of this approach is that the personal experience can be investigated and separated, to a degree, from the qualities of the emergent system. This is particularly important with integrated systems and data; it may not be the individual piece of technology which has a positive or negative outcome, but rather the technology within multiple interrelated systems (digital and process, i.e., bureaucratic systems). We applied this approach to explore six themes which were prompted or emerged during the citizens' jury sessions.

While raising some scepticism and concern, participants generally want to be more engaged in the design and implementation of health technologies. The participants stressed the importance of testing technologies on older adults, echoing ideas that technologies need to be simple and accessible. This collaborative approach reduced concerns of being forced to engage with technologies that are not wanted and allowing older adults to regain control.

4.2. Internal Validity—Strengths and Weaknesses

A range of views were expressed from male and female respondents and across the group which had previous involvement in the project and the group which was new to the project. No specific patterns were detected across these groups. Furthermore, we did not detect a self-selection issue.

These were small groups ($n = 9$ and $n = 12$) from one city in England. The views were likely to be influenced and contingent on the public discourse within the city. However, this approach was important to recognise for a city-based initiative such as "Smart City Nottingham" because processes and public communications should be adapted to local contexts.

We took a very broad approach to digital technology, rather than focusing on a particular platform or device. The weakness of this approach was that various comments may not relate, and there may be a lack of depth of discussion. However, the advantage was that the analysis gained a "bigger picture" interpretation of concerns which may be important to understand at an overarching level.

4.3. External Validity—How Does It Compare to the Literature

Our broad approach relates to many different disciplines, from healthcare to data-systems design. This approach is consistent with "lifeworld-led healthcare" and the previous body of work on patient-centred care [23,24]. We have built on a Habermasian analysis of the medical encounter where the intermediary between doctor and patient, a language interpreter, implicitly negotiates between life-world and systems-world [25]. Whereas, in our study, digital technologies and systems act as intermediaries between citizens and health professionals and the city bureaucracy. This approach has enabled a detailed interpretation of complex interrelationships which are often conceptualised as a "wicked problem" of the "digital divide" [26].

4.4. Future Work

Whilst some discourses perpetuate the view that older people respond in a passive way to innovative technology, our study has found a desire of individuals to be consulted and participate in the co-design of smart systems. There is a growing awareness of potential inequalities that may emerge as older people find it difficult to access services due to technological barriers. From a human rights perspective, older people have a right to be involved in the design and implementation of technologies and systems where they are the main beneficiary. Further work is needed to explore the two elements of health literacy and digital literacy and how these interact at a personal level and at a city-wide level.

5. Conclusions and Recommendations

Our study took a co-design approach in developing citizens' jury sessions to explore the views of how a smart city may affect people's health and well-being. Using a persona to discuss several dilemmas enabled exploration and deliberation on a number of common themes of data control, privacy, and convenience of technology. Surveys before and after the jury sessions captured the range of perspectives within the group and could counter any claims that these groups of participants represented any particular interest. Participants expressed concerns about the risks of data sharing and use of data; however, the convenience of booking appointments or accessing online healthcare records was valued. Participants were aware of the benefits of digital systems to the health and care sector, especially for efficiency and collection of data. Our interpretation of life-world and systems-world perspectives enabled a nuanced understanding of these tensions or trade-offs within the implementation and experience of a smart city for older people.

We recommend further research in the following topics that were found to resonate with participants: data-sharing and trust in use of data; personalisation or standardisation; and surveillance in the home. Many of these topics relate to trust between citizens and the organisations involved in the system (especially health and social care providers). Co-production may facilitate trusting relationships, and citizens' juries are one method to achieve this with a rights-based deliberative consultation. Further research is required to explore how statutory, private, and third-sector organisations can best respond and incorporate these views in strategy and implementation.

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References

1. Solanas, A.; Patsakis, C.; Conti, M.; Vlachos, I.S.; Ramos, V.; Falcone, F.; Postolache, O.; Pérez-Martínez, P.A.; Di Pietro, R.; Perrea, D.N.; et al. Smart health: A context-aware health paradigm within smart cities. *IEEE Commun. Mag.* **2014**, *52*, 74–81. [CrossRef]
2. Sinclair, D.; Creighton, H. *Opportunity Knocks: Designing Solutions for an Ageing Society*; International Longevity Centre: London, UK, 2015; Available online: https://www.theiet.org/impact-society/factfiles/manufacturing/opportunity-knocks/ (accessed on 31 March 2019).
3. Kim, K.-I.; Gollamudi, S.S.; Steinhubl, S. Digital technology to enable aging in place. *Exp. Gerontol.* **2017**, *88*, 25–31. [CrossRef] [PubMed]
4. Saunders, T.; Baeck, P. *Rethinking Smart Cities from the Ground up*; Nesta: London, UK, 2015; Available online: https://www.nesta.org.uk/report/rethinking-smart-cities-from-the-ground-up/ (accessed on 31 March 2019).

5. Institution of Engineering and Technology. *Smart Cities – Time to Involve the People?* Institution of Engineering and Technology: Stevenage, UK, 2016; pp. 1–8. Available online: https://www.theiet.org/impact-society/factfiles/built-environment/smart-cities/ (accessed on 31 March 2019).
6. Henwood, M. *Future Imperfect? Report of the King's Fund Care and Support Inquiry*; King's Fund: London, UK, 2001; Available online: https://www.emeraldinsight.com/doi/pdfplus/10.1108/14608790200200013 (accessed on 31 March 2019).
7. Greenhalgh, T.; Procter, R.; Wherton, J.; Sugarhood, P.; Shaw, S. The organising vision for telehealth and telecare: Discourse analysis. *BMJ Open* **2012**, *2*, e001574. [CrossRef] [PubMed]
8. Van den Berg, N.; Schumann, M.; Kraft, K.; Hoffmann, W. Telemedicine and telecare for older patients—A systematic review. *Maturitas* **2012**, *73*, 94–114. [CrossRef] [PubMed]
9. Sponselee, A.A.G. *Acceptance and Effectiveness of Telecare Services from the End-User Perspective*; Eindhoven University of Technology: Eindhoven, The Netherlands, 2013; Available online: https://research.tue.nl/en/publications/acceptance-and-effectiveness-of-telecare-services-from-the-end-us (accessed on 31 March 2019).
10. Brunton, L.; Bower, P.; Sanders, C. The Contradictions of Telehealth User Experience in Chronic Obstructive Pulmonary Disease (COPD): A Qualitative Meta-Synthesis. *PLoS ONE* **2015**, *10*, e0139561. [CrossRef] [PubMed]
11. Renedo, A.; Marston, C. Healthcare professionals' representations of 'patient and public involvement' and creation of 'public participant' identities: Implications for the development of inclusive and bottom-up community participation initiatives. *J. Community Appl. Soc. Psychol.* **2011**, *21*, 268–280. [CrossRef]
12. Peek, S.; Wouters, E.; Luijkx, K.; Vrijhoef, H. What it Takes to Successfully Implement Technology for Aging in Place: Focus Groups with Stakeholders. *J. Med. Internet Res.* **2016**, *18*, e98. [CrossRef] [PubMed]
13. Brown, C.; Czerniewicz, L. Debunking the 'digital native': Beyond digital apartheid, towards digital democracy. *J. Comput. Assist. Learn.* **2010**, *26*, 357–369. [CrossRef]
14. Habermas, J. *The Theory of Communicative Action: Lifeworld and Systems, a Critique of Functionalist Reason*; Wiley: Cambridge, UK, 2015.
15. Elder-Vass, D. Lifeworld and systems in the digital economy. *Eur. J. Soc. Theory* **2018**, *21*, 222–224. [CrossRef]
16. Löffler, E. A Future Research Agenda for Co-Production: Overview Paper. In *Co-Production A Series of Commissioned Reports*; Local Authorities & Research Councils' Initiative; 2009; pp. 9–25. Available online: http://www.govint.org/fileadmin/user_upload/publications/LARCI_CoproductionPapers_2010.pdf (accessed on 31 March 2019).
17. Cooper, A. *The Inmates Are Running the Asylum*; Sams: Indianapolis, IN, USA, 2004.
18. Grudin, J.; Pruitt, J. Personas, participatory design and product development: An infrastructure for engagement. In Proceedings of the 7th Biennial Participatory Design Conference, Malmø, Sweden, 23–25 June 2002; Binder, T., Gregory, J., Wagner, I., Eds.; pp. 144–161.
19. Vallejos, E.P.; Koene, A.; Carter, C.J.; Statache, R.; Rodden, T.; McAuley, D.; Cano, M.; Adolphs, S.; O'Malley, C.; Pothong, K.; et al. Juries: Acting out digital dilemmas to promote digital reflections. *ACM SIGCAS Comput. Soc.* **2016**, *45*, 84–90. [CrossRef]
20. Perez Vallejos, E.; Koene, A.; Portillo, V.; Dowthwaite, L.; Cano, M. (Eds.) Young people's policy recommendations on algorithm fairness. In Proceedings of the 2017 ACM on Web Science Conference, Troy, NY, USA, 25–28 June 2017; pp. 247–251.
21. Coleman, S.; Pothong, K.; Vallejos, E.P.; Koene, A. *The Internet on Trial: How Children and Young People Deliberated about Their Digital Rights*; University of Nottingham: Nottingham, UK, 2017; Available online: http://casma.wp.horizon.ac.uk/wp-content/uploads/2016/08/Internet-On-Our-Own-Terms.pdf (accessed on 31 March 2019).
22. Ennis, L.; Rose, D.; Denis, M.; Pandit, N.; Wykes, T. Can't surf, won't surf: The digital divide in mental health. *J. Ment. Health* **2012**, *21*, 395–403. [CrossRef] [PubMed]
23. Dahlberg, K.; Todres, L.; Galvin, K. Lifeworld-led healthcare is more than patient-led care: An existential view of well-being. *Med. Health Care Philos.* **2009**, *12*, 265–271. [CrossRef] [PubMed]
24. Todres, L.; Galvin, K.T.; Holloway, I. The humanization of healthcare: A value framework for qualitative research. *Int. J. Qual. Stud. Health Well-Being* **2009**, *4*, 68–77. [CrossRef]

25. Greenhalgh, T.; Robb, N.; Scambler, G. Communicative and strategic action in interpreted consultations in primary health care: A Habermasian perspective. *Soc. Sci. Med.* **2006**, *63*, 1170–1187. [CrossRef] [PubMed]
26. Neter, E.; Brainin, E. eHealth literacy: Extending the digital divide to the realm of health information. *J. Med. Internet Res.* **2012**, *14*, e19. [CrossRef] [PubMed]

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Technology to Support Aging in Place: Older Adults' Perspectives

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Abstract: The U.S. population over 65 years of age is increasing. Most older adults prefer to age in place, and technologies, including Internet of things (IoT), Ambient/Active Assisted Living (AAL) robots and other artificial intelligence (AI), can support independent living. However, a top-down design process creates mismatches between technologies and older adults' needs. A user-centered design approach was used to identify older adults' perspectives regarding AAL and AI technologies and gauge interest in participating in a co-design process. A survey was used to obtain demographic characteristics and assess privacy perspectives. A convenience sample of 31 retirement community residents participated in one of two 90-min focus group sessions. The semi-structured group interview solicited barriers and facilitators to technology adoption, privacy attitudes, and interest in project co-design participation to inform technology development. Focus group sessions were audiotaped and professionally transcribed. Transcripts were reviewed and coded to identify themes and patterns. Descriptive statistics were applied to the quantitative data. Identified barriers to technology use included low technology literacy, including lack of familiarity with terminology, and physical challenges, which can make adoption difficult. Facilitators included an eagerness to learn, interest in co-design, and a desire to understand and control their data. Most participants identified as privacy pragmatics and fundamentalists, indicating that privacy is important to older adults. At the same time, they also reported a willingness to contribute to the design of technologies that would facilitate aging independently. There is a need to increase technology literacy of older adults along with aging literacy of technologists.

Keywords: retirement community; co-design; privacy; research ethics; artificial intelligence; robots

1. Introduction

The preference of older adults to "age in place," or to live independently at home, rather than in an assisted living facility, is widely recognized [1–4]. Individuals who develop disabilities and are no longer able to age in place are likely to be institutionalized in assisted living facilities. These declines, which can occur with advanced age, are key barriers to one's ability to maintain an independent lifestyle [5,6]. This often leads to more significant mental and physical decline, as well as quality of life decline and increased cost of care, compared to older adults who continue to live independently [7]. As a result, effective means of providing support for older adults are of central public health and ethical significance. In many cases, external aids provide crucially needed assistance that can prolong independent living.

Technologies, such as internet of things (IoT), Ambient/Active Assisted Living (AAL) robots and other artificial intelligence (AI), have been shown to have great potential in fostering independent living, improving mental and physical health, and increasing quality of life [8–11]. At the same time, they can also reduce caregiver burden, which can lead to more targeted and better quality care [12]. However, despite playing a significant part in successful interventions, adoption of these technologies has been limited [13,14]. One key barrier to wider adoption has been the "top-down" design process that is often used in creating technology for older adults. This process is based on technologists', or at best geriatricians', preconceptions of the needs of older adults with little consideration of user perspectives and preferences or their real-world constraints.

While there are a number of studies that have indicated the need for well-designed technologies that meet the needs of older adults [15], few have addressed user-related issues in the design process of these technologies. It has been recognized that effective technologies are those that prioritize the needs and wishes of older adults, general acceptance of potential users, and suitable preconditions for its adoption [16], but this is often difficult to achieve with a top-down design methodology that fails to engage users in the design process. This has frequently created significant mismatches between the needs and preferences of the users and the products that are developed to fulfill their needs. Areas of concern for users include visual appearance, functionality, affordability, platform sustainability, privacy concerns, and interaction complexity [17–19]. These mismatches can hinder meaningful adoption and sustained usage, and risk leaving priority needs of end-users unmet. Employment of user- or human-centered design (HCD) involves the end user in the early planning phases to better understand the needs of individuals for whom a product is being developed and to ensure relevant safety, access, and utility are built in [20]. A design process involving end users can reveal untapped areas for improvement, which can lead to improved user satisfaction and lower adoption barriers, and ultimately to much improved support for individuals who wish to age in place [21,22].

The goals of this study were to: (1) involve residents of a local continuing care senior housing community (CCSHC) in conversations about technologies that might facilitate their continued independent living status [23]; (2) assess their privacy attitudes and preferences; and (3) identify whether residents would be interested in co-designing technologies moving forward and if so, how to foster next steps.

2. Materials and Methods

2.1. Recruitment

Two focus groups were convened at a local retirement community located in San Diego, California, to explore barriers and facilitators to technology adoption as well as interest in participating in a "tech" co-design process. This study was carried out in conjunction with a longitudinal, observational study involving over 100 residents. Both focus groups were held in August 2018. Residents of the retirement community were invited to participate via an IRB-approved flyer. Community leadership helped distribute the flyer and placed copies in the community lobby. Input was solicited from community leadership to determine appropriate time slots for the focus groups. Residents interested in participating were directed to sign up for one of two time slots offered. Selection criteria included any resident of the independent living facility with an expressed interest in the study and willingness to participate in a 90-min group discussion. Residents requiring assisted living or skilled care were excluded from the study. To confirm attendance, an email reminder was sent to those who signed up for a time slot. On the day focus group sessions were held, no individuals were turned away. The study was verified as exempt by the UC San Diego Institutional Review Board. Focus group attendees were provided with an introduction to the project purpose and they gave verbal consent to participate. Each participant received $30.00 as compensation for their participation.

2.2. Data Collection

Data were collected via focus group and survey methodology, both of which are described below:

2.2.1. Focus Group Semi-Structured Interview Guide

The focus group protocol was developed with a goal of obtaining the perspectives and guidance of older adults over 65 years old regarding their: (a) use of and interest in technology and connections to personal health; (b) preferences for involvement in participatory design of AI assistive aids; (c) familiarity with terms, concepts, and processes associated with the design of AI aids for aging in place; and (d) advice and preferences for how technology development experts should most effectively communicate such information to enable an authentic and informed participatory design process (see Appendix A). An initial draft of the semi-structured interview protocol was reviewed by a resident leader of the retirement community and revised to incorporate comments.

Focus groups were conducted in a conference room located on-site in the CCSHC's main building. Each group session was allocated 90 min and was led by a trained focus group facilitator (CN). A student research assistant took notes and managed logistics while two residents volunteered to record individual comments on poster paper (SW). The moderator asked open-ended questions and participants were asked to answer asynchronously. Some questions prompted the participants to reflect on their answers and write down their thoughts on a 3×5 card before further questions were asked. Group discussions were digitally recorded (audio) and professionally transcribed. The focus groups aimed to deepen the understanding of the topic as participants built on one another's discussions and viewpoints. At the end of the focus group session, participants were asked to complete a written survey to gather demographic information as well as to assess privacy attitudes.

2.2.2. Survey

A survey was used to obtain demographic characteristics of the participants with the four scales designed to measure privacy attitudes described below:

Westin Privacy Segmentation Index

The Westin Privacy Segmentation Index (PSI) is used to classify participants into three groups: Privacy Fundamentalists, Privacy Unconcerned, and Privacy Pragmatists [24]. The PSI consists of three questions that assess whether consumers trust businesses and regulations to safeguard their privacy.

Westin Privacy Concern Index

The Privacy Concern Index (PCI) is another scale that was developed by Westin et al. in the 1990s [24]. Scoring is used to classify participants into three groups: high, medium, and low with respect to the level of privacy concern. The PCI used for this study included five questions from the original six-item version. One item regarding the creation of a privacy commission by the government was omitted as it was unrelated to the present study. The survey also asked participants about their concerns on current threats to their personal privacy. While this question is not part of the PSI or PCI, it was also developed by Westin and Louis, and was used in prior privacy research [24].

Internet Users' Information Privacy Concerns (IUIPC)

The Internet Users' Information Privacy Concerns (IUIPC) scale by Malhotra et al. consists of ten questions with three subscales (Cronbach's alpha = 0.92) [25]. The first three questions (1–3) comprise the Control subscale and focus on the extent to which participants believe that control is the key issue with consumer privacy. Questions 4–6 are labeled the *Awareness* subscale and are used to rate the importance of disclosure and awareness of information collection. The last four questions (7–10) are labeled the *Collection* subscale and focus on the amount of information that is collected by companies. Along with these ten questions, two additional questions developed by Malhotra et al. were also included. One asked whether participants falsified their personal information during registration on websites and the other focused on how frequently participants heard about the potential misuse of the information collected from the internet [25].

Data Sensitivity

The last section of the survey assessed participant perspectives of the sensitivity of different kinds of personal information. The 12 different types of personal information were rated using a ten-point scale with 1 = "Not sensitive at all" to 10 = "Very sensitive." The majority of the 12 types of personal information focused on health information (e.g., electronic health records and present fitness), with three types being more general (e.g., internet search terms, GPS).

2.3. Data Analysis

The transcribed audio recordings were analyzed using a methodology of "Coding Consensus, Co-occurrence, and Comparison" and rooted in grounded theory (i.e., theory derived from data and then illustrated by characteristics examples of data) [26,27]. Each transcript was independently coded by two project investigators (JR and KB) at a general level in order to condense the data into analyzable units. Segments of transcript were assigned codes based on a priori (i.e., questions in the focus group guide) or emergent themes. In a few instances, the same text segment could be assigned more than one code. The investigators subsequently met to discuss and refine the codes and to develop a final list of codes, construed through consensus, consisting of a numbered list of themes and sub-themes, issues, and opinions. With the final coding structure, interrater reliability was assessed for a subset of 10 pages of each transcript (about half of the total pages), with a kappa value of 0.97, indicating a high degree of concordance between raters.

Quantitative data were analyzed using SPSS.

3. Results

Participants included 31 older adults between the ages of 67 and 94 years (mean = 80.0, SD = 6.2) with 20 females and 11 males, and 70% having a college or graduate degree. Most (97%) were White, with 60% reporting an annual income of over $100 K (see Table 1). Two individuals did not complete the demographic and privacy survey.

The qualitative analysis revealed several key barriers toward adoption of technologies and digital platforms, namely: (1) technology usability, (2) technology literacy, (3) data management and privacy, and (4) technology co-design. Below, each theme is defined and characterized by participant comments and survey results.

Table 1. Demographics of the Sample.

Age (mean, SD)	80.0 (6.2)
Gender (n, % female)	20 (64.5%)
Highest education (n, %)	
Graduated from high school or GED completed	4 (13.3%)
Graduated from 2-year college	5 (16.7%)
Graduated from 4-year college	6 (20.0%)
Completed some post-college education	6 (20.0%)
Completed Master's degree	6 (20.0%)
Completed professional degree or Ph.D.	3 (10.0%)
Ethnicity (n, %)	
Hispanic or Latino	2 (6.5%)
Not Hispanic or Latino	28 (90.3%)
NA	1 (3.2%)
Race (n, %)	
Caucasian/White	30 (96.8%)
Asian	1 (3.2%)
Approximate annual household income (n, %)	
\$50,000–\$99,999	12 (40.0%)
\$100,000–\$149,999	14 (46.7%)
\$150,000–\$199,999	3 (10.0%)
\$300,000 or more	1 (3.3%)

3.1. Technology Usability

The theme of "technology usability" was defined by how accessible a product is to those attempting to use it. Sub-themes point to barriers around user interface making intuitive navigation of a product difficult, and physical challenges that become obvious when technologies are not designed for the older demographic.

3.1.1. Lack of Unified Frameworks and User Interfaces

Because of the fragmentation of different digital platforms and services, there are many cases where the lack of a unified user interface can lead to increased user frustration and compromise usability. For example, one participant was trying to set up an email service and expressed frustration with navigating what should have been a fairly routine task.

> *"To get email hooked up, to get this done, to get the keyboard . . . all that stuff, and a lot of folks just give up."*

Another purchased a backup system for her computer, but had no idea how to set it up.

> *"I'm going 160 days without backup because even the geek group that we have here can't answer my question in order for me to get it set up."*

Frustration appeared to be a significant barrier, which led to a lack of self-confidence and motivation to pursue using the technology.

> *"I think technology can, for some people, get to the point where life is more difficult than it was before we had that technology."*

> *"I have a smart phone. My kids think I can use this, but I don't really know how to use this, and they bought it for me thinking it would be a great tool, but I don't really know what to do with it."*

Devices that were easy to use due to having simple features, such as the "on/off" switch for an electronic toothbrush, or plugs that worked regardless of how you inserted it (i.e., the Apple Lightning

Connector [28]), were noted as being supportive technologies. Lastly, concerns were voiced about technologies that introduce hazards to older adults, such as the use of power cords. Since having power cords around the house creates a tripping hazard and fall risk, several participants advocated for more wireless functionality.

3.1.2. Increased Mobility and Visual Challenges When Using Technologies

Older adults often face challenges in accessing hardware features or digital content due to a lack of accommodation of their limitations in mobility and decreased visual capacity. In some cases, the technology is designed to keep the battery charge connection out of sight—perhaps for aesthetics or weather proofing. However, when concealed, connectors can be more difficult for an older adult to access. One participant described his experience trying to charge the electric scooter that he uses to get around. Specifically, the connection was underneath the seat, requiring that he either bend over or get on his hands and knees to locate and connect the plug for charging.

> *"One of the biggest frustrations that I've seen was folks with power carts and a lot of them, to charge the battery, the plug is way down underneath your seat . . . . Couldn't bend over to put it in, can't see it . . . "*

There are also times when a simple solution, such as replacing a battery, proves challenging as evidenced by this comment:

> *"I have had more calls from people who say, "I just put a brand-new battery and it doesn't work." They put the battery in backwards (laughter) and, at times, it burns out the unit."*

Participants noted that the difficulty in replacing a battery was related to the inability for many to visually see the positive and negative symbols.

3.1.3. Recommendations for Improving Technology Usability

Participants were pragmatic in their recommendations for improving usability. Simple instructions, fewer buttons, larger fonts, and speech-activated tools were noted during the discussion.

> *"Why don't they have a senior version or an app that can get to on, off, volume up/down, channel, and make it kind of simple?"*

Of interest, but not surprising, were also suggestions such as having a universal remote to operate the television and peripheral devices—technologies that are often already on the market as finished products, but plagued by a lack of awareness of their existence.

3.2. Technology Literacy

Technology literacy is a theme defined by having sufficient knowledge to independently understand the instructions to facilitate use of a technology. Sub-themes point to knowledge barriers, need for resources, and data management.

3.2.1. Knowledge Barriers

A lack of understanding of modern technologies and digital platforms was identified as a barrier resulting in underutilization of technology and dependence on others to operate basic features. Participants mentioned purchasing services (e.g., Netflix) they did not use, because they could not understand how it worked.

> *"I know I'm looking for this connection, but I don't know what it's called, I don't know what the things are, and so there is no . . . terminology, you know . . . um."*

Another participant commented that in order to use her smart phone, she needed guidance from her granddaughter. Moreover, many of the participants left the workforce before technology was integrated into the daily work flows in a significant way, leaving them without the vocabulary or basic skills needed to function in the digital age. One participant described this tech literacy gap as follows:

> *" . . . I retired 20-something years ago, so I didn't have the opportunity to work with them [technology] at work. So we got less work-based training on them and I don't understand the language of it. Trying to hook a printer up to my laptop—they said to put in the IPP [sic IP] address. Uhh, I can't find it . . . you know, and things like that, I don't know what they are talking about."*

3.2.2. Recommendations for Improving Technology Literacy: Need for Resources

The tech literacy problem could be addressed with the "how to" manuals that accompany technology devices; however, the "Getting Started" instructions were described by participants as too technical due to the unfamiliar terminologies that were used. Most people relied on family members to help with setup, but this did not always result in the type of help they needed.

> *"Show me, slow down, and it's hard to get 'em to slow down. And you know, and I feel like I'm being a burden or they just don't think Nana is smart enough. Maybe I'm not, but I could try to be if they were a little more patient."*

One participant asked if university students were being trained to help older adults learn to use the technologies. From a technology perspective, user interface is optimal if fewer, rather than more, support personnel are needed. The fact that older adults need assistance in using technologies is indicative of suboptimal designs for this demographic.

3.3. Data Management and Privacy

The theme of data management and privacy is characterized by three sub-themes: (1) how data can be collected and used; (2) whether knowledge gained is shared in a form that results in value to the participant; and (3) privacy attitudes.

3.3.1. Data Collection and Use

While highly educated, most participants lacked understanding of the granularity of data that can be captured with pervasive sensing technology and the associated analytics used by digital platforms to identify patterns. The mystery of AI, including what it is and how it works, contributed to fears of data loss or being harmed from decisions made from their personal data.

> *"If they're [the technology] so sensitive, they know three weeks before we know what's going wrong with our bodies. It seems to me that that kind of information could really be compromised, and seniors could, uh, who are very vulnerable, could really be hoodwinked more easily."*

3.3.2. Return of Value

Moreover, the idea that data could be collected about them without a return of value was problematic. Participants expressed a desire for more instantaneous and understandable feedback, especially when participating in health research. The lack of feedback could potentially hamper enthusiasm for research study participation.

> *"You need to talk to your doctor about X, Y and Z. Um, but if you just keep gathering data and nothing happens to that data . . . um . . . except that you can look at it and . . . and you can't really interpret it . . . "*

3.3.3. Privacy

There was widespread desire by participants to understand how to use different technologies and how to control personal data. In addition, in order to better understand participants' privacy attitudes, this issue was discussed during the focus group, and participants' attitudes were measured via a survey.

Westin Privacy Concern Index

For this index, three questions are used to classify a person as low, medium or high with respect to their concern about privacy in the context of trust that business and law will protect their privacy.

A majority of participants (66.7%) reported a medium privacy concern compared with 20% reporting a low concern, and 13.3% reporting a high concern (see Figure 1).

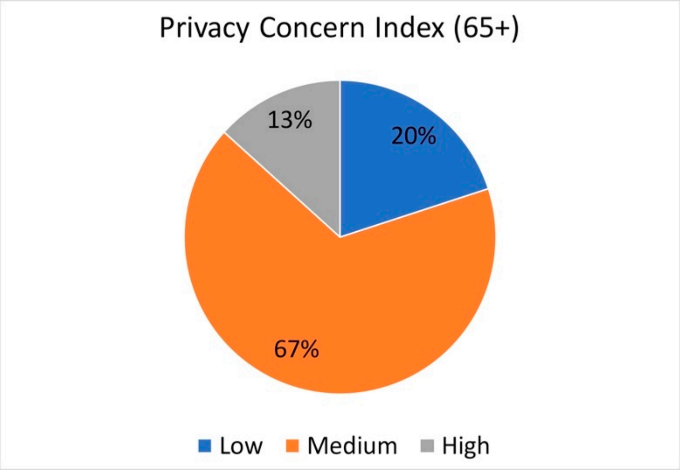

Figure 1. Westin Privacy Concern Index Results.

Westin Privacy Segmentation Index

Between 1979 and 2001, Westin randomly selected U.S. citizens to gauge privacy attitudes across a variety of domains, including health information, consumer and e-commerce [29], and identified three key privacy categories: pragmatists, fundamentalists or unconcerned [24]. Results from Westin's "Privacy On and Off the Internet" survey revealed that 25% of those surveyed were fundamentalists, 55% were pragmatists, and 20% were unconcerned [24,30]. Fundamentalists were described as having a high value for privacy, believing they own their information, and supporting strong laws and regulations to secure privacy rights. Pragmatists were characterized as open to information disclosure if to a trusted entity providing a personal benefit; and unconcerned were described as not having a high need for privacy and control of information [30]. While there has been some criticism of Westin's scale, it is a potentially useful baseline for understanding privacy attitudes. For the purpose of this study, we used this scale to compare our sample with national survey results. Nearly half of our older adult participants (46.7%) were categorized as "privacy pragmatist", compared to 55% from Westin's sample. Only 13% of our older adult sample was considered "privacy unconcerned", with 40% categorized as "privacy fundamentalist", compared with 20% and 25% of Westin's sample, respectively (see Figure 2). When asked about the level of concern regarding threats to personal privacy in America nowadays, a majority of the participants (58.1%) reported being "somewhat concerned", with 29.0% being "very concerned". Compared to national averages, our sample of older adults scored lower in the privacy pragmatic and unconcerned categories and much higher in the privacy fundamentalist category.

Results of the Westin Privacy Concern Index showed that a majority of older adults in our sample had a medium or high privacy concern (80%) with 40% categorized as privacy fundamentalist using the Privacy Segmentation Index. These results indicate that the older adults we sampled are less willing to share information about themselves with others. However, we learned during the focus group discussion that participants were willing to share information if they received something in return, which is more aligned with the privacy fundamentalist classification where people weigh sharing information based on what they get back. For example, with respect to sharing personal information, one participant stated:

> *"That's fine, you can take all the data you want, I mean … but is it gonna be of benefit to me?"*

Another participant liked the idea of getting personalized feedback from artificial intelligence tools as noted here:

> *"Well, I think if you can get some sort of readout that is, you know, available from the unit in your apartment, the status of where you are today, to be interactive in a sense, broadcasting the information that is . . . is collected about you and be analyzed by the artificial intelligence obviously to give you some kind of status, you know, you . . . you're doing okay today or . . . or you ate too much yesterday."*

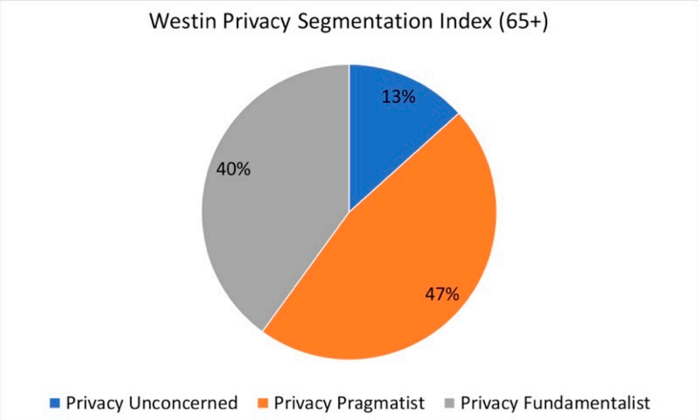

Figure 2. Westin Privacy Segmentation Index Results.

Internet Users' Information Privacy Concerns (IUIPC):

The IUIPC is a 10-item scale with a high internal consistency (Cronbach's alpha = 0.90). The level of internet privacy concerns was high among participants with an average rating of 6.1 out of 7 (SD = 1.3). The *awareness* subscale score was high with an average rate of 6.5 out of 7 (SD = 1.2). This subscale showed that 70% of the older adults were aware of the issue of personal information collection online and strongly agreed that disclosure of information usage was important. Additionally, the *control* subscale was moderate with an average rate of 5.8 out of 7 (SD = 1.6). In fact, a majority (50%) of the older adults strongly agreed with the idea that control is the key issue with consumer privacy. These older adults also reported a moderate level of concern on the *collection* subscale with an average rate of 6.0 out of 7 (SD = 1.6). Specifically, 60% of participants felt offended about the amount of information that is being collected by companies (see Figure 3).

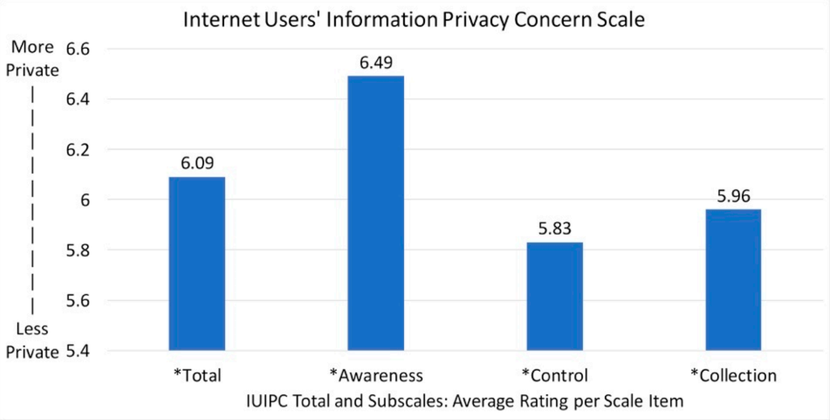

Figure 3. Internet Users' Information Privacy Concerns (IUIPC) Results.

When asked about the percentage of time older adults falsify their personal information during registration on a website, 86.7% of the older adults reported either never falsifying their personal information or falsifying their information less than 25% of the time. This suggests that older adults are less likely to take certain online privacy protection methods to protect themselves. When asked about how frequently they heard about the potential misuse of the information collected from the internet, the mean score was 4.5 (SD = 1.6) out of 7 (Very Much), indicating that most of the older adults had heard or read some information on this topic.

Sensitivity to Personal Information

To better understand privacy attitudes, our survey asked the participants to rate the sensitivity of 12 different types of personal information (see Figure 4). The results indicate that participants regarded their bank account information as the most sensitive data type with an average sensitivity rate of 9.7 (SD = 1.1) out of 10 (Very Sensitive). Across all 12 sensitive information types, participants rated present fitness and addictions as having the lowest sensitivity, with an average rating of 6.4 (SD = 3.0 and SD = 4.0, respectively) out of 10 for both. Next to bank account information, smartphone GPS data and internet search history ranked among the most sensitive types of data, both with an average rating of 8.1 (SD = 2.8) out of 10, suggesting that older adults generally consider online information as more sensitive. The highest sensitivity rating on health information was the electronic health records (EHR) with an average sensitivity rating of 7.7 (SD = 3.4) out of 10.

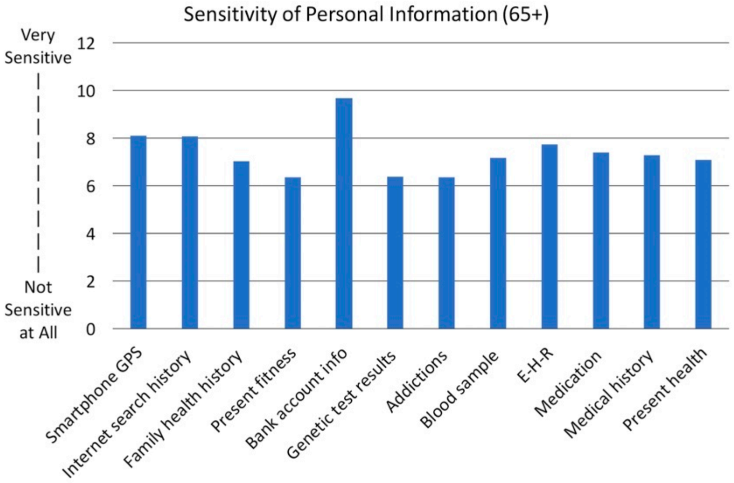

Figure 4. Sensitivity of Personal Information Analysis.

3.4. Co-Design of Technology

Participants favored the idea of participatory design and were eager to participate in a co-design process. The consensus was that as people who have lived experiences being older, they brought a perspective to the tech development process that might not be present otherwise.

> *" … ethics and morality and seeing further from having lived longer that I think collective wisdom of the elderly might be extremely important in the checks and balances put in place."*

> *"I think it's a deal of bioethics. Sometimes the 85 and above have more human knowledge than the people working in the industry."*

Participants also expressed ideas around what an ideal design project might include to better meet their needs.

> *"Why can't there be a feature on the TV that I can get the sound to come straight to my hearing aid electronically?"*

> *"If they would come up with a universal remote that worked for the TV, for the iPhone … for everything so that you could program into it that you could remotely operate … I think that would solve some of the problems we all have."*

Clearly, there is a significant desire to participate and contribute to the ideation and development process, which could lead to technology better designed for adoption by older adults.

4. Discussion

The growth of general purpose and healthcare-related technologies has created the potential to help more older adults to age in place. Living independently is preferred by older adults and smart technologies like IoT, AI, and AAL can provide the necessary assistance. Due to improvements in communication and remote data gathering capabilities by healthcare providers and researchers, operationalizing smart communities will become more dependent than ever on sensors and predictive analytics of collected data. The results from this study reveal barriers to the adoption of technologies and facilitators that could foster increased access to and usability of technologies to support independent living. Factors identified through this study were: (1) technology usability, (2) technology literacy, (3) data management, (4) privacy attitudes, and (5) co-design.

4.1. Technology Usability

Older adults in our study tended to associate adoption of new technologies with a lack of confidence in their ability to understand or access them. A significant source of frustration in their interactions with digital products lay in the inadequacies in software and hardware interfaces that permit access to different functionalities. Participants gave examples of technologies they interacted with every day and identified specific examples of problems with their access to these technologies.

The physical decline that can occur as people age creates physical access barriers in technologies. These can be attributed to the dimensions and locations of certain components and how they interface with power sources and other technologies to conduct data transfer or data input. Another noticeable concern in physical access is the existence, or lack thereof, of visibility enhancement features. Visual aids are often inadequate or poorly designed for common use cases that can allow for easier access to content displayed in a visual medium.

It has been suggested that a key motivation in technology adoption by older adults is the presence of a significant perceived benefit [31]. Despite the fact that many participants in the study indicated ownership of a diverse set of modern devices, many of the features that participants wished for in future technologies already existed on the personal devices they already possessed. The lack of knowledge of the existence of these functionalities can vastly diminish the perceived potential of many technologies, affecting adoption or continual usage.

4.2. Software Interface

The software interface is also a potential source of friction for older adults. Lack of familiarity with and understanding of technology can make it difficult for older adults to be at ease while operating user interfaces. Because older adults were not introduced to modern digital work environments until later in life (or in many cases not at all), their ability to adapt to changes is hindered by a lack of fundamental knowledge in how digital infrastructures operate and how data is utilized.

While the lack of understanding in operating a device could be alleviated somewhat by instructional material documenting steps to access functionalities, older adults tend to rely on static content, such as printed manuals, to fulfill this need. Few participants in the study were capable of effectively utilizing online instructional and troubleshooting materials. In some cases, the barrier was a small font size that was difficult to read, even with prescription glasses. The vocabulary was often unfamiliar (e.g., Bluetooth) and proved meaningless when trying to understand instructions. For many, this meant an increased reliance on assistance from younger and more "tech savvy" family members. While relying on family is a possible solution for those who are fortunate enough to have younger and helpful family members who are more knowledgeable, it is less effective in helping older adults solve future problems.

Modern software and internet platforms have also adopted the model of constant incremental updates and iterations to adapt to user preferences. This has created fluid interfaces that change without warning, quickly rendering previous usability knowledge and documentation obsolete. This unpredictability is especially problematic with the fragmentation in interface philosophies on different digital platforms, necessitating repeated familiarization processes to keep pace with the latest changes. How to make these incremental updates while considering the impact on the digital novices is important if we are to design for needs of an older demographic.

4.3. Data Control and Privacy

A large majority (87.1%) of the participants indicated that they were concerned with data privacy in their day-to-day usage of technology. This high level of concern with controlling their personal data suggests a hesitancy in adopting a technology or submitting personal data to a digital platform. This mistrust and misunderstanding of the handling of data can be an especially serious obstacle to the adoption of technology that requires large amounts of personal data to be effective, such as machine learning algorithms.

Another concern voiced by the participants was a lack of feedback from data collected by digital devices or researchers. The awareness subscale in IUIPC showed that 70% of the participants were aware of the online information collection and strongly agreed that disclosure of information usage is important. However, the lack of feedback could potentially lead to decreased enthusiasm to participate in studies or an unwillingness to provide personal data. This is particularly an area of interest for digital health research, where the data collected and their analysis can be of high interest to the participants who are concerned about their health. At the same time, it is often unclear how to return the data back to the research participants in a manner that is meaningful to them. In traditional clinical research, research data are rarely returned to the participants. As such, there is a lack of a clear pathway to determine what would be meaningful (e.g., raw data or a short report) nor how often to provide feedback. The answer is likely to be person-specific—for instance, a person who requests and can process complex information versus someone who is satisfied with a very brief summary. In keeping with the growing focus on personalized medicine, there should be a framework for providing personalized data feedback.

4.4. Implications for Creating Age-Friendly Communities

As the number of older adults increases, the World Health Organization has initiated a movement to establish age-friendly communities [32]. An important component of this initiative should be identifying technologies that support aging in place. Our early stage HCD research sheds light on important issues that are unique to older adults specific to privacy and technology literacy. Engagement of older adults in the design of technologies is often overlooked or an afterthought. Technologies that are commonly used by older adults are often developed without consulting them at the early stage of product conception. This top-down design model means that user input is only received by the product developer after it is completed, making it much harder to alter in order to fit user needs. Our study showed that older adults are experts in their lived experiences and can identify the potential barriers to technology adoption and use.

In this study, participants voiced their concerns about technologies they interacted with daily, albeit with varying levels of success, and offered ideas for how to improve these products. One issue was their lack of understanding of fundamental technology concepts. A common barrier to the participatory design process involving older adults is the lack of expertise in product development and programming [33]. Because of this technology literacy gap, there is significant potential value in providing an educational component in the co-design process to overcome this issue. While impractical to educate older adults on more complicated topics in computer science and human computer interaction, basic knowledge about current technologies and how they interact with each other would be immensely valuable. For instance, one participant commented that the facility personnel spend a lot of time letting people into their apartments because residents often misplace or forget their keys. An eye scanning or finger print sensor that could be used to unlock the door of the residence, or a system that mimics the proximity-based keyless lock system on modern cars, was suggested by a participant. By gaining a high-level understanding, the resulting ideas and concepts generated by older adults can be more meaningful, particularly in the prototyping stage of the participatory design process, where practical knowledge is needed [34].

In addition to the understandability and usability of different technologies, concerns were raised by participants over the use of data and the importance of privacy and control. This feedback is especially useful when designing technologies for older adults, who may have a very different perception of data and expectations around privacy than younger generations. Many indicated their willingness to provide more sensitive data if it meant getting meaningful feedback on the status of their heath. At the same time, they were also reluctant about sharing data of other categories due to hacking or data loss concerns. This indicates the importance of addressing privacy concerns in different scenarios for different technologies. A participatory design process that values privacy could be a key factor in improving user adoption.

By including residents in this formative research, we were able to identify what would be needed to engage older adults in the design process in a meaningful way and what they would like to receive in the form of feedback. With a better understanding of the technology that they are using, older adults can shape the design philosophy to better serve their needs as users. A next step in this research is to develop a co-design process that incorporates technology education as a component with a goal of increasing “tech literacy.” We anticipate this education will facilitate identifying and prioritizing problems that can be addressed with a technological solution that residents help to co-design.

4.5. Limitations

The results presented here are part of a larger study to determine how AI can be used to assess individual cognitive and physical status through the use of traditional means and sensor technologies. Due to the parameters of the larger study, the sample drawn for this study involved people residing in a CCSHC, which is not a random nor representative sample of older adults. These results are also based on a relatively small sample of 31 participants. However, all participants contributed to the discussion and a data saturation point was reached. Finally, the PSI, PCI and IUIPC scales were developed for testing consumer and internet privacy.

5. Conclusions

This study demonstrates the significant gap that exists between the potential benefits offered by technologies such as AI and other AAI and the barriers that plague older adults in the adoption of these technologies. Education is critical not only for older adults, but also for technologists. While increasing “technology literacy” of older adults can provide meaningful improvements in helping these users interact more successfully with technology, we also must address the need to educate technology creators about older adults—i.e., increasing “aging literacy” of technologists. This education can occur through pragmatic exercises that involve partnering with older adults to design future technologies. Through co-design partnerships, we can create technologies that are useful and capable of reducing barriers at the design phase. Rather than intervening after a product is in the market place, we can preempt the problems introduced by low technology literacy and fundamentalist privacy attitudes. Moreover, feedback loops can be built in that will help older adults to better understand their data and how these data are used to predict their healthcare needs.

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Appendix A

Focus group protocol
CO-DESIGN TECHNOLOGY FOR AGING IN PLACE—HEALTHY AGING
August 9, 2018

INTRODUCTION

Welcome: Hello everyone! I'd like to thank you for accepting our invitation to participate in this focus group.
Confidentiality: Your contributions to our discussion are important and Shengzhi will be taking notes to help us remember what we discuss today. To make sure we don't forget anything, we are audio recording each session. In our transcript of the recording, we will not identify you by name and your responses will be confidential. Only members of our research team will have access to the recording, transcripts and our notes.
Purpose: We are conducting this research as part of a UC San Diego Health Sciences project on technology-enabled health research. We've asked you here today to talk about how technology might be used to facilitate living independently. We are also interested in knowing how your think about your health information and privacy. In addition to asking you to respond to questions, I will also ask that you complete a survey which will take about 10 min.
Consent: As with any research, you are free to ask questions at any time and your involvement is completely voluntary. If you have any concerns about being recorded or decide you don't want to participate in this focus group, please know that you can leave at any time and there will be no hard feelings. To acknowledge your time and contributions, we will give you a $30.00 script that can be exchanged for cash at a local bank.
So, to get started, I would like mention some basic instructions for how this works ... This session will last about 90-min. Near the end of our time we will ask you to complete a survey. After that, we will give you a check that's called "script" that you can take to the bank to exchange for cash. We are interested in your thoughts and opinions—there are no right or wrong answers here. We expect that there will be some areas where most people agree but, there will also be times when there is disagreement. That's not a problem—we want to be respectful of each other's opinions. Differences of opinion are expected so feel free to share yours even if it's different. Please make sure everyone has a chance to chime in and please don't interrupt each other!

A. Curiosity about technology and connection to personal health

1. **Digital technologies you currently use** There is growing interest in how digital technologies can be used to support healthy living and aging-in-place. To get started, I would like you to think about what "digital technologies" you use in your daily life. Feel free to use the 3 × 5 cards in front of you to jot down any thoughts you have. <*Give 1-2 min to think*> Okay, what are some of the technologies that you're using? <*Write key words identified by participants on butcher paper*> Think back to a time when you felt that you'd like to use a technology like a smart phone app or Facebook and were not quite sure

how to do it? Can you tell us about that? Think back to a time when you felt that using a technology or a smart phone app has made you feel great. Can you tell us about that?

2. **Technology use over time** We've talked a little about how we think about technology—we're also curious about how your thoughts about technology has change over time. Is the way you think about using technology different than how your family might think about it? Why did you start using the technologies on your list? Why have you continued using them?
3. **Health Practices and Tools** Now, we want to talk about how you keep yourself healthy. Think about the kinds of tools you use daily to track your health and to keep yourself healthy. Write those down on the index card. *(Examples: hearing aids, blood sugar or blood pressure monitor, scale, exercise machines, fitness trackers, pill trackers (whether a box or a digital device), medication reminders, mail-order prescription delivery services, safe-alert buttons, diet/nutrition aids, electronic health record monitoring, canes, wheelchairs, etc.)* Why do you use these tools or adopt these practices? How did you come to acquire them? Why do you keep using them? Think of a time that using your health practice or tool was frustrating, or when you struggled to use it correctly. Can you tell us about that? Think of a time that your health practices or tools has made you feel reassured, or safer. Can you tell us about that? How could keeping track of your health and keeping yourself healthy be made easier? What would make you feel confident transitioning adopting a new health practice or tool?
4. **Health Data and Privacy** With technology, there have been problems with handling of personal information and people are worried about their privacy. How would you describe the characteristics of a very private person? How about a not at all private person? *Make notes on your 3 × 5 cards* Do you think privacy means something different today than say 30 years ago? Is the way you think about privacy different than how your family might think about it? Most people think about their health information being located in their electronic health record but, nowadays, our information is found on Facebook, Twitter as well as in sensor technologies and apps that we download onto our phones. There are now fitness devices and apps that can track your steps, diet and sleep as well as mood. Do you currently use any apps or wearable devices? What are you using and what do you like or dislike about it? These devices capture information that could be personal and health related. Would you want to control who has access to this information? Why or Why Not? Would you want to share information from your personal devices or apps with your doctor? What about with researchers like me? We are interested in using wearable sensors to learn about how people live in their everyday lives. *Show a variety of devices (lumo, empatica, sensecam, authographer, garmin, fitbit)* Wearable Sensors

   What do you think about the wearable camera? Would you wear it for a day or a week? What concerns would you have? What would motivate you to wear it?
   What do you think about the wrist worn devices? Would you wear it for a day or a week? What concerns would you have? What would motivate you to wear it?
   What do you think about the waist worn devices? Would you wear it for a day or a week? What concerns would you have? What would motivate you to wear it?
   What do you think of the overall design of these devices? Can you get it on/off easily? Is the information that is collected useful to you?

   Home Sensors

   What do you think about having sensors placed in your apartment that could alert you or a friend about how you're doing?

Show examples of data produced.

B. **Preferences for involvement in participatory design of intelligent assistive technologies**

1. **Interest in co-design** Some researchers are trying to make activities such as tracking your health, keeping you safe, taking care of your home, communicating with your family even easier with new technologies and tools. < *Show figure of technologies* >

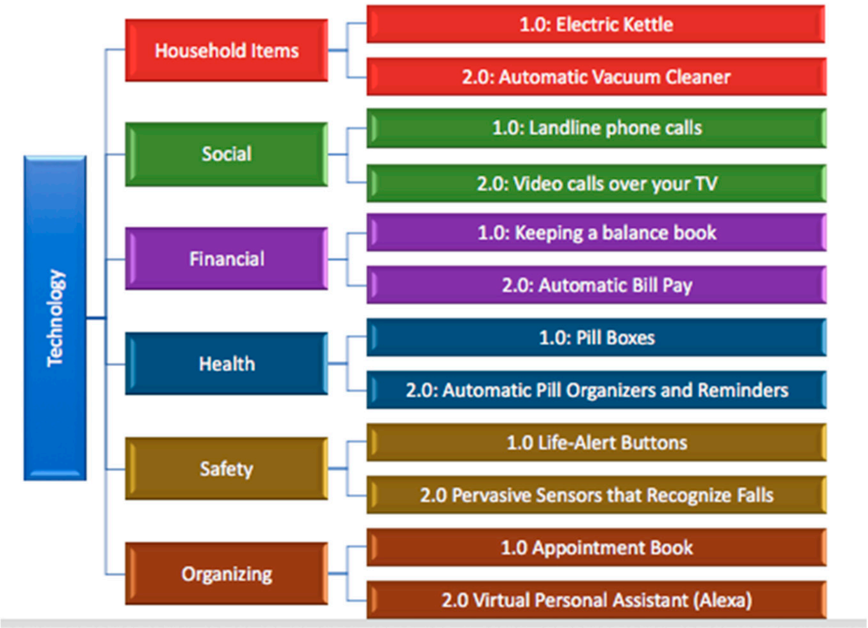

Figure A1. Technology by Domains.

Now, researchers, and especially engineers and technology developers, might think they know how to best help you, but they also need your input to make sure that they create products that actually fulfill *your* goals and are easy for *you* to use. Would you be interested in having conversations with technology makers to guide the design process of products that are specifically geared toward people in retirement communities? If you could develop technology to improve your life in any way, what would you develop? Do you have an idea of what it would look like? Could you draw a picture of it?

2. **Familiarity with terms, concepts, and processes associated with the design of assistive technologies for aging in place Term 1: Aging in Place**

What does "aging in place" mean to you?
What kinds of technologies do you think could support aging in place?
What would "success" mean for the design of aids for aging in place?

Term 2: Participatory Design

Participatory design means that stakeholders are involved in the design of new products and devices. What do you think this means in practice?
What can you contribute?
How would you think of your role on the design team?
What type of process would you want to feel like you a part of it?

Term 3: Assistive Technologies/Intelligent Assistive Technologies

<*Show videos or prototypes, such as: https://www.smithsonianmag.com/innovation/how-will-artificial-intelligence-help-aging-180962682/*>

3. **Advice and preferences for how technology development experts should most effectively communicate such information to enable an authentic and informed participatory design process** We want to know how we could maximize your involvement in a participatory design process. How much time would you want to spend? Do you want to do it at your home, or do you want to meet elsewhere? How often can you fit this in? Would you be willing to test out devices while they are still in development? Why or why not? That's the end of our session. Thank you for participating!

References

1. Woolhead, G.; Calnan, M.; Dieppe, P.; Tadd, W. Dignity in older age: What do older people in the United Kingdom think? *Age Ageing* **2004**, *33*, 165–170. [CrossRef]
2. Eckert, J.K.; Morgan, L.A.; Swamy, N. Preferences for receipt of care among community-dwelling adults. *J. Aging Soc. Policy* **2004**, *16*, 49–65. [PubMed]
3. Matsumoto, H.; Naruse, T.; Sakai, M.; Nagata, S. Who prefers to age in place? Cross-sectional survey of middle-aged people in Japan. *Geriatr. Gerontol. Int.* **2016**, *16*, 631–637. [CrossRef]
4. Boldy, D.; Grenade, L.; Lewin, G.; Karol, E.; Burton, E. Older people's decisions regarding "ageing in place": A Western Australian case study. *Australas J. Ageing* **2011**, *30*, 136–142. [CrossRef]
5. Ball, M.M.; Perkins, M.M.; Whittington, F.J.; Connell, B.R.; Hollingsworth, C.; King, S.V.; Elrod, C.L.; Combs, B.L. Managing Decline in Assisted Living: The Key to Aging in Place. *J. Gerontol. B Psychol. Sci. Soc. Sci.* **2004**, *59*, S202–S212. [PubMed]
6. Diehr, P.H.; Thielke, S.M.; Newman, A.B.; Hirsch, C.; Tracy, R. Decline in health for older adults: Five-year change in 13 key measures of standardized health. *J. Gerontol. A Biol. Sci. Med. Sci.* **2013**, *68*, 1059–1067.
7. González-Colaço Harmand, M.; Meillon, C.; Rullier, L.; Avila-Funes, J.-A.; Bergua, V.; Dartigues, J.-F.; Amieva, H. Cognitive decline after entering a nursing home: A 22-year follow-up study of institutionalized and noninstitutionalized elderly people. *J. Am. Med. Dir. Assoc.* **2014**, *15*, 504–508. [CrossRef]
8. Task Force on Research and Development for Technology to Support Aging Adults. *Emerging Technologies to Support an Aging Population*; Committee on Technology of the National Science & Technology Council: Washington, DC, USA, 2019.
9. Mihailidis, A.; Carmichael, B.; Boger, J. The use of computer vision in an intelligent environment to support aging-in-place, safety, and independence in the home. *IEEE Trans. Inf. Technol. Biomed.* **2004**, *8*, 238–247. [CrossRef] [PubMed]
10. Cody, M.J.; Dunn, D.; Hoppin, S.; Wendt, P. Silver surfers: Training and evaluating internet use among older adult learners. *Commun. Educ.* **1999**, *48*, 269–286. [CrossRef]
11. Chiu, C.-J.; Hu, Y.-H.; Lin, D.-C.; Chang, F.-Y.; Chang, C.-S.; Lai, C.-F. The attitudes, impact, and learning needs of older adults using apps on touchscreen mobile devices: Results from a pilot study. *Comput. Hum. Behav.* **2016**, *63*, 189–197. [CrossRef]
12. Wang, J.; Carroll, D.; Peck, M.; Myneni, S.; Gong, Y. Mobile and Wearable Technology Needs for Aging in Place: Perspectives from Older Adults and Their Caregivers and Providers. *Stud. Health Technol. Inf.* **2016**, *225*, 486–490.
13. Hoque, R.; Sorwar, G. Understanding factors influencing the adoption of mHealth by the elderly: An extension of the UTAUT model. *Int. J. Med. Inf.* **2017**, *101*, 75–84. [CrossRef] [PubMed]
14. Aging Well in the 21st Century: Strategic Directions for Research on Aging. Available online: https://www.nia.nih.gov/about/aging-well-21st-century-strategic-directions-research-aging (accessed on 2 April 2019).
15. Khosravi, P.; Ghapanchi, A.H. Investigating the effectiveness of technologies applied to assist seniors: A systematic literature review. *Int. J. Med. Inform.* **2016**, *85*, 17–26. [CrossRef] [PubMed]
16. Peek, S.T.M.; Wouters, E.J.M.; Luijkx, K.G.; Vrijhoef, H.J.M. What it Takes to Successfully Implement Technology for Aging in Place: Focus Groups with Stakeholders. *J. Med. Internet Res.* **2016**, *18*, e98. [CrossRef]
17. Renaud, K.; Karen, B.J. Judy Predicting technology acceptance and adoption by the elderly: A qualitative study. In Proceedings of the ACM International Conference Proceeding Series, Wilderness, South Africa, 6–8 October 2008; Volume 338.

18. Lorenz, A.; Oppermann, R. Mobile health monitoring for the elderly: Designing for diversity. *Pervasive Mob. Comput.* **2009**, *5*, 478–495. [CrossRef]
19. Iwaya, L.H.; Gomes, M.A.L.; Simplício, M.A.; Carvalho, T.C.M.B.; Dominicini, C.K.; Sakuragui, R.R.M.; Rebelo, M.S.; Gutierrez, M.A.; Näslund, M.; Håkansson, P. Mobile health in emerging countries: A survey of research initiatives in Brazil. *Int. J. Med. Inform.* **2013**, *82*, 283–298. [CrossRef] [PubMed]
20. Designing for Older Adults: Principles and Creative Human Factors Approaches, Second Edition. Available online: https://www.crcpress.com/Designing-for-Older-Adults-Principles-and-Creative-Human-Factors-Approaches/Fisk-Czaja-Rogers-Charness-Czaja-Sharit/p/book/9781420080551 (accessed on 23 March 2019).
21. Scandurra, I.; Sjölinder, M. Participatory Design with Seniors: Design of Future Services and Iterative Refinements of Interactive eHealth Services for Old Citizens. *Med. 2.0* **2013**, *2*, e12. [CrossRef]
22. Ritter, F.E.; Baxter, G.D.; Churchill, E.F. *Foundations for Designing User-Centered Systems: What System Designers Need to Know about People*; Springer: London, UK, 2014; ISBN 978-1-4471-5133-3.
23. Zarem, J.E. *Today's Continuing Care Retirement Community (CCRC)*; LeadingAge: Washington, DC, USA; American Seniors Housing Association: Washington, DC, USA; National Investment Center: Annapolis, MD, USA, 2010.
24. Kumaraguru, P.; Cranor, L.F. *Privacy Indexes: A Survey of Westin's Studies*; Carnegie Mellon University: Pittsburgh, PA, USA, 2005.
25. Malhotra, N.K.; Kim, S.S.; Agarwal, J. Internet users' information privacy concerns (IUIPC): The construct, the scale, and a causal model. *Inf. Syst. Res.* **2004**, *15*, 336–355. [CrossRef]
26. Glaser, B.G.; Strauss, A.L. *The Discovery of Grounded Theory: Strategies for Qualitative Research*; Aldine de Gruyter: Hawthorne, NY, USA, 1967; ISBN 978-0-202-30260-7.
27. Willms, D.G.; Best, J.A.; Taylor, D.W.; Gilbert, J.R.; Wilson, D.M.C.; Lindsay, E.A.; Singer, J. A Systematic Approach for Using Qualitative Methods in Primary Prevention Research. *Med. Anthropol. Q.* **1990**, *4*, 391–409. [CrossRef]
28. Golko, A.; Jol, E.; Schmidt, M.; Terlizzi, J. Dual Orientation Connector with Exteral Contacts and Conductive Frame. U.S. Patent US20130115821, 9 May 2013.
29. Elueze, I.; Quan-Haase, A. Privacy Attitudes and Concerns in the Digital Lives of Older Adults: Westin's Privacy Attitude Typology Revisited. *Am. Behav. Sci.* **2018**, *62*, 1372–1391.
30. Westin, A.F. Intrusions Privacy tradeoffs in a free society. *Public Perspect.* **2000**, *11*, 8.
31. Melenhorst, A.-S.; Rogers, W.A.; Caylor, E.C. The Use of Communication Technologies by Older Adults: Exploring the Benefits from the User's Perspective. *Proc. Hum. Factors Ergon. Soc. Annu. Meet.* **2001**, *45*, 221–225. [CrossRef]
32. Jeste, D.V.; Blazer, D.G.; Buckwalter, K.C.; Cassidy, K.-L.K.; Fishman, L.; Gwyther, L.P.; Levin, S.M.; Phillipson, C.; Rao, R.R.; Schmeding, E.; et al. Age-Friendly Communities Initiative: Public Health Approach to Promoting Successful Aging. *Am. J. Geriatr. Psychiatry* **2016**, *24*, 1158–1170. [PubMed]
33. Davidson, J.L.; Jensen, C. What Health Topics Older Adults Want to Track: A Participatory Design Study. In Proceedings of the 15th International ACM SIGACCESS Conference on Computers and Accessibility, Bellevue, WA, USA, 21–23 October 2013; ACM: New York, NY, USA, 2013; pp. 26:1–26:8.
34. Spinuzzi, C. The Methodology of Participatory Design. *Tech. Commun.* **2005**, *52*, 163–174.

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Article

Living Alone Among Older Adults in Canada and the U.S.

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Abstract: Increasing proportions of people, including older adults, live alone. Studying living arrangements of the elderly is important because these affect and reflect general well-being of the elderly and inform communities' response to elderly housing needs. We analyze data from the 2006 Canadian Census and the 2006 American Community Survey to examine living alone among non-married older adults aged 55 and older in Canada and the U.S. The paper has two parts. First, we compare native- and foreign-born elderly to see if immigrants are less likely to live alone. Second, we examine factors associated with living alone among older immigrants. While older immigrants in both countries are less likely to live alone, the large differences are substantially reduced once various explanatory variables are considered. Comparisons of four gender/country groups of older immigrants show the positive role of economic and acculturation factors on living alone among older immigrants. With few exceptions, predictors of living alone are similar for older immigrants in Canada and the U.S.: living alone is mainly explained by a combination of economic and acculturation factors, taking demographic variables into account. Findings underline the need for age-friendly housing with innovative design and technology that can accommodate older people who live alone, including older immigrants who may have different needs and cultural preferences.

Keywords: living alone; older adults; older immigrants; Canada; U.S.; older age-friendly housing

1. Introduction

Studying the living arrangements of older or elderly populations is important for several reasons. First, living arrangements affect and reflect family type and household structure among older people. These are in turn related to social support, inter-generational relations, health status, social isolation, satisfaction with life, and general wellbeing [1–5]. An older person living alone has different family and social relations from another living with a spouse or partner, or co-residing in a multi-generational family with an adult son or daughter and grandchildren, or co-residing with non-relatives.

Second, another reason for studying elderly living arrangements pertain to the idea of "age-friendly communities" that incorporate suitable physical environments, including housing, transportation services, and home modification programs with innovative assistive technology and designs, with a supportive social environment that promotes positive social relations for older residents [2,6]. Older adults may not need as much space as that provided by the usual single-family home, so smaller housing units would be more appropriate. Declines in physical mobility and health may mean that older adults are less able to climb stairs, for example, or bend low or reach high to access shelves, kitchen cabinets, and other storage areas. Housing designs that minimize such potential barriers, and innovative technologies, for example, voice recognition software for operating doors and appliances, can be part of age-friendly communities.

Factors that influence living arrangements of the elderly include preferences and resources that people have, and health and other constraints as they age. Residential options for older people include living alone if not married or partnered; living with spouse or partner only if married or partnered; co-residence with family members or extended family living; co-residence with non-family members; and institutional living, including retirement homes and assisted living facilities. Researchers often refer to the first two types of living arrangements (that is, living alone if not married or partnered, and living with spouse or partner only if married or partnered) as residential independence or independent living arrangements [7–9]. In the following review, the majority of references will be Canadian or U.S.-based, given the paper's focus.

1.1. Rise in Independent Living Arrangements among the Elderly

There has been a rise in independent living arrangements, as defined above, among older people in many countries, particularly in the west and more developed countries [10–13]. For example, a comprehensive report on living arrangements of older people around the world by the United Nations Population Division [13] shows marked differences between the elderly in more and less developed countries in independent living arrangements: 68 percent in the former and 20 percent in the latter live alone or with a spouse only. Conversely, 27 percent of elderly in more developed countries co-resided with a child or grandchild compared with 75 percent in less developed countries. Similar trends of independent living arrangements among the elderly are observed in Canada and the U.S. [7,8].

Over the past fifty years, there have been absolute and relative increases in the number of Canadian elderly people in independent living arrangements, mainly for married or partnered couples to live with spouse or partner only [1,5,14]. This contrasted with declining proportions in co-residential living arrangements, including living with other family members or with non-relatives. Recent data from the 2011 National Household Survey [15] show that among the population aged 65 and older, the majority (56.4 percent) lived as part of a couple and another 25 percent lived alone. In other words, over 80 percent of the population aged 65 and older were in independent living arrangements. The prevalence of living alone increases after age 50 for women and after age 70 for men, with a sharper increase for women [15].

Living arrangement patterns for the U.S. population aged 65 and older are fairly similar. Data for 2012 show that about 59 percent lived with a spouse or unmarried partner only and another 28.5 percent lived alone. Together, almost 88 percent of the population aged 65 and older were in independent living arrangements [16] (Table 3). The percent of older adults living alone was about 40 percent in 1990, but decreased to around 36 percent in 2000 and 2010 [17] (Table 72). As in Canada, living alone is higher among women, and increases with age, with sharper increases for women. For example, 47 percent of women aged 65 and older lived alone compared with 22 percent of men, in 2010 [17] (Table 72).

1.1.1. The Special Case of "Living Alone"

While living alone is not a new form of living arrangement, Klinenberg [10] describes the increased trend of "going solo" as a new "social experiment" that is fundamentally at odds with much of human history. Using the term "singleton" to refer to a person who lives alone, Klinenberg [10] documents a global increase in singletons, driven by increased economic prosperity and social security, "cult of the individual", greater geographical mobility, greater job mobility, and several "revolutions", specifically, in gender relations (leading to improved economic and social status of women), communications, mass urbanization, and longevity.

The global rise in living alone occurs across the age range, but for this paper, we focus on "aging alone" [10], or the increase in older people living alone, a trend that is more pronounced in developed countries in the west and some parts of Asia [18]. Statistics on elderly living alone among developed countries include 38.4 percent in France, 32.7 percent in England and Wales, 30.8 percent in the U.S., and

22.5 percent in South Korea [18]. More elderly people are also living alone in China [19] and Japan [20]. For example, the 2015 census of Japan reported that the percent living alone among adults 65 and older was 12.5 percent among men and 20 percent among women [20]. Increased longevity is the main demographic reason for the rise in elderly people living alone. As people live longer, the risk of other life-course events increases, such as divorce and widowhood, which changes living arrangements, including a change to living alone [21]. As noted earlier, living alone is more frequent among elderly women [3,10,15,16,18,20] because of the gender gap in longevity and the common pattern of women marrying older men, which increases the risk of widowhood.

Conventional beliefs about elderly people living alone have some truth. Many are widows, and experience poverty, social isolation, poorer physical and mental health, and lower life satisfaction and quality of life [1,3,4,10,21]. Turcotte and Schellenberg [22] report that poverty is highest among female seniors who live alone. However, despite the distinctive challenges of aging alone, many elderly people who live alone express a strong preference for this over other living arrangements, including living with adult offspring and grandchildren, if this option were available, preferring "intimacy at a distance" [10]. Some persons who live alone may be in a stable relationship with a partner who also lives alone. However, these "living apart together" (LAT) couples are more common among young adults. For example, only about 2 percent of people over 60 in Canada are in a LAT relationship [23]. Many elderly people who live alone value their independence and privacy, and would not willingly change their independent living arrangements, and especially fear losing their ability to reside independently [3,4,10].

1.1.2. Older Immigrants

While statistics on living arrangements show an increased trend to independent living arrangements among the older population, several U.S. and Canadian studies show that immigrants, including elderly immigrants, are more likely to live in extended family living arrangements, and by implication, less likely to reside in independent living arrangements, including living alone [8,24–26]. The preference for extended living arrangements among immigrants has been explained by several factors, including economic factors (co-residence as an immigrant economic coping strategy) or cultural and acculturation factors (immigrants from some cultural backgrounds have stronger family values that encourage co-residence and less acculturated immigrants retain traditional customs including those about extended living arrangements).

Still, older immigrants may be exposed to similar demographic forces such as increased longevity, gender gap in longevity, age gap between spouses, divorce and widowhood, as well as changing social norms and values regarding individualism, privacy, and independence, although the influence of these factors may vary between immigrant and native-born elderly. Older immigrants, particularly those who are more acculturated, may prefer independent living arrangements, including living alone if not married or partnered.

1.2. Research Questions and Contributions

This paper consists of two parts to addresses two research questions. First, are older immigrants less likely than Canadian- or U.S.-born elderly to live alone, once appropriate factors are considered? Second, we conduct additional analysis of older immigrants and examine the main factors associated with living alone among older immigrants in each country. Statistics and previous studies suggest that age and gender, and economic and acculturation factors will be particularly important. We examine similarities and differences in factors related to living alone among older immigrants across the two countries by comparing four groups by country and gender: Canada/female, Canada/male, U.S./female, and U.S./male.

We recognize that population aging has become an important demographic trend in many parts of the world [13,27]. Many countries including European and Asian countries are responding to changing social, health, and housing needs with population aging [18–20]. We chose to compare the

U.S. and Canada mainly because of our focus on older immigrants as these two countries have long histories of immigration and have relatively large immigrant populations (more details are provided in Section 1.3).

This paper makes three contributions to existing research on living arrangements among the elderly. First, the focus on living alone highlights this form of living arrangement among older adults, with additional focus on immigrants. Much previous research on living arrangements of older immigrants had examined co-residence or extended living arrangements [24–26]. Living alone as a form of living arrangement has not received much attention. Although we do not directly examine the implications of living alone for older immigrants' well-being, identifying the factors associated with living alone among elderly immigrants furthers our understanding of the demographic, economic, acculturation, and other characteristics of elderly immigrants who live alone.

Second, this paper contributes to research on elderly immigrants in Canada and the U.S., a population which has not received much attention, as noted by Gelfand [28] and Wilmoth [9], compared to extensive research and discussion of the elderly in general. Aging immigrants are a growing part of the aging population in countries such as Canada and the U.S.; for example, 2006 Canadian census data show that more than one-quarter of the population aged 65 and older in Canada are foreign-born [22]. In the U.S., 12.7 percent of the population aged 55 and older are foreign-born [29].

Third, findings from this research provide evidence to support housing and other policy initiatives to respond to growing populations of older adults who may want to live alone but are unable to do so because of lack of appropriate housing designs and types. Most housing units in Canada and the U.S. are single-family units with front and/or backyards that become less appropriate over the lifecycle as children leave and parents age or become widowed. If we can document that more older adults are living alone (with potentially more who would have preferred to live alone but for lack of appropriate housing), public and private sectors can use this information to promote age-friendly housing and communities (for example, smaller housing units with close by amenities such as shops and healthcare facilities). The concept of "environmental gerontology" highlights the need for a multi-disciplinary approach to designing neighborhoods and housing that facilitate "mobility, independence, and quality of life of older people living in the community" [6] (116).

Finally, this study is the first comparative analysis of living alone among older immigrants in Canada and the U.S., offering a useful comparison of two large immigrant-receiving countries that have older immigrants from many different countries of origin. While Canada and the U.S. are distinctive in many ways, both countries have long histories of immigration with relatively high levels of current immigration from diverse source countries. In the following section, we discuss why a comparative study of Canada and the U.S. can be especially productive in advancing understanding of living alone among older immigrants.

1.3. Comparing Canada and the U.S.

While there are distinctive challenges in cross-country research, including the need for comparable variables and sensitivity to historical and contextual differences, a comparative analysis can advance knowledge in many unique ways. A comparative analysis has the advantage of allowing researchers to conduct similar analyses using different data from the countries selected to identify similarities and differences in how various factors and characteristics affect the outcome being examined. If the influence of particular factors is similar, this increases confidence in the validity and reliability of the findings.

Comparing Canada and the U.S. for this analysis is not simply based on the fact that they are North American neighbors with a long mostly amicable joint history, and that the two countries have been strong allies in modern times. Canada and the U.S. are far from "two peas in a pod" [30], but besides being North American neighbors and close economic trading and foreign policy partners, there are other similarities and differences between Canada and the U.S. that make for a fruitful comparative study of living alone among older adults, including immigrants. There are also differences, for example, Canada's population and economy are much smaller than that of the U.S.: Canada's population is about 33.5 million in 2011 [31] compared with 308.7 million in the U.S. in 2010 [32]. However, Canada and the U.S. share several sociodemographic trends. We describe similarities as well as differences to show the value of such a comparative study of living alone among older adults, including older immigrants.

1.3.1. Role of Immigration

First, immigration has always been a major factor in both countries, historically and today. Canada and the U.S. are among the leading destinations for global migration streams in recent decades [33]. Both countries have long histories of immigration and generally take pride in their immigrant heritage.

However, we should note differences in immigration policies and systems. Canada has a selective points-based immigration system whereby potential immigrants are screened based on such human capital characteristics as age, education, English and/or French language proficiency (Canada's two official languages), and adaptability whereas the U.S. immigration system is primarily based on family reunification.

While the U.S. continues to admit more immigrants than other major immigrant destination countries [34], immigration has a larger influence on Canada's population. The percent foreign-born of Canada's national population stands at 24 percent compared with 13 percent for the U.S. [34]. Immigration has been the main source of Canada's population growth since 1993/1994 [31]. For the year ending June 30, 2012, net international migration accounted for two-thirds of Canada's population growth [31]. Population growth increasingly stems from the contribution of immigration because fertility levels are below replacement. In contrast, immigration accounts for a lower percent of U.S. population growth, at about one-third of U.S. population growth in recent decades [34].

1.3.2. Population Aging

Second, population aging is another demographic trend shared by both countries. The Canadian population is aging, indicated by increased median age of the population from 26.2 in 1971 to 40.0 in 2011 [31]. Elderly immigrants are a growing segment of Canada's aging population, with more than one-quarter of the population aged 65 and older being foreign-born [22].

Similar population aging trends are observed in the U.S. [35]. The median age of the U.S. population has steadily increased, from 30.0 in 1980 to 37.2 in 2010 [17] (Table 7). The percent of the U.S. population aged 55 and older has also increased, from 20.8 percent in 1980 to 24.9 percent in 2010 [17] (Table 7). Of the population aged 55 and older, 12.7 percent are foreign-born [29].

Aging-in-place of younger foreign-born cohorts and the immigration of older immigrants contribute to the growth of the elderly immigrant population in each country. While both the Canadian and U.S. populations are aging, and aging immigrants are part of this demographic trend, statistics cited above show that Canada's population is older and elderly immigrants are a larger proportion of its elderly population.

1.3.3. Racial and Ethnic Diversity

Third, closely related to the role of immigration is the expanded racial, ethnic, and cultural diversity of the Canadian and U.S. populations. Mainly because of immigration from Asia and other non-traditional (that is, non-European or North American) sources in recent decades, Canada's population has evolved from one dominated by the two founding peoples (British and French) and the indigenous (Aboriginal) population to the current situation where over two hundred ethnic origins were reported, and thirteen different ethnic origins had one million or more responses [36].

In 2011, close to 20 percent (19.1 percent) of Canada's population identified as members of "visible minority" groups, that is, racial minority groups other than Aboriginal peoples. The *Employment Equity Act* of Canada defines visible minorities as 'persons, other than Aboriginal persons, who are non-Caucasian in race or non-white in colour'. The visible minority population consists mainly of the following groups: South Asian, Chinese, Black, Filipino, Latin American, Arab, Southeast Asian, Korean, and Japanese [36].

The U.S. population has also been transformed by increased racial and ethnic diversity, also closely related to immigration. The main group, non-Hispanic White, has been slowly declining as a percent of the total population, to 63.7 percent in 2010, down from 69.1 percent in 2000. This means that other racial groups and Hispanics have been increasing in numbers and proportions, and together comprise about 36 percent of the total U.S. population in 2010 [37].

Asians were the fastest growing racial minority between 2000 and 2010, but account for just 5.6 percent of the population in 2010. The most notable change has been the growth of the Hispanic or Latino population to become the largest minority population in the U.S. since the 1990s. Hispanics are now 16.3 percent of the U.S. population compared with 13.6 percent Black and 5.6 percent Asian, the other main racial minority groups [37].

While both Canada and the U.S. have become more racial and ethnically diverse, there are important differences, including the larger share of racial/ethnic minority populations in the U.S. (36 percent), compared with 19 percent of visible minority groups in Canada, and the large presence of Hispanics in the U.S.

2. Data and Methods

We analyze data from two data sets. Data for Canada are from the Public Use Microdata File (PUMF) on individuals in the 2006 Census of Canada (see [38] for detailed technical and data documentation). These data are a 2.7 percent representative sample of the population enumerated in the census. The microdata sample for individuals is selected using a three-phase sampling plan. The first sampling phase consists of the sample of one-fifth of the population (20% sample data). This is a cluster sample. It consists of all households who completed the long questionnaire in the census. This sample was divided into two parts that are representative of Canada in order to create two sampling frames used to select the microdata samples. The first frame was used to select microdata from the individuals file. The second frame was used to select microdata from the hierarchical file. The third phase consisted in selecting records from the individuals file. The final sample contains 844,476 records, representing 2.7% of the target universe, which is the Canadian population.

U.S. data are from the 2006 American Community Survey (ACS) Public Use Microdata Sample (PUMS) (see [39,40] for detailed information on the ACS and technical documentation for the 2006 ACS PUMS file). During previous decennial censuses up to the 2000 census, most households received a short-form questionnaire, while one household in six received a long form that contained additional questions and provided more detailed socioeconomic information about the population (this was the long-form census). The 2010 census was a reengineered short-form only census, counting all residents living in the United States and asked for name, sex, age, date of birth, race, ethnicity, relationship and housing tenure, taking just minutes to complete. The more detailed socioeconomic information once collected via the long-form questionnaire is now collected by the ACS. The 2006 ACS PUMS consists of 1,277,561 housing unit records (1 percent of all housing units) from which 2,923,336 person records were sampled.

We chose these two data sets because in 2005, the United Nations published a pioneering piece on living arrangements of older people around the world [13] and in the following year, the World Health Organization released its guide to global age-friendly cities in response to global population aging [27]. This motivated us to conduct a comparative analysis of living arrangements of the elderly in Canada and the U.S. (see previous Section 1.3 for why we focus on Canada and the U.S.), using comparable nationally representative data from each country from around the time of the U.N. and WHO publications to provide baseline findings for future research on the subject.

For statistical analysis, we define the study sample as persons 55 years and older. The meaning and definition of “aging” and the “elderly” are increasingly open to question. Researchers studying the “elderly” or the “aged” recognize that using a particular age to define the elderly is arbitrary. We recognize that the "elderly" are a very heterogeneous group and reaching a particular age (be it 55, 60, 65 or 70) does not always imply declining economic or health status. Many statistics on the elderly refer to persons aged 65 and older, or persons aged 55 and older. In this study, we use age 55 in order to show more clearly potential differences that occur between age groups and to cover a wider age range at the "older" ages.

Given the outcome variable—living alone—we exclude persons who are married or living common-law (the latter status is officially recognized in Canada and often treated as equivalent to being married) or co-habiting. We include men and women, who are never married, separated, divorced, or widowed. We exclude older persons living in group quarters. Recent statistics show that for the population aged 65 and older, over 92 percent in Canada live in private households [41], and the comparable figure is 95 percent in the U.S. [42] (Table 35). For our study population of persons aged 55 and older, the percentages would likely be higher.

We identify Canadian-born or U.S.-born elderly and immigrants from responses to the questions on citizenship at birth and place of birth. Persons who are Canadian or U.S. citizens at birth are considered native-born while persons who are not Canadian or U.S. citizens at birth are considered immigrants. This avoids including persons born abroad to Canadian or U.S. citizens as immigrants (based on foreign place of birth) as these persons are not considered immigrants in Canada or the U.S., respectively.

Variables included in the analysis are as directly comparable as possible across the two data sets. We note where it is not possible to develop directly comparable categories for some variables.

2.1. *Outcome Variable*

The outcome variable, living alone, is coded as a binary variable (1 = live alone; 0 = don't live alone) based on responses to questions on household type, family structure, and individual family status.

2.2. *Explanatory Variables and Expected Effects*

We include explanatory variables that previous research had shown to influence living arrangements of older adults. Expected results are based on previous research and published statistics.

2.2.1. Demographic Variables

Age is coded in seven age groups, 55–59, 60–64, 65–69, 70–74, 75–79, 80–84, and 85 years or older for descriptive analysis. We use 5-year age groups because 2006 Canadian census public-use microdata are limited to five-year age groups. Age is recoded into a continuous variable in the multivariate analyses. We use the mid-point of each 5-year age category to assign age values for the Canadian sample (for example, persons aged 55–59 were assigned an age of 57.5).

Statistics on living alone from Statistics Canada [41] and the U.S. Census Bureau [42] suggest that living alone increases with age but these statistics do not take into account marital status, health, and other factors that may make it more difficult for older adults to live alone. It is possible that living alone increases with age, but it is equally likely that once additional factors are considered, age may have negative or only modest influence on living alone.

Gender is a binary variable (0 = female; 1 = male). Living alone is expected to be more likely among women because of women's longer longevity. However, this may not be the case once other factors are considered.

Marital status includes four non-married categories: divorced, separated, widowed, and never-married. Living alone may be more likely among widowed adults.

2.2.2. Economic Variables

The influence of economic variables is expected to be positive, as living alone requires adequate income to pay for a housing unit that is inhabited by only one person.

Education is coded in five categories: less than high school, high school graduate, some post-high school education but less than a Bachelor's degree, Bachelor's degree, and post-Bachelor's degree. Education is expected to have a positive influence on living alone.

Individual income is coded in six categories: less than $10,000; $10,000–19,999; $20,000–39,999; $40,000–59,999; $60,000–99,999; $100,000 and over for descriptive analysis. Income and other monetary variables are measured using Canadian dollars in the Canadian sample and U.S. dollars in the U.S. sample. In 2006, the Bank of Canada exchange rate was around US $1 equals CAD 1.14.

In the multivariate analyses, individual income is a continuous variable. Living alone is expected to increase with income.

Government retirement income is a binary variable (0 = received less than $100 in government retirement income during the past year or 1 = received $100 or more in government retirement income during the past year). In Canada, government retirement income refers to benefits from the Canada or Quebec Pension Plan. In the U.S., government retirement income refers to payments and benefits from the Social Security Administration. Having government retirement income increases the likelihood of living alone.

Guaranteed retirement income is a binary variable (0 = received less than $100 in retirement income from a private or personal pension plan during the past year or 1 = received $100 or more in retirement income from a private or personal pension plan during the past year). Guaranteed retirement income refers to regular income received from being a member of an employer's pension plan, payments from individual annuities, private pensions paid to widows or widowers, pensions of retired civil servants, and other annuities paid to individuals by a private insurance company. Having guaranteed retirement income is expected to increase the chances of living alone.

Homeownership is a binary variable (0 = does not own home or 1 = own home). Homeownership's influence is expected to be positive on living alone because owning a home implies having sufficient economic resources to own a home. In addition, homeownership facilitates living alone, removing the need to look for alternative housing in the event of marital dissolution or widowhood.

2.2.3. Cultural and Acculturation Variables

Culture and acculturation are closely related but distinct concepts. Ethnic origin, language background, religion, and other characteristics are usually used to indicate cultural background. Given differences across ethnic groups on other characteristics such as marriage, fertility, and family patterns, ethnicity has frequently been used as a sociodemographic variable to indirectly measure these differences. We describe ethnic origin as a demographic variable in the descriptive analysis. For immigrants, acculturation is usually indicated by duration of residence in the host country and proficiency in host country language [24,43,44].

Ethnic origin is coded using fifteen groups. These are "American" (in the U.S. sample) or "Canadian" (in the Canadian sample); British; French; Other European; Arab or Middle Eastern; South Asian/Asian Indian; Chinese; Filipino; Korean; Vietnamese; Other Asian; Latin American/Latino/Hispanic; African, Black, or Caribbean; Other single ethnic origins (including persons reporting Aboriginal only in the Canadian sample and Native American or Alaskan Native or Native Hawaiian/Pacific Islander only in the U.S. sample); and Multiple ethnic origins. Persons reporting ethnic origins that are culturally closer to mainstream American or Canadian culture (that is, American, Canadian, and various European groups) are more likely to live alone.

For immigrants, knowledge of official languages (in Canada) or proficiency in English (in the U.S.) is coded using four categories. Besides being an indirect indicator of acculturation, language knowledge or proficiency implies an ability to communicate and navigate social and other situations and understanding of broader societal norms.

The four categories range from excellent to poor competence in Canada's two official languages (English and French) or in English (for the U.S. sample), although the specific definitions differ for Canada and the U.S. For the Canadian sample, the four categories are (1) English or French mother tongue, and English or French home language; (2) other mother tongue, and English or French home language; (3) other mother tongue, and other home language, knows English or French; and (4) other mother tongue, other home language, and does not know English or French. For the U.S. sample, the four categories are: (1) only speaks English; (2) speaks English very well; (3) speaks English well or not well; and (4) does not speak English. Cultural closeness to the host country and/or acculturation decreases from category 1 to 4 for both the Canadian and U.S. samples, and living alone is expected to decrease from the first to the fourth category of the language variable.

Duration of residence for immigrants measures how many years immigrants have resided in Canada or the U.S. It is coded in five categories for descriptive analysis, from 0–9, 10–19, 20–29, 30–39, and 40 years or more. In the multivariate analyses, duration of residence is a continuous variable. Duration of residence is expected to have a positive influence on living alone as increased duration implies greater acculturation.

2.2.4. Other Control Variables

Place of residence indicates metropolitan and non-metropolitan residence, and residence in several specific Canadian and U.S. cities. Metropolitan categories for this variable include three Canadian and five U.S. cities with the largest number of older immigrants. We include only three Canadian cities because immigrants in Canada are highly concentrated in them: 63.4 percent of Canada's immigrants reside in these three cities [36].

The codes for place of residence are (1) Montreal (Canada) or Chicago (U.S.); (2) Toronto (Canada) or Los Angeles (U.S.); (3) Vancouver (Canada) or Miami (U.S.); (4) New York City; (5) San Francisco; (6) other metropolitan areas; and (7) non-metropolitan areas. Living alone is expected to be higher in non-metropolitan areas because of lower cost of housing which facilitates independent living arrangements, including living alone.

2.3. Methods of Analysis

We begin with descriptive analyses to describe and compare the study samples. For multivariate analyses, we use Stata 12 statistical software [45] to estimate several logistic regression models because the outcome variable is coded as a binary variable. For the first research question on nativity differences in living alone, we estimate two regression models (Models I and II). Model I is estimated separately for Canada and the U.S., for all non-married elderly, aged 55 and older. Each equation includes dummy variables for nativity and gender, and other explanatory variables described above (except for duration of residence because it is collinear with nativity). Second, we estimate a logistic regression of living alone for all non-married elderly, aged 55 and older (Model II), for four groups: females in Canada, males in Canada, females in U.S., and males in U.S. Each equation includes a dummy variable for nativity, and explanatory variables described above (except for duration of residence because it is collinear with nativity, and gender). Results from Models 1 and 2 address our first research question.

For the second research question on predictors of living alone among older immigrants, we limit analysis to older immigrants only, and estimate a logistic regression model of living alone (Model III) for four groups: females in Canada, males in Canada, females in U.S., and males in U.S., to identify and compare predictors of living alone among older immigrants. Model III includes duration of residence, in addition to other explanatory variables.

For interpreting the logistic regression results, we calculate predicted probabilities for each explanatory variable using the margins command in Stata 12 [45]. The predicted probabilities provide a useful interpretation of the net effect of each categorical variable on living alone, evaluated by holding constant the effects of all other variables in the model [46]. Multiplying predicted probabilities by 100 converts them into percentages or proportions, which facilitates presentation and discussion of results. We include the logistic regression results from which the predicted probabilities are calculated in the Supplementary Tables.

3. Results

3.1. Descriptive Results

Selected characteristics of the Canadian and U.S. study samples are shown in Table 1. Non-married immigrant elderly in both Canada and the U.S. are much less likely to live alone than native-born elderly. In Canada, 54.8 percent of non-married older immigrants live alone, compared with 70.7 percent of Canadian-born non-married elderly (a difference of 15.9 percent). In the U.S., 51.7 percent of non-married older immigrants live alone, compared with 73.2 percent of U.S.-born non-married elderly (a difference of 21.5 percent). The gap is larger in the U.S.

Table 1. Descriptive statistics for non-married elderly, Canada and U.S. (in percents).

Characteristic/Variable	**Canada**			**United States**		
	All	**Canadian-Born**	**Immigrants**	**All**	**U.S.-Born**	**Immigrants**
Live Alone	66.5	70.7	54.8	70.8	73.2	51.7
Demographic Characteristics						
Gender:	100.0	100.0	100.0	100.0	100.0	100.0
Female	69.1	67.8	72.6	68.9	68.2	74.2
Male	30.9	32.2	27.4	31.1	31.8	25.8
Age Groups:	100.0	100.0	100.0	100.0	100.0	100.0
55–59 years old	20.5	21.6	17.4	25.4	25.2	26.9
60–64	15.9	16.5	14.3	19.6	19.6	20.1
65–69	13.4	13.1	14.4	15.5	15.4	16.6
70–74	13.7	13.5	14.1	13	13	13.1
75–79	14.2	13.9	15.1	11.1	11.2	10.1
80–84	12.2	11.4	14.3	8.4	8.5	7.4
85 years old and older	10.1	10.0	10.5	7.0	7.2	5.9
Marital Status:	100.0	100.0	100.0	100.0	100.0	100.0
Divorced	25.5	26.8	22.0	32.2	32.9	26.4
Separated	7.3	7.1	8.1	4.2	3.7	8.1
Widowed	50.0	47.8	56.3	49.2	49.1	50.5
Never-married	17.1	18.4	13.6	14.4	14.3	15.0
Ethnic Origin [a]:	100.0	100.0	100.0	100.0	100.0	100.0
Single Origin						
Canadian/American [b]	18.5	24.9	0.6	7.2	8.1	0.2
British	14.0	14.1	13.6	7.4	7.8	3.8
French	6.5	8.4	1.3	0.9	0.9	0.8
Other European	15.3	9.2	32.3	26.2	26.6	23.1
Arab/Middle Eastern	0.7	0.1	2.5	0.5	0.2	3.1
South Asian/Asian Indian	1.7	0.0	6.2	0.3	0.0	2.2
Chinese	2.4	0.1	8.7	0.6	0.1	4.5
Filipino	0.6	0.0	2.2	0.6	0.1	4.6
Korean	0.1	0.0	0.4	0.3	0.0	2.2
Vietnamese	0.2	0.0	0.7	0.2	0.0	2.1
Other Asian	0.3	0.2	0.5	0.6	0.3	2.9
Latin American/Latino/Hispanic	0.3	0.0	1.0	6.6	3.4	32.1
African/Black/Caribbean	1.4	0.1	4.9	11.4	12.0	7.0
Other Single Origin [c]	1.5	2.0	0.2	13.3	14.3	5.6
Multiple Origins	36.7	40.8	25.1	24.0	26.3	5.9
Economic Characteristics						
Education:	100.0	100.0	100.0	100.0	100.0	100.0
Less than High School	40.5	40.9	39.3	27.2	25.2	43.7
High School Graduate	22.4	22.7	21.5	33.1	34.2	23.8
Post-High School	26.5	26.4	27.1	21.6	22.4	15.0
Bachelor′s Degree	7.5	7.4	7.9	10.3	10.3	10.4
Post-Bachelor′s	3.1	2.7	4.2	7.8	7.9	7.1
Mean Years of Education	11.7	11.5	12.1	12.1	12.3	10.3
Individual Income:	100.0	100.0	100.0	100.0	100.0	100.0
Below $10,000	8.5	7.8	10.3	26.9	24.7	44.4
$10–19,999	37.5	36.5	40.0	29.6	30.2	24.8
$20–39,999	32.5	33.3	30.7	24.9	25.8	17.9
$40–59,999	12.4	13.0	11.0	9.7	10.1	6.4
$60–99,999	6.3	6.5	6.0	5.9	6.2	4.1
$10,000 and over	2.8	2.8	2.9	3.1	3.2	2.4
Mean Individual Income ($)	31,318	31,738	30,143	26,832	27,832	20,755
Homeownership:	100.0	100.0	100.0	100.0	100.0	100.0
Yes	61.5	59.6	66.7	70.2	71.3	61.7
No	38.5	40.4	33.3	29.8	28.7	38.3

Table 1. *Cont.*

Characteristic/Variable	Canada			United States		
	All	Canadian-Born	Immigrants	All	U.S.-Born	Immigrants
Acculturation Characteristics (foreign-born only)						
Duration of Residence in Canada or U.S.:			100.0			100.0
0–9 years			5.5			10.7
10–19			12.6			14.7
20–29			14.4			18.0
30–39			23.8			20.3
40 and more years			43.8			36.4
Mean Years of Duration of Residence			37.7			34.8
Language Proficiency [d]:			100.0			100.0
(1)			37.6			25.2
(2)			28.6			19.5
(3)			19.1			36.4
(4)			14.6			18.9
Other Characteristics						
Metropolitan Residence:	100.0	100.0	100.0	100.0	100.0	100.0
Yes	65.8	58.5	86.4	75.4	73.1	93.8
No	34.2	41.5	13.6	24.6	26.9	6.2
Sample Size (Number of cases)						
Unweighted	67,948	50,054	17,894	300,573	273,185	27,573
Weighted	2,514,076	1,851,998	662,078	27,821,402	24,721,329	3,100,073

[a] For Canada, based on responses to the ethnic origin question. For the U.S., based on responses to the ancestry question. Two responses are allowed in the U.S. question while multiple responses are allowed in the Canadian question. [b] 'Canadian' ethnic origin in Canada, 'American' ancestry for the U.S. The latter is recorded if 'American' is the only response. [c] Includes persons reporting single Aboriginal origin in Canada, and single Native American or Native Alaskan or Native Hawaiian/Other Pacific Islander origin in the U.S. [d] The categories are not directly comparable. For Canada, (1) English or French mother tongue or home language; (2) other mother tongue, English or French home language; (3) other mother tongue and home language, knows English or French; (4) other mother tongue and home language, does not know English or French. For the U.S., (1) speaks English only; (2) speaks English very well; (3) speaks English well or not well; (4) does not speak English.

3.1.1. Demographic Characteristics

Gender: There are more females in both samples, about 69 percent. There are also more women in the immigrant samples, at around 73–74 percent in both the Canadian and U.S. samples.

Age: The distribution across age categories is as expected, with higher percents in the younger age categories. The U.S. immigrant sample has higher percents in the younger age categories.

Marital Status: Marital status refers to non-married categories only. Being widowed is the most common marital status for both Canadian and U.S. samples, with a higher percent widowed among immigrants in Canada. The percent divorced is higher among the native-born in both samples.

Ethnic Origin: For describing the sample, ethnic origin is considered a demographic characteristic. Most native-born Canadian and U.S. elderly report European or multiple origins but immigrants are distributed over a wider range of ethnic origins compared with the native-born. There are two striking differences between the Canadian and U.S. immigrant samples. First, older immigrants in Canada have higher percentages of people reporting European origins (72.8 percent—this percent includes the 25 percent reporting multiple origins), compared with 33.8 percent (including the 5.9 percent reporting multiple origins) in the U.S. sample. Studies of ethnic origin in Canada show that persons reporting multiple origins are mainly reporting "Canadian" in combination with other European origins, and persons reporting "Canadian" used to report European origins, particularly French or British [47–49]. Second, almost one-third (32.1 percent) of older immigrants in the U.S. report Latin American/Hispanic/Latino origin while no single ethnic group dominates the immigrant sample in Canada (the largest three are British at 13.6 percent, Chinese at 8.7 percent, and South Asian at 6.2 percent).

3.1.2. Economic Characteristics

Education: On average, older immigrants in Canada have more years of schooling compared to Canadian-born elderly (a mean of 12.1 years versus 11.5 years) whereas in the U.S., older immigrants have fewer years of schooling, with a mean of 10.3 years versus 12.3 years for the U.S.-born. The distribution across levels of educational attainment of Canadian-born and immigrant elderly is generally quite similar but higher percents of immigrants in the U.S. sample are in the lower educational categories.

Income: In both samples, older immigrants have lower mean incomes, and the percent of immigrants in the two lowest income categories exceeds that of the native-born in both countries. Homeownership: Homeownership is higher for the U.S. sample (70 percent are homeowners compared with 62 percent for the Canadian sample). However, immigrants in Canada are more likely to own their homes (67 percent, compared with 60 percent for Canadian-born elderly), while immigrants in the U.S. sample are less likely to be homeowners (62 percent, compared with 71 percent of U.S.-born elderly).

3.1.3. Other Characteristics

Metropolitan Residence: Notably higher percentages of elderly immigrants in both samples reside in metropolitan areas. The metropolitan concentration of older immigrants in the U.S. is higher, at 94 percent, compared with 86 percent in Canada. U.S.-born elderly are also more likely to reside in metropolitan areas (73 percent) compared with Canadian-born elderly (at 59 percent).

3.1.4. Immigrant-Specific Characteristics

There are two immigrant-specific characteristics in Table 1: duration of residence in the host country and host country language proficiency.

Duration of Residence: On average, older immigrants in Canada have resided in Canada for 37.7 years compared with 34.8 years for older immigrants in the U.S. Higher percentages of elderly immigrants in the Canadian sample have resided in Canada for 40 or more years (43.8 percent) compared with 36.4 percent of immigrants in the U.S. sample. More immigrants in the U.S. sample are recent arrivals: 10.7 percent have been in the U.S. for less than 10 years, compared with 5.5 percent of immigrants in the Canadian sample.

Language Proficiency: As noted earlier in the section describing variables and in Table 1, categories of the language proficiency variable are not directly comparable between the two samples. However, there is a similar pattern for interpreting its effects, that is, acculturation (indirectly indicated by language proficiency/knowledge) decreases from category 1 to category 4. About two-thirds of the Canadian sample are in the first two categories and would be considered highly acculturated but 14.6 percent are in the fourth category (considered the least acculturated). 44.7 percent of the U.S. sample are in the first two categories while 19 percent are in the fourth category.

3.2. Logistic Regression Results

Logistic regression results from Models I and II focus on the role of nativity on living alone. We begin with results from Model I, which was estimated separately for Canada and the U.S. Complete logistic regression results for Model I are in Supplementary Tables S1A and S1B. Table 2 compares observed (or descriptive) and adjusted results by nativity. Given the large amount of statistical results, we do not show predicted probabilities for all the explanatory variables included. The complete tables of predicted probabilities are available upon request. We highlight differences by nativity, as this is the main focus for this part of the analysis.

While the role of nativity is statistically significant (foreign-born older adults are less likely to live alone), the observed large gaps in living alone between native- and foreign-born elderly are substantially reduced once other factors in the equation are taken into account. Specifically, the observed difference of 15.9 percent between Canadian-born and immigrant elderly living alone is reduced to 3.4 percent, and the observed difference of 21.5 percent between U.S.-born and immigrant elderly is reduced to 1.6 percent. This shows that differences in living alone between older native-born and immigrants are modest, once all other factors in Model I are considered.

Table 2. Model I: observed and predicted (adjusted) percents, living alone, by nativity, non-married elderly, Canada and the U.S. [a].

Country/Nativity	Observed	Adjusted
Canada		
Native-born	70.7	68.1
Foreign-born	54.8	64.7
Difference	15.9	3.4
U.S.		
Native-born	73.2	68.9
Foreign-born	51.7	67.3
Difference	21.5	1.6

[a] Model I was estimated separately for the Canadian and U.S. samples. It includes a dummy variable for nativity. Adjusted or predicted percentages control for age, gender, marital status, individual income, government pension, private retirement income, homeownership, education, ethnic origin, language proficiency, and place of residence. Duration of residence for immigrants was not included because it is collinear with nativity. Predicted probabilities were multiplied by 100 to show the predicted (adjusted) percent living alone.

Results for Model II, estimated for four groups, Canada/female, Canada/male, U.S./female, and U.S./male, are shown in Table 3. Again, we highlight the role of nativity. Complete results from the logistic regressions for Model II are shown in Supplementary Tables S2A–D. While the influence of nativity remains statistically significant (except in the logistic regression for the U.S. female sample—Supplementary Table S2C), fairly large observed differences in living alone between native- and foreign-born females and males in Canada and the U.S. are greatly reduced.

Table 3. Model II: observed and predicted (adjusted) percentages living alone, gender and nativity comparisons, Canada and U.S. [a].

Country/Gender/Nativity	Observed	Adjusted
Canada		
Females		
Native-born	70.7	67.2
Foreign-born	52.4	63.5
Difference	18.3	3.7
Males		
Native-born	70.6	70.1
Foreign-born	61.0	67.4
Difference	9.6	2.7
U.S.		
Females		
Native-born	70.6	65.6
Foreign-born	47.3	64.2
Difference	23.3	1.4
Males		
Native-born	78.8	76.0
Foreign-born	64.1	74.1
Difference	14.7	1.9

[a] Model II was estimated for all non-married elderly, for each of these four groups: Canada/female, Canada/male, U.S./female, U.S./male. It includes a dummy variable for nativity, and all the other explanatory variables included in Model I.

Model III is estimated for older immigrants only and addresses the second research question: what factors are associated with living alone among older immigrants? Complete results from estimating Model III for Canada/female, Canada/male, U.S./female, and U.S./male are shown in Supplementary Tables S3A–D. Table 4 shows predicted probabilities for categorical variables from estimating Model III for the four gender/country groups and results for three continuous variables—age, individual income, and duration of residence—are shown in Figures 1–3 (in the figures, predicted probabilities have been converted to proportions to facilitate presentation and description).

Table 4. Model III: predicted probabilities of living alone for categorical explanatory variables, non-married older immigrants in Canada and U.S. [a].

Variable Category	**Canada**		**United States**	
	Females	**Males**	**Females**	**Males**
A. Demographic Characteristics				
Marital Status:				
Divorced	0.5662	0.6824	0.4957	0.6773
Separated	0.5373	0.7047	0.3972	0.6267
Never-married	0.5496	0.6660	0.4791	0.6690
Widowed	0.5447	0.6460	0.4357	0.5256
B. Economic Factors				
Government Pension Income:				
No	0.5112	0.6361	0.3993	0.5861
Yes	0.5698	0.6872	0.5068	0.6718
Retirement Pension Income:				
No	0.5282	0.6433	0.4453	0.6231
Yes	0.5784	0.7015	0.4893	0.6281
Homeownership:				
No	0.4985	0.6122	0.4254	0.5718
Yes	0.6014	0.7371	0.4913	0.6581
Highest Degree Completed:				
Less than high school	0.5013	0.5812	0.4171	0.5904
High School	0.5462	0.6502	0.4358	0.6025
Post-High School (not Bachelor's)	0.6054	0.7169	0.5132	0.6606
Bachelor's Degree	0.6082	0.7229	0.5060	0.6732
Post-Bachelor's Degree	0.6792	0.7819	0.5569	0.6997
C. Acculturation Factors				
Ethnic Origin:				
Canadian/American	0.5820	0.8103	0.4989	0.8750
British	0.5801	0.6767	0.5944	0.7517
French	0.6303	0.7995	0.6677	0.8484
Other European	0.6347	0.7448	0.6177	0.7529
Arab/Middle Eastern	0.5328	0.7397	0.4855	0.6456
South Asian/Asian Indian	0.3845	0.5316	0.3301	0.5946
Chinese	0.5405	0.6503	0.5232	0.6442
Filipino	0.3272	0.4595	0.3387	0.4851
Korean	0.6881	0.5235	0.5988	0.7636
Vietnamese	0.4147	0.5550	0.4448	0.5352
Other Asian	0.5769	0.7126	0.5035	0.5407
Latin American/Latino/Hispanic	0.4885	0.3765	0.4274	0.6009
African/Black/Caribbean	0.4107	0.5073	0.3816	0.5889
Other Single Origin	0.6173	0.6757	0.6050	0.7609
Multiple Origins	0.4908	0.6122	0.5442	0.6617
Official Language Proficiency [b]:				
(1)	0.6025	0.7203	0.5279	0.6835
(2)	0.5711	0.6865	0.4549	0.6331
(3)	0.5246	0.5790	0.4611	0.6203
(4)	0.4253	0.5271	0.4079	0.5805
D. Other Controls				
Place of Residence:				
Montreal/Chicago [c]	0.5127	0.6473	0.4134	0.6130
Toronto/Los Angeles [c]	0.4983	0.5965	0.4126	0.5686
Vancouver/Miami [c]	0.5668	0.6772	0.4834	0.6873
—/New York City [c]	—	—	0.4136	0.5523
—/San Francisco [c]	—	—	0.4316	0.6086
Other Metropolitan Areas	0.5916	0.7384	0.4737	0.6468
Non-Metropolitan	0.6402	0.7496	0.5193	0.7066

[a] Model III was estimated for four groups of older immigrants: Canada/female, Canada/male, U.S./female, and U.S./male. [b] Language proficiency in official language(s) is not comparable for Canada and the United States. See text and notes for Table 1 for description of how this variable is coded. [c] The first city listed is for Canada and the second city is for the U.S.

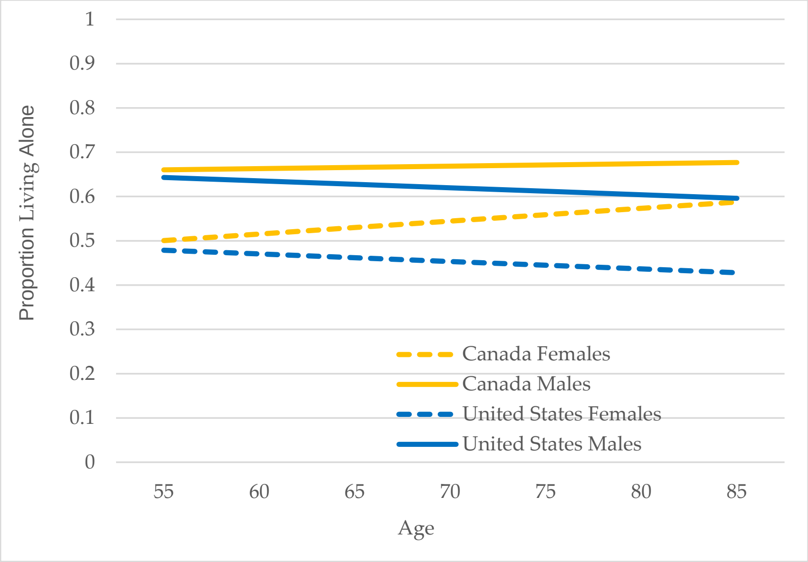

Figure 1. Predicted proportions living alone by age: Canada and U.S., female and male older immigrants.

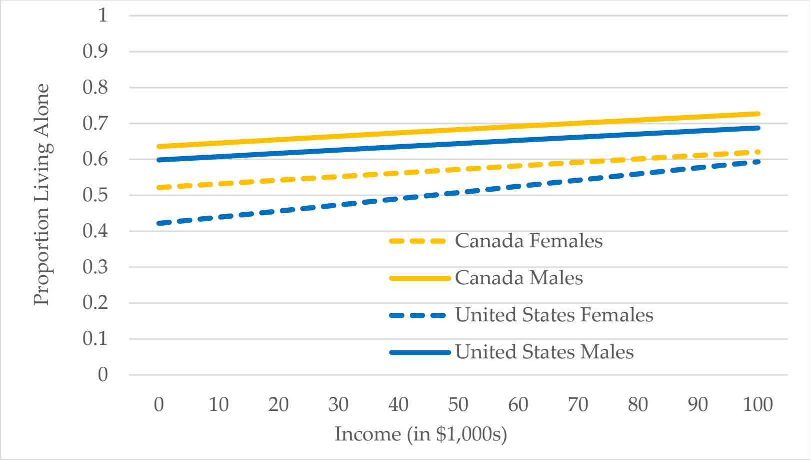

Figure 2. Predicted proportions living alone by individual income: Canada and U.S., female and male older immigrants.

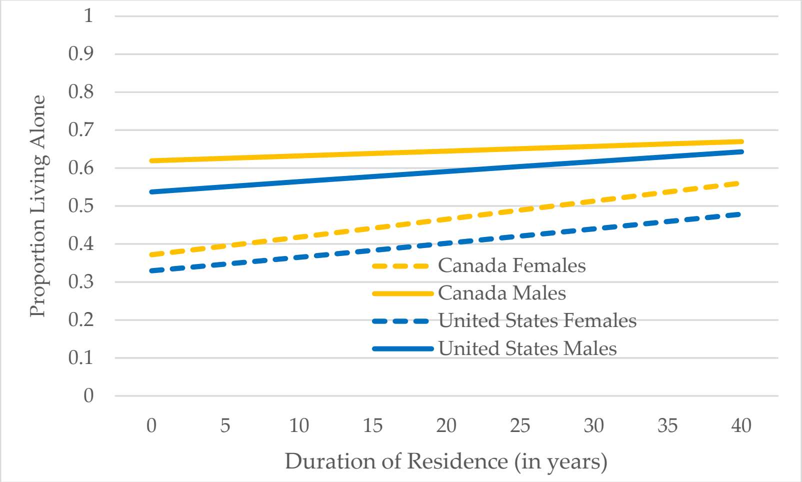

Figure 3. Predicted Proportions Living Alone by Duration of Residence: Canada and U.S., Female and Male Older Immigrants.

3.2.1. Demographic Characteristics

Age: Age is an important factor in living arrangements among older adults because of age-related health declines which can be expected to influence the ability to live alone [7,11,18]. The results for age are shown in Figure 1. Age differences are statistically significant for female immigrants in both Canada and the U.S., but not for males. Living alone increases with age for older immigrants in Canada, with sharper increases for females. The influence of age is negative for both sexes in the U.S., is more pronounced for females, and as noted, not statistically significant for males.

Marital Status: The results for marital status are shown in Panel A, Table 4. We highlight the role of marital status because of conventional views that most elderly who live alone are female widows. Logistic regression results show that the influence of marital status were not statistically significant for most groups and differences in predicted probabilities of living alone are relatively modest. Around 54–57 percent of female immigrants in Canada live alone across different marital status categories. Among male immigrants in Canada, widowed males have the lowest proportion living alone while separated males have the highest proportion. Differences by marital status are larger than those for females but are still modest.

Among female immigrants in the U.S., those who are separated are least likely to live alone while divorced female immigrants are most likely to live alone. Among males, widowed males have the lowest proportion living alone, while divorced and never-married males have the highest proportions living alone. In both samples, divorced older immigrants have higher proportions living alone.

3.2.2. Economic Factors

Individual income: Individual income results are shown in Figure 2.

As expected, the proportions living alone increase with income, with the sharpest increase observed for females in the U.S. The influence of other economic factors are shown in Panel B, Table 4, and are all also in the expected positive direction.

Government and private retirement income: Older immigrants who have government or private retirement income are more likely to live alone. These results hold across all groups, but the impacts are larger for males in both Canada and the U.S.

Home ownership: Older immigrants who are homeowners are more likely to live alone, a pattern observed for all four gender/country groups. Older male immigrants in Canada who are homeowners have the highest proportion living alone.

Educational Attainment: The proportions living alone increase for all four groups as educational attainment increases. The proportions living alone are higher among males in both countries at each level of educational attainment.

3.2.3. Acculturation Factors

The results for ethnic origin and language proficiency are shown in Panel C, Table 4.

Ethnic Origin: The influence of ethnic origin is not statistically significant for almost all ethnic origins. We interpret the influence of ethnic origin as a largely cultural and acculturation variable, but acknowledge that ethnic origin relates to other characteristics that can also influence living alone, such as ethnic group differences in marriage and fertility patterns, which relate to family size and availability of family for elderly co-residence. The lack of statistically significant results for all but a few ethnic origins suggests that this may not be an adequate proxy for characteristics that affect living alone among older immigrants.

However, ethnic group differences in living alone do generally support cultural expectations: older immigrants of European backgrounds are culturally closer to “mainstream” Canadian and U.S. culture, and higher proportions of these groups live alone. In contrast, lower proportions of older immigrants reporting Asian, Latin American, and other non-European origins live alone. Older female immigrants of all ethnic origins in both Canada and the U.S. are less likely to live alone than male co-ethnics (there are two exceptions to this pattern: Korean and Latin American female immigrants in Canada have higher proportions who live alone compared to co-ethnic males).

Language Proficiency: This variable indicates high to low linguistic and related acculturation (from Category 1 to Category 4) and its influence is as expected. The proportions living alone decrease from Category 1 to Category 4 for both samples and for both genders. For example, 60 percent of older female immigrants in Canada in Category 1 live alone, compared with 43 percent of female immigrants coded Category 4. The difference by linguistic acculturation is larger among males: 72 percent of male immigrants in Canada classified in Category 1 live alone versus 53 percent of males classified in Category 4.

Duration of Residence: Acculturation is also indicated by duration of residence, increasing as years of residence increase. As expected, living alone among older immigrants increases with duration of residence, shown in Figure 3.

The increase is sharper among female immigrants in both Canada and the U.S., and immigrants in Canada (both females and males) have higher proportions living alone compared to their U.S. counterparts at all values of duration of residence.

3.2.4. Other Controls

Place of Residence: Older immigrants who live in non-metropolitan areas are more likely to live alone, a pattern that is similar for all four sub-groups. Lower proportions of older immigrants in Canada who reside in one of Canada's three largest immigrant destination cities (Montreal, Toronto, and Vancouver) live alone, compared to immigrants who live in other metropolitan and non-metropolitan areas. For older immigrants in the U.S., a similar pattern holds, except for those who reside in Miami where the proportion living alone (69 percent) is quite close to the percent living alone in non-metropolitan areas.

4. Discussion

We return to our two research questions in this section. The first question focuses on the role of nativity and asks whether non-married older immigrants are less likely than Canadian- or U.S.-born non-married elderly to live alone. Descriptive results show that older immigrants in Canada and the U.S. are much less likely to live alone than native-born elderly. The difference is larger in the U.S. This finding is consistent with other research showing lower rates of independent living arrangements, including living alone, among immigrants, including older immigrants [9,24,43].

However, once appropriate factors are taken into account, nativity differences, while still statistically significant, are substantially reduced. Differences by gender and nativity are also reduced or become modest once various factors are considered. These findings suggest that aggregate differences in living arrangements between older immigrants and native-born elderly are largely due to differences in demographic, economic, and acculturation characteristics between the older native-born and immigrant populations. Findings show that notable proportions of older adults, including immigrants, in both countries live alone, reinforcing the need to consider these groups when discussing age-friendly communities.

Our second research question is directed at older immigrants and examines predictors of living alone among non-married older immigrants in Canada and the U.S. The main findings show higher levels of living alone for older male immigrants in both Canada and the U.S., across different characteristics, including age, marital status, income, education, and duration of residence. With some exceptions, the proportion living alone is higher among immigrants in Canada across different characteristics.

Factors influencing living alone are generally similar for older immigrants in Canada and the U.S., suggesting that living alone among older immigrants is mainly explained by a combination of economic and acculturation factors, after taking demographic variables into account. More acculturated older immigrants, and immigrants with more economic resources, are more likely to live alone, findings that are consistent with previous studies on extended living arrangements among older immigrants: the predictors of living alone are opposite to those for extended living arrangements where less acculturated older immigrants with fewer economic resources are more likely to co-reside [26,50].

Aggregate statistics on older people living alone contribute to widespread beliefs and images that older women are more likely to live alone. It is of course correct that higher proportions of older women live alone, as shown in statistics from many countries [13,18,20], as well as Canada and the U.S. However, when appropriate demographic, economic, and acculturation factors are taken into account, this study of older immigrants shows that male older immigrants are more likely to live alone. Therefore, being male is a stronger predictor of living alone among older immigrants, once additional appropriate factors are considered. Perhaps the inclusion of several key factors in this analysis such as acculturation measures (host language proficiency and duration of residence) and economic resources (indicated by not just individual income but access to private and government pensions) permitted a more comprehensive examination of the role of gender on living alone among older immigrants. Other factors such as stronger male preference for living alone and greater social acceptability of males living alone could also be implicated. Different research using different data with information on availability and type of kin, social networks and relationships, and gender differences in preference for and acceptability of living alone would be useful to further explore these findings.

Another widespread image of elderly people who live alone is that of elderly widows living alone. Again, this is not entirely wrong, given women's longer longevity and the common age gap between spouses. However, once appropriate factors are taken into account, older immigrants who are widowed are not the most likely group to live alone, compared to other marital status groups. It is possible that widowed older immigrants have adult children with whom they can co-reside following widowhood, an option that may be unavailable to divorced, separated, and never-married older immigrants. Divorced and separated older immigrants are more likely to live alone than the widowed, and in the U.S., older male immigrants who are never-married are as likely as divorced males to live alone. Marital disruptions due to divorce is therefore a better predictor of living alone among older immigrants than widowhood. Marital disruptions can also be associated with other forms of disruptions such as moving away, which also disrupts previous family and social networks, thereby increasing the chances of living alone. Unfortunately, we are unable to examine the role of geographical mobility as well as other factors such as gendered differences in cultural norms about living alone and subjective preference for living alone with the data examined in this paper.

This paper contributes to the literature on living alone and housing in two ways. First, we show that notable percentages of older adults, including older immigrants, in two large countries with aging populations, live alone. This trend is expected to continue and reinforces the need for more private and public policies to design and build age-friendly communities that allow older adults to continue to live independently and participate fully in their community. Second, the findings show that once appropriate factors are taken into account, there are only modest differences between native-born and immigrant elderly's likelihood of living alone. This suggests that elderly immigrants should be included in housing initiatives that include more units geared towards elderly living alone, instead of mistakenly assuming, based on aggregate statistics, that elderly immigrants are somehow different, and are less likely to live alone and do not need to be included in these efforts.

Many countries have already implemented initiatives on age-friendly communities in response to population aging and the rise in independent living arrangements among the elderly, including living alone [6,18,20]. Such initiatives would need to include community services such as home care services, senior community centers, transport services, housing designs such as greater availability of smaller housing units, for example, one or two-bedroom single-level apartments, and other factors such as support for innovative technology that may make it easier for non-married older adults to continue to live alone at older ages.

Additionally, older immigrants may have different cultural preferences in housing design and use of technology. For example, Chinese immigrants may place great importance on the role of feng shui in housing alignment and design, immigrants may be less familiar with advanced technology, and some immigrants' accented speech may pose challenges for voice-recognition software. These potential differences would have to be considered in elderly housing designs and use of technology in planning age-friendly housing.

While this study has produced some new and useful findings, we note several limitations. First, this is a cross-sectional analysis, and findings refer only to the period when the data were collected in 2006. We do not know if the living arrangement recorded at time of data collection is temporary or permanent, and the findings cannot speak to trends in factors related to living alone.

Second, the sampling frame for both data sets are private households and individuals and families in private households. This misses the population in group or institutional living quarters, an important limitation for studying the elderly. As health declines accelerate with increased age, the oldest old are less likely to live alone in private households and more likely to be in group housing such as retirement or assisted living housing. This limitation may be implicated in the finding of age's negative influence on living alone among U.S. female older immigrants.

Third, the outcome, living alone, poses some conceptual challenges. Living alone is one type of living arrangement, and living arrangements are inherently dynamic and may be recursive. This means that an individual can transit through different types of living arrangements over her/his life (for example, living at home with parents → living alone as a young adult → living with spouse upon marriage → living with spouse and children → living alone upon divorce → remarriage, living with new spouse → widowed, living alone). In this example, living alone occurs at different stages over the life course, and has different determinants and implications. The study of living arrangements has therefore to be particularly sensitive to age, gender, and life course influences, including marital status.

Fourth, there are measurement challenges for studying living alone as a form of living arrangement. The data examined in this study do not tell us whether the person living alone is in a relationship with another person (the "living apart together" couples noted earlier). It is likely that the predictors and implications of living alone for such individuals would differ in important ways from others who live alone and are not in a relationship.

Finally, while the census and ACS data used are appropriate for identifying and comparing sociodemographic, economic, and acculturation factors on living alone among older immigrants, there is no information on other factors that influence older immigrants' living arrangements, including the key role of health status (the ACS includes a question on disability but there is no comparable information in the Canadian census). Other unmeasured factors include availability of family or friends to share housing, and community characteristics that either facilitate or discourage living alone (for example, community support for innovative housing designs and technology, and availability and affordability of housing units for older singletons).

5. Conclusions

We began our analysis by making no assumptions about whether living alone is the "best" living arrangement for non-married older adults. The increased social trend to elderly residential independence suggests that most elderly prefer independent living arrangements [10], but we recognize that for some older adults, particularly immigrants, co-residence may actually be preferable and more advantageous, and lowers the risk of social isolation [1,4,9].

However, as we reflect on our findings, a picture emerged suggesting that living alone is associated with characteristics that can only be described as advantageous. Results from examining older immigrants show that those who live alone have higher income and education and are more acculturated. These characteristics may be related to other dimensions of wellbeing, such as more extensive social ties and support because of being more acculturated, and better health, given the well-known socioeconomic status-health gradient [51,52]. Still, we cannot conclude that living alone is the optimal living arrangement for all non-married older immigrants, given study limitations noted above. However, this comparative research provides a reference point for additional research on living alone among older adults, including older immigrants, in other aging societies, particularly where aging immigrants are part of the aging population. The findings also provide useful information for planning and designing age-friendly communities to include older adults who live alone.

Supplementary Materials: The following are available online at http://www.mdpi.com/2227-9032/7/2/68/s1, Table S1A–B: Logistic Regression Analysis Predicting Living Alone for Elderly Adults in Canada and the United States, 2006, Table S2A–D: Logistic Regression Analysis Predicting Living Alone for Elderly Adults in Canada and the United States, by Nativity and Gender, 2006, Table S3A–D: Logistic Regression Analysis Predicting Living Alone for Elderly Immigrants in Canada and the United States, 2006.

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References

1. Gee, E.M. Living arrangements and quality of life among Chinese Canadian elders. *Soc. Indic. Res.* **2000**, *51*, 309–329. [CrossRef]
2. Gaymu, J. The housing conditions of elderly people. *Genus* **2003**, *59*, 201–226.
3. Gaymu, J.; Springer, S.; Stringer, L. How does living alone or with a partner influence life satisfaction among older men and women in Europe? *Population* **2012**, *67*, 43–69. [CrossRef]
4. Lee, J.J. An exploratory study on the quality of life of older Chinese people living alone in Hong Kong. *Soc. Indic. Res.* **2005**, *71*, 335–361. [CrossRef]
5. Wister, A. Living arrangements and informal social support among the elderly. *J. Hous. Elder.* **1990**, *6*, 33–43. [CrossRef]
6. Lui, C.; Everingham, J.; Warburton, J.; Cuthill, M.; Bartlett, H. What makes a community age-friendly: A review of international literature. *Aust. J. Ageing* **2009**, *28*, 116–121. [CrossRef] [PubMed]
7. Burr, J.A.; Mutchler, J.E. Residential independence among older persons: Community and individual factors. *Popul. Res. Policy Rev.* **2007**, *26*, 85–101. [CrossRef]
8. Lee, S.M.; Edmonston, B. Residential independence of elderly Immigrants. *Can. J. Aging* **2014**, *33*, 359–377. [CrossRef]
9. Wilmoth, J.M. Living arrangements among older immigrants in the United States. *Gerontologist* **2001**, *41*, 228–238. [CrossRef]
10. Klinenberg, E. *Going Solo: The Extraordinary Rise and Surprising Appeal of Living Alone*; Penguin Press: New York, NY, USA, 2012.
11. Kramarow, E.A. The elderly who live alone in the U.S.: Historical perspectives on household change. *Demography* **1995**, *32*, 335–352. [CrossRef] [PubMed]
12. Ruggles, S. The decline of intergenerational coresidence in the United States, 1850 to 2000. *Am. Soc. Rev.* **2007**, *72*, 962–989. [CrossRef]
13. United Nations. *Living Arrangements of Older Persons around the World*; United Nations: New York, NY, USA, 2005.
14. Priest, G.E. *Living Arrangements of Canada's Elderly: Changing Demographic and Economic Factors*; Occasional Paper No. 85-1; Gerontology Research Center, Simon Fraser University: Burnaby, BC, Canada, 1985.
15. Statistics Canada. *Living Arrangements of Seniors, 2011*; Census in Brief No. 4; Catalogue No. 98-312-X2011003; Statistics Canada: Ottawa, ON, Canada, 2012.
16. Vespa, J.; Lewis, J.M.; Kreider, R.M. *America's Families and Living Arrangements: 2012*; U.S. Census Bureau: Washington, DC, USA, 2013.
17. U.S. Census Bureau. *Statistical Abstract of the United States: 2012*; U.S. Government Printing Office: Washington, DC, USA, 2012.
18. Reher, D.; Requena, M. Living alone in later life: A global perspective. *Popul. Dev. Rev.* **2018**, *44*, 427–454. [CrossRef]

19. Lei, X.; Strauss, J.; Tian, M.; Zhao, Y. Living arrangements of the elderly in China: Evidence from the CHARLS national baseline. *China Econ. J.* **2015**, *8*, 191–214. [CrossRef]
20. AARP International. *The Aging Readiness and Competitiveness Report: Japan*; AARP: Washington, DC, USA, 2017.
21. Bess, I. *Widows Living Alone*; Can. Soc. Trends; Catalogue No. 11-008; Statistics Canada: Ottawa, ON, Canada, 1999.
22. Turcotte, M.; Schellenberg, G. *A Portrait of Seniors in Canada, 2006*; Catalogue No. 89-519-XIE; Statistics Canada: Ottawa, ON, Canada, 2007.
23. Turcotte, M. *Insights on Canadian Society: Living Apart Together*; Catalogue No. 75-006-X; Statistics Canada: Ottawa, ON, Canada, 2013.
24. Glick, J. Nativity, duration of residence, and the lifecourse pattern of extended family living in the U.S. *Popul. Res. Policy Rev.* **2000**, *19*, 179–198. [CrossRef]
25. Glick, J.; van Hook, J. Parents' co-residence with adult children: Can immigration explain racial and ethnic variations? *J. Marriage Fam.* **2002**, *64*, 240–253. [CrossRef]
26. Kaida, L.; Moyser, M.; Park, S.Y. Cultural preferences and economic constraints: The living arrangements of elderly Canadians. *Can. J. Aging* **2009**, *28*, 303–313. [CrossRef]
27. World Health Organization. *Global Age-Friendly Cities: A Guide*; WHO: Geneva, Switzerland, 2007.
28. Gelfand, D.E. Immigration, aging, and intergenerational relationships. *Gerontologist* **1989**, *29*, 366–372. [CrossRef]
29. U.S. Census Bureau. *Current Population Survey, Annual Social and Economic Supplement, 2012*; U.S. Census Bureau: Washington, DC, USA, 2013.
30. Bloemraad, I. "Two Peas in a Pod," "Apples and Oranges," and Other Food Metaphors: Comparing Canada and the United States. *Am. Behav. Sci.* **2011**, *55*, 1131–1159. [CrossRef]
31. Statistics Canada. *Canada's Population Estimates: Age and Sex*; The Daily; Statistics Canada: Ottawa, ON, Canada, 2012.
32. Howden, L.M.; Meyer, J.A. *Age and Sex Composition: 2010*; 2010 Census Briefs; U.S. Census Bureau: Washington, DC, USA, 2011.
33. Martin, P. *The Global Challenge of Managing Migration*; Population Bulletin; Population Reference Bureau: Washington, DC, USA, 2013; Volume 68.
34. Martin, P.; Midgley, E. *Immigration: Shaping and Reshaping America*; Revised and Updated 2nd Edition; Population Bulletin; Population Reference Bureau: Washington, DC, USA, 2006; Volume 61.
35. Gist, Y.J.; Hetzel, L.J. *We the People: Aging in the United States*; Census 2000 Special Report; U.S. Census Bureau: Washington, DC, USA, 2004.
36. Statistics Canada. *Immigration and Ethnocultural Diversity in Canada*; National Household Survey, 2011; Catalogue No. 99-010-X2011001; Statistics Canada: Ottawa, ON, Canada, 2013.
37. Humes, K.R.; Jones, N.A.; Ramirez, R.R. *Overview of Race and Hispanic Origin: 2010*; 2010 Census Briefs; U.S. Census Bureau: Washington, DC, USA, 2011.
38. Statistics Canada. *2006 Census Public Use Microdata File-Individuals File Documentation and User Guide*; Catalogue No. 95M0028XVB; Statistics Canada: Ottawa, ON, Canada, 2011.
39. U.S. Census Bureau. *Design and Methodology: American Community Survey*; U.S. Census Bureau: Washington, DC, USA, 2009.
40. U.S. Census Bureau. *American Community Survey PUMS File Data and Technical Documentation*; U.S. Census Bureau: Washington, DC, USA, 2006.
41. Statistics Canada. *Portrait of Families and Living Arrangements in Canada*; Catalogue No. 98-312-X2011001; Statistics Canada: Ottawa, ON, Canada, 2012.
42. U.S. Census Bureau. *Persons 65 Years and Over—Living Arrangements and Disability Status: 2009*; 2009 American Community Survey; U.S. Census Bureau: Washington, DC, USA, 2011.
43. Gurak, D.T.; Kritz, M.M. Elderly Asian and Hispanic foreign- and native-born living arrangements: Accounting for differences. *Res. Aging* **2010**, *32*, 567–594. [CrossRef] [PubMed]
44. Lee, S.M.; Edmonston, B. Age-at-arrival's effects on Asian immigrants' socioeconomic outcomes in Canada and the U.S. *Int. Migr. Rev.* **2011**, *45*, 527–561. [CrossRef]
45. Stata. *Stata 12 Data Analysis and Statistical Software*; Stata Press: College Station, TX, USA, 2011.

46. Long, J.S.; Freese, J. *Regression Models for Categorical Outcomes Using Stata*, 2nd ed.; Stata Press: College Station, TX, USA, 2006.
47. Boyd, M.; Norris, D. Who are the "Canadians"—Changing census responses, 1986–1996. *Can. Ethn. Stud.* **2001**, *33*, 1–24.
48. Goldmann, G. Shifts in ethnic origins among the offspring of immigrants: Is ethnic mobility a measurable phenomenon? *Can. Ethn. Stud.* **1998**, *30*, 121–148.
49. Lee, S.M.; Edmonston, B. "Canadian" as national ethnic origin: Trends and implications. *Can. Ethn. Stud.* **2009/2010**, *41–42*, 77–108. [CrossRef]
50. Blank, S.; Torrecilha, R.S. Understanding the living arrangements of Latino immigrants: A lifecourse approach. *Int. Migr. Rev.* **1998**, *32*, 3–19. [CrossRef] [PubMed]
51. Adler, N.E.; Boyce, T.; Chesney, M.A.; Cohen, S.; Folkman, S.; Kahn, R.L.; Syme, S.L. Socioeconomic status and health: The challenge of the gradient. *Am. Psychol.* **1994**, *49*, 15–24. [CrossRef]
52. Smith, J.P. The impact of socioeconomic status on health over the lifecourse. *J. Hum. Resour.* **2007**, *42*, 739–764. [CrossRef]

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Perspectives of Stakeholders on Technology Use in the Care of Community-Living Older Adults with Dementia: A Systematic Literature Review

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Abstract: Although technology has the potential to promote aging in place, the use of technology remains scarce among community-living older adults with dementia. A reason might be that many stakeholders are involved who all have a different perspective on technology use (i.e., needs, wishes, attitudes, possibilities, and difficulties). We systematically searched the literature in order to provide an overview of perspectives of different stakeholders on technology use among community-living older adults with dementia. After selection, 46 studies were included. We mainly found perspectives of informal caregivers and, to a lesser extent, of persons with dementia and formal caregivers. Perspectives of suppliers of technology were not present. Shared perspectives among persons with dementia and informal and formal caregivers were, among other things, ease of use, stability and flexibility of technology, importance of privacy, and confidentiality. We also found that among older persons, fun and pleasure, in addition to enhancing freedom and independence, facilitates technology use. Informal caregivers' peace of mind and relief of burden also appeared to be important in using technologies. Formal caregivers value the potential of technologies to improve monitoring and communication. Insight in shared, and conflicting perspectives of stakeholders are essential to enhance the use of technology.

Keywords: dementia; older adults; technology; perspectives; informal caregivers; formal caregivers

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1. Introduction

Older adults prefer to live independently and to stay in their own home if possible, also referred to as 'aging in place' [1,2]. Aging in place is not only preferred by older adults themselves, but also encouraged by policy makers, because of the increasing number of older people within Western societies, the shortage of health care professionals, and the increase of healthcare costs [3]. However, older adults may experience difficulties in performing a variety of home maintenance tasks [4], especially when having cognitive impairments. Smart homes and technologies are often proposed as solutions for promoting aging in place [5,6]. There are various technologies that all have the potential to meet specific unmet needs of persons with dementia and their informal caregivers. Technologies may be useful in monitoring older adults with dementia in order to improve quality of life, promote physical independence, or to reduce caregiver burden [5,7–9]. For instance, GPS technologies may stimulate older adults with dementia to get outside more often since they enhance feelings of safety and may reduce fear or anxiety. Another example is technologies to monitor and ensure home safety such as sensors and alarms ('remote monitoring'). These technologies are useful for risk reduction and consequently evoke feelings of safety among persons with dementia themselves, but also among their (in)formal caregivers. Other technologies can specifically help older adults with dementia to maintain functional knowledge of their personal details and of the reality around them, or provide memory training in order to retrieve information about daily activities. Finally, technologies may provide general and personalized information, support with regard to dementia symptoms, social support and company, enhancing physical activity, or health monitoring and perceived safety [10,11]. Despite the potential of technologies to facilitate and enhance aging in place for older adults with dementia, evidence for the effectiveness of technology use remains scarce and technology use often fails or is not sustainable in the long term [5,12–15].

Using technologies in the care of community-living older adults with dementia appears to be difficult. Dementia is a complex disorder; manifestation and progression can vary greatly, and the condition is poorly characterized and understood as well as unpredictable. All of this complicates the use of technologies [12]. Another explanation for the difficulties in using technologies for community-living older adults with dementia is the fact that many different stakeholders are involved. Older adults with dementia themselves are an important stakeholder, but many other stakeholders are involved, such as informal caregivers, formal caregivers, managers of healthcare organizations, and suppliers of technologies [16–19]. All of these stakeholders play a role in using technologies and, naturally, all have different needs, wishes, attitudes, knowledge, expectations, and experiences in this process. The Triple-I model can be useful to disentangle the differences in the perspectives of stakeholders and unravel the complexities of using technologies. According to this model, stakeholders have different identities or intrinsic values, different interests, and different ideals that play a role in using technology [20,21]. For successful use of technologies, it is essential that stakeholders who are involved interact with each other in order to achieve mutual understanding and cooperation. However, there is a lack of understanding and insight in the mutual and different perspectives of the stakeholders involved in technology use for community-living older adults with dementia [17,19].

The objective of our study was to provide an overview about what is known in the scientific literature about the perspectives of the different stakeholders who are involved in using technologies for community-living older adults with dementia. We define perspectives as the needs, wishes, attitudes, possibilities, and difficulties of stakeholders regarding technology use. The research questions of this study were (1) what is known about the similarities and differences in perspectives between the relevant stakeholders concerning using technologies among community-living older adults with dementia? And (2) what is the influence of the various perspectives of stakeholders on the successful use of technologies in the care for community-living older adults with dementia?

2. Materials and Methods

The databases PubMed, Web of Science, PsycINFO, Sociological Abstracts, and Sociological Services Abstracts have been systematically searched for articles published in English or Dutch since 2006. We searched a broad diversity of databases in order to cover literature from different fields such as biomedical (PubMed), psychological (PsycINFO), and social and behavioral sciences. We combined three groups of search terms, namely, (1) stakeholder perspective, (2) technologies, and (3) dementia. Table 1 shows the specific search terms we used per group combined with "OR" between the search terms or synonyms. The groups of search terms were combined by "AND" in order to find articles that focus on stakeholder perspectives as well as technology and dementia. The search strategy was identical for each database, and the final search was conducted in March 2017.

Table 1. Groups of search terms.

1. Stakeholder perspective	
Stakeholder(s)	Organization(s)
General practitioner(s)	Client(s)
Caregiver(s)	Patient(s)
Care professional(s)	Elderly
Supplier(s)	Elderly people
Provider(s)	Older people
Management	Different perspectives
Manager(s)	
2. Technology	
Ehealth/e-health	Telemedicine/tele-medicine
mhealth/m-health	Assistive technology
Robotics	Assisted living
Robotic technology	Technology acceptance
Sensor-based networks	Technology adoptation
Domotics	Tele-monitoring/telemonitoring
Smart home(s)	Electronic tracking
Home automation	Sensor technology
Care technology	Gero(n)technology
Telecare/tele-care	
3. Dementia	
Dementia	Alzheimer's disease
Alzheimer	Alzheimers disease

Figure 1 displays a flowchart of the selection process. The search process yielded 1391 articles after removal of duplicates. In the first selection phase, titles were screened to see whether articles concerned stakeholder perspectives in the use of technology in dementia care. Articles of which the reviewer (BG) was uncertain proceeded to the next selection phase. In the second selection phase (n = 187), abstracts were judged by two independent reviewers (BG, EW, KL, and NM) on the following criteria: (1) at least one stakeholder is involved in the study, (2) the study is about technology, (3) the study concerns persons with dementia living at home, and (4) empirical research (e.g., no reviews or commentaries). Disagreements were resolved by discussion to reach consensus or when unresolved went on to the last selection phase. In this third selection phase (n = 100), articles were judged based on the inclusion and exclusion criteria by reading the full text, again by two independent reviewers (all authors).

Table 2 shows the specific inclusion and exclusion criteria and definitions that were used during the selection process. We were searching for studies about the perspectives (needs, wishes, attitudes, possibilities, or difficulties in using technologies) of different stakeholders on the use of technology for community-living older adults with dementia. Since we were also interested in attitudes and opinions regarding technology, which the stakeholders did not always actually use or have experience with, sometimes the technology was only presented or described in a study as opposed to real-world use. Stakeholders who we considered to be involved in the process of technology use among persons with dementia were as follows: persons with dementia themselves, informal caregivers, formal caregivers (e.g., nursing staff, general practitioners (GPs), physicians, and home care staff), management of healthcare organizations, and suppliers of technology. We were interested in studies that focused on technologies aimed at community-living older adults with dementia to maintain independence or enhancing quality of life. Studies focusing on a specific technology (e.g., internet platform or GPS monitoring) as well as studies concerning various technologies or technology in general were all included. The technology in question did not have to be primarily or exclusively focused on persons with dementia themselves. For instance, an internet intervention to reduce burden among informal caregivers of persons with dementia was included since it was related to community-living older adults with dementia. Studies that were limited to the description of the development phase or needs assessment concerning a technology without actual use were excluded. In case a study concerning community-living older adults with dementia as well as in an institutional setting, studies were only included when the majority was living at home or, instead, we limited data extraction to results about the first and not the latter. We only included empirical studies. If a study contained a literature review as well as empirical data, we only extracted data and results from the empirical section.

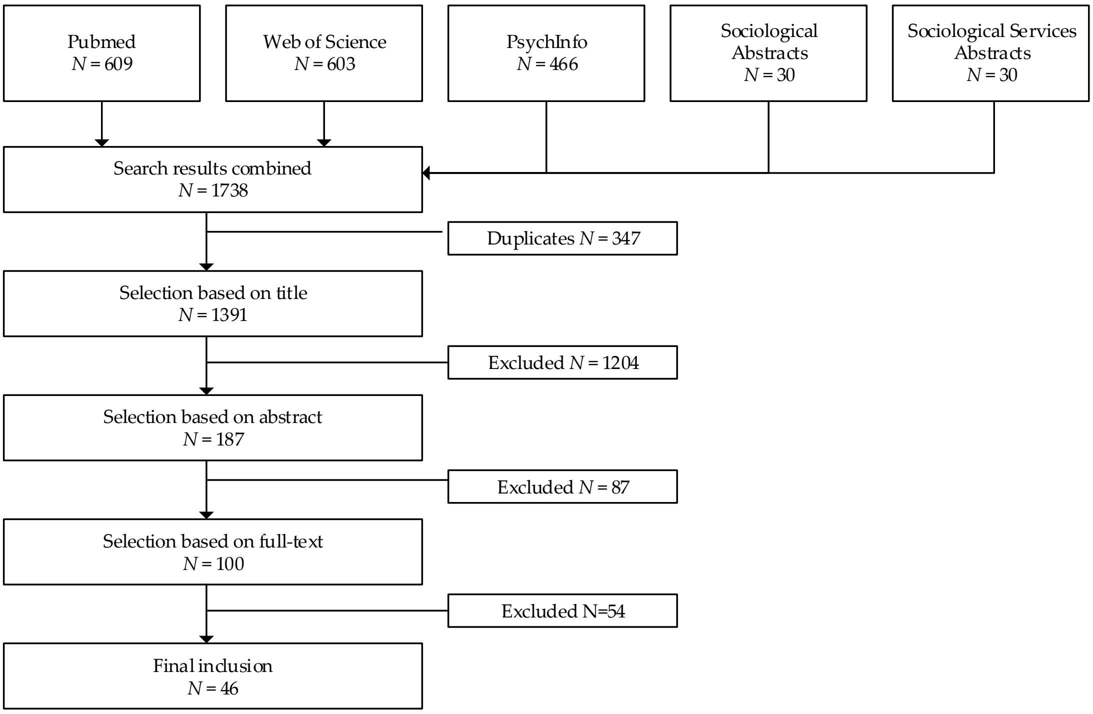

Figure 1. Flowchart of the selection process.

Table 2. Inclusion and exclusion criteria.

Inclusion Criteria
• Studies that investigate a perspective (needs, wishes, attitudes, possibilities, or difficulties) towards technology use; • Subject of the study is at least one stakeholder involved in the use of technology (persons with dementia, informal caregivers, formal caregivers, (management) of healthcare organization, or suppliers of technology); • Studies concerning technology (not necessarily primarily) aimed at persons with dementia living at home to maintain independence or quality of life; • Empirical studies (published in English or Dutch and after 2006)
Exclusion Criteria
• Subject of the study is limited to (health care) students only; • The majority of the included participants or groups of interest in the study are persons with dementia living in an institutional setting; • Study is limited to the description of the development/pilot phase of a technology without actual use of the technology among persons with dementia; • Study is limited to a needs assessment among stakeholders regarding the development of technology.

The following data were extracted for each study: author, year, journal, originating country, stakeholder(s) included in the study, description of the technology or description of the measurements, description of the setting or care situation, description of the target group and/or stage of dementia, description of the perspectives of the stakeholders on technology use, (if relevant) description of the differences in perspectives of stakeholders, and (if relevant) outcomes of the intervention. The quality of the studies was assessed using the mixed methods appraisal tool (MMAT) [22]. The MMAT is a unified quality assessment tool for the appraisal of qualitative as well as quantitative and mixed methods studies. Data extraction and quality appraisal were performed by pairs of two independent reviewers (LB, BG, KL, and EW). Disparities were resolved by discussion between the reviewers, consulting a third reviewer, or by consulting the authors of the original studies.

3. Results

3.1. General Findings

Table S1 provides an overview of the features of the primary studies. Of the 46 studies [9,23–67] included, the majority were conducted in Europe ($n = 30$), seven studies in Asia, and seven studies in North America, while two were multi-country studies. Informal caregivers were the most prevalent stakeholders in the primary studies ($n = 43$). Persons with dementia themselves were also often involved in studies ($n = 24$). However, it differed per study whether data collection actually took place among persons with dementia or whether a proxy served as input for the perspective of persons with dementia. Formal caregivers were a stakeholder in 16 primary studies, varying from GPs to nurses to occupational therapists. In one study, managers were included as stakeholders, albeit as part of a larger group of formal caregivers (9 managers within a group of 96 formal caregivers) [42]. Considering the small number of managers in the primary studies, the perspective of managers will not be reported separately, but included among the perspectives of the formal caregivers as a whole. The perspectives of suppliers of technology were not present in the included studies, although we included them in the initial search string.

In 28 studies, a technology was actually used by participants of the study, and 18 studies focused on stakeholders' attitudes, opinions, or expectations regarding technology in general or a technology that they did not (yet) actually use. The technologies investigated in 28 studies were heterogeneous; technologies providing support to informal caregivers (e.g., information, peer-to-peer contact, and personalized advice) $n = 6$, assistive technologies (e.g., alarms, sensors) $n = 6$, intervention program via internet or telephone $n = 4$, GPS monitoring system $n = 3$, technology to facilitate or improve communication between caregivers and/or persons with dementia $n = 3$, technology providing support for persons with dementia (e.g., reminders, picture dialing, information about hometown) $n = 3$, monitoring system in the home of the person with dementia (e.g., several sensors and detectors within the home) $n = 2$, and simple remote control n=1. The 18 studies investigating attitudes, opinions, or expectations with regard to a technology predominantly involved informal caregivers. In these studies, persons with dementia were not included.

The perspectives we found in the studies are reported separately per group of stakeholders and as shared perspectives. If a perspective was particularly relevant for one category of technologies, it was highlighted. In general, most perspectives were applicable for various technologies. Table S2 provides an overview of the main findings per study sorted by perspectives of the stakeholder.

3.2. Shared Perspectives on Technology use Among all Stakeholders

Shared perspectives that were mentioned by persons with dementia as well as informal and formal caregivers are the importance of ease of use and having a sense of capacity to use the technology [9,30,31,35,37,47–49,53]. Being worried about user-friendliness appeared to be a barrier for technology use. Furthermore, the stability and flexibility of the technology appeared to be important for all stakeholders. Technologies that are not functioning as intended cause frustration, and it takes time and energy to solve possible problems. In addition, unstable technologies may cause loss in confidence and reliability perception that can be a barrier to continue use [9,43,48,51]. The importance of privacy and confidentiality of the technology were mentioned by all stakeholders [35,40,49]. Especially in GPS technologies, this perspective appeared to be important [33,40,53,61]. A facilitator for technology use among all stakeholders was the fact that a technology could be easily incorporated in daily life and habits [36,43,51,62]. Finally, the timing of the introduction of the technology with regard to disease progression appeared to be crucial [9,28,29,34,36,37,40,52,53]. When a technology is introduced too early, the person with dementia may not take it seriously. When a technology is introduced rather late, it is difficult for persons with dementia to understand and to get used to, which in turn sometimes makes it more difficult to incorporate the use of the technology in a patient's daily life.

3.3. Perspectives on Technology Use among Persons with Dementia

Facilitators for the use of technology among persons living with dementia are the potential of technology to maintain or enhance their freedom and independence and subsequently allow them to live longer at home or postpone institutionalization [33,46,49,53,58]. The use of technology among persons with dementia may also evoke positive emotions such as a feeling of mastery and the feeling of being digitally included [24,43]. In addition, having fun and pleasure are facilitators for technology use [31,32,52]. Several facilitators for the use of technology correspond to the aim of the technology. For instance, GPS evokes a feeling of safety and security, which was found to be a facilitator for persons with dementia to use GPS [33,46,58]. In addition, technologies for communication purposes stimulate social interactivity or enhance support for persons with dementia, which was positively evaluated [54]. In sum, the aforementioned facilitators for technology use among persons with dementia are, in most cases, in line with the purposes of the technology.

In the development and design of technologies, there are a few points of interest to keep in mind since they play a role in the use of technology for persons with dementia. First, the visibility and aesthetics of the technology. The technology should not be stigmatizing or embarrassing, since this may be a barrier for persons with dementia to use it [33,34,46,61]. Persons with dementia may also have certain concerns that are important to keep in mind in using technologies, such as the costs of technologies, the possibility of breaking the technology, or a heightened vulnerability to criminals [47,52,53,61]. In addition, noises and lights might be confusing for persons with dementia and may therefore be a barrier in the use of technology [9,34,60].

3.4. Perspectives on Technology Use among Informal Caregivers

Informal caregivers are in favor of using technologies when they see potential and positive effects for the person with dementia. For instance, technologies that enhance freedom and independence for persons with dementia are evaluated positively [33,36,40,46,58,66]. Furthermore, informal caregivers value the effect that technology can have on quality of life or quality of healthcare delivery for the person with dementia [55,61,66]. Informal caregivers attach great value to risk reduction, protection, and safety for persons with dementia as a consequences of technology use [35,40,46,66]. On the other side of the coin, informal caregivers sometimes attach less value to consequences of technology use on liberty and autonomy of the person with dementia [49,59,61,66].

Informal caregivers also mention specific reasons for using technologies that have positive effects for themselves. For instance, technologies have the potential to reduce informal caregivers' level of stress, increase peace of mind, and reduce their worries about the person with dementia [26,28,35,40,42,61,65]. Technology can also provide them more freedom, save them time, and provide them with a relief from a burden that was evaluated positively [24,34,35,47,49,58,63,66]. Some technologies can also provide support for informal caregivers, such as provision of information, and increase their confidence level or peer-to-peer contact [44,63,65]. In addition, technologies that improve the relationship between the informal caregiver and person with dementia are positively evaluated. For instance, doing something together, having less conflicts, or improving communication [32,38].

Informal caregivers mentioned potential barriers for the person with dementia in using technology. These are in line with barriers mentioned by persons with dementia themselves. For instance, sounds and lights may be confusing or cause anxiety; there are also the aforementioned concerns about privacy and vulnerability for criminals [59,61,63]. Informal caregivers perceive costs of technologies and time commitment to learn to use the technology or to solve problems with the technology as barriers in technology use [30,47,59]. Consequently, technical support or assistance from formal caregivers in technology use can be a facilitator for technology use [44]. In addition, informal caregivers mention the importance of the flexibility, stability, and simplicity of the technology [62]. Lastly, it is important that it is easy to learn to use the technology and that it is useful for multiple users [30].

3.5. Perspectives on Technology Use among Formal Caregivers

Formal caregivers value the potential of technologies to improve documentation and monitoring of their patients [63]. This provides the opportunity to react timely on status changes. In addition, improvement of interaction between them and informal caregivers and persons with dementia by the use of technologies was positively evaluated [63]. Technologies can also save (travel) time and as a consequence save costs for formal caregivers [25,35,52]. However, costs can also be a barrier for formal caregivers to use technologies [35,51]. Among formal caregivers, there are some concerns that technologies might decrease face-to-face contact with persons with dementia or dehumanize care [35]. Additionally, less involvement of family and reduced personal contact or more distance in the relationship (between informal and formal caregivers) were mentioned as a potential barrier [40,64]. However, the opposite can also hold true, where technology has the potential to actually improve the relationship between formal and informal caregivers, or between informal caregivers and their peers [64]. Especially in rural areas, technologies might be useful to enhance support and contact between informal and formal caregivers [63]. Finally, privacy issues are also a concern among formal caregivers [35,40,42].

4. Discussion

In this literature review, we predominantly found perspectives of informal caregivers on technology use and, to a lesser extent, perspectives of persons with dementia and formal caregivers. The perspectives of suppliers of technology was not present in the included studies. Shared perspectives among all stakeholders were, among other things, the ease of use, stability, and flexibility of technology, and the importance of privacy and confidentiality. Persons with dementia value the potential of technology to have fun and pleasure with it as well as its potential to enhance their freedom and independence. Among informal caregivers, having peace of mind and relief of burden were important facilitators for technology use. Formal caregivers appreciate the fact that technologies may improve monitoring of their patients and interactions with other stakeholders. Although we specifically searched for perspectives of stakeholders on technology use among community-living older adults with dementia, it appears that the perspectives we found are to a large extent in line with previous findings among older adults without dementia [19,68].

In some cases, we found conflicting facilitators and barriers for the use of technology among community-living older adults with dementia. For instance, informal caregivers as well as persons with dementia value the fact that technology, especially GPS solutions, enhance their freedom and independence. Nevertheless, in this case it is always known where persons with dementia are located, which reduces their privacy. The same applies to monitoring systems such as alarms, sensors, or cameras within the home of persons with dementia. Formal caregivers value the fact that technologies can enhance contact with their patients and their informal caregivers. However, dehumanizing care and less face-to-face contact is a consequence of technology use that was mentioned as a potential barrier. Insight into the different perspectives of the stakeholders is important to prevent conflicting or contradictory perspectives from becoming a barrier to using technologies. For instance, to prevent privacy issues from becoming a barrier to technology use, it is important to be clear about who has access to data, how data are stored, and how they are used. In addition, it is important to agree who is responsible to act upon signals or problems [69].

The timing of the introduction of technologies appears to be crucial, since it came up in several studies among various stakeholders and various technologies. As mentioned before, dementia is a complex disease that comes with different (sometimes distinct, sometimes gradual) phases. The same applies for the available technologies; some are specifically designed for the first phases of dementia, such as GPS technologies or memory assistive technologies. Other technologies better suit more advanced stages of dementia, such as sensory stimulating technology or monitoring systems within the home. When introducing a technology, it is therefore vital that it matches the phase of dementia. Additionally, among community-dwelling older adults who do not suffer from dementia, timing of the introduction of technology is essential [68]. As suggested by Nijhof and colleagues [70,71], besides specific technologies for every phase of dementia, the involvement of stakeholders is different per phase of dementia. In the first phase of dementia, persons with dementia themselves play a major role, since they are still relatively independent and able to learn. In more advanced stages of dementia, (in)formal caregivers become more important in the use of technologies. Since stability and flexibility of the technology, as well as timing of the introduction of the technology, appear to be of great importance for successful use, it might be worthwhile for suppliers to make it possible to rent or lease technologies for community-living older adults. This would make technology use more flexible; it may be more cost-effective and therefore more feasible to introduce technologies at the right moment within the disease progress.

The results of our study should be considered in the light of some limitations. First, the majority of the included studies in this literature review are from Western countries. It is known that social support, coping, and the dementia caregiving experience are largely affected by race, ethnicity, and culture [72]. Therefore, the reported perspectives of the stakeholders may not be, or only partially, applicable to non-Western societies. Secondly, we only included 'perspectives' in our search string. It might have been better to include search terms that capture perspectives such as wishes, needs, attitudes, possibilities, or difficulties. However, we explicitly included the different stakeholders in our search terms, and therefore we expect that we have found most studies that capture perspectives of stakeholders. Another limitation is the fact that in some studies, it was unclear whether perspectives were the actual opinions of persons with dementia or whether (in)formal caregivers thought it might be of importance for persons with dementia. Nowadays, there are research methods and knowledge available about how to ask, observe, or involve persons with dementia themselves instead of asking a proxy [73–75]. Since the perspectives of the stakeholders were sometimes different, especially the perspective of informal caregivers, is it important to include persons with dementia themselves to unravel their perspectives on technology use.

This literature review provides an extensive overview of perspectives of persons with dementia and their informal and formal caregivers on a broad variety of technologies. It appeared that the perspectives on technology use are to a great extent comparable with findings among community-living older adults without dementia or cognitive problems. There is a paucity of knowledge in academic literature about the perspective of suppliers of technology. This study provides insight into whether perspectives of people with dementia and their informal and formal caregivers correspond or are differ with each other. This knowledge is important, since it may influence, impede, or enhance technology use among community-living older adults with dementia.

5. Conclusions

This literature review provides an extensive overview of perspectives of persons with dementia and their informal and formal caregivers on a broad variety of technologies. It appears that the perspectives on technology use are to a great extent comparable with findings among community-living older adults without dementia or cognitive problems. There is a paucity of knowledge in academic literature about the perspective of suppliers of technology. This literature study has some practical implications. The themes described are, in general, applicable to a variety of technologies for community-living older adults. In addition, the findings provide insight into perspectives of people with dementia and their informal and formal caregivers regarding technology use. As aforementioned, this insight regarding perspectives of involved stakeholders is crucial since it may influence, impede, or enhance technology use among community-living older adults with dementia. Successful use of technology in complex situations such as dementia care, with multiple stakeholders, requires acknowledgement of the perspectives of all these stakeholders.

Supplementary Materials: The following are available online at http://www.mdpi.com/2227-9032/7/2/73/s1, Table S1: Features of primary studies, Table S2: Results of perspectives of stakeholders per study.

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References

1. Boldy, D.; Grenade, L.; Lewin, G.; Karol, E.; Burton, E. Older people's decisions regarding 'ageing in place': A Western Australian case study. *Australas J. Ageing* **2011**, *30*, 136–142. [CrossRef] [PubMed]
2. Eckert, J.K.; Morgan, L.A.; Swamy, N. Preferences for receipt of care among community-dwelling adults. *J. Aging Soc. Policy* **2004**, *16*, 49–65. [CrossRef] [PubMed]
3. World Health Organization. *Global Age-friendly Cities: A Guide.*; World Health Organization: Geneva, Schwitzerland, 2007.
4. Fausset, C.B.; Kelly, A.J.; Rogers, W.A.; Fisk, A.D. Challenges to Aging in Place: Understanding Home Maintenance Difficulties. *J. Housing Elderly* **2011**, *25*, 125–141. [CrossRef]
5. Peek, S.T.M.; Aarts, S.; Wouters, E. Can smart home technolog deliver on the promise of independent living? A critical reflection based on the perspecties of older adults. In *Handbook of Smart Homes, Health Care and Well-being*; van Hoof, J., Demiris, G., Eds.; Springer international Publishing: Cham, Schwitzerland, 2017; pp. 203–214.
6. Reeder, B.; Meyer, E.; Lazar, A.; Chaudhuri, S.; Thompson, H.J.; Demiris, G. Framing the evidence for health smart homes and home-based consumer health technologies as a public health intervention for independent aging: A systematic review. *Int. J. Med. Inform.* **2013**, *82*, 565–579. [CrossRef]
7. Frisardi, V.; Imbimbo, B.P. Gerontechnology for demented patients: smart homes for smart aging. *J. Alzheimer's Disease JAD* **2011**, *23*, 143–146. [CrossRef]
8. Nijhof, N.; van Gemert-Pijnen, L.J.; Sixsmith, A.; Seydel, E.R. User evaluation of ADLife technology to improve wellbeing and to save cost for people with dementia. *Gerontechnology* **2012**, *11*, 256. [CrossRef]
9. Nijhof, N.; van Gemert-Pijnen, L.J.; Woolrych, R.; Sixsmith, A. An evaluation of preventive sensor technology for dementia care. *J. Telemed. Telecare 19*, 95–100. [CrossRef] [PubMed]
10. Lauriks, S.; Reinersmann, A.; Van der Roest, H.G.; Meiland, F.J.; Davies, R.J.; Moelaert, F.; Mulvenna, M.D.; Nugent, C.D.; Droes, R.M. Review of ICT-based services for identified unmet needs in people with dementia. *Ageing Res. Rev.* **2007**, *6*, 223–246. [CrossRef]
11. Maresova, P.; Klimova, B. Supporting Technologies for Old People with Dementia: A Review. *IFAC-PapersOnLine* **2015**, *48*, 129–134. [CrossRef]
12. Greenhalgh, T.; Wherton, J.; Papoutsi, C.; Lynch, J.; Hughes, G.; A'Court, C.; Hinder, S.; Fahy, N.; Procter, R.; Shaw, S. Beyond Adoption: A New Framework for Theorizing and Evaluating Nonadoption, Abandonment, and Challenges to the Scale-Up, Spread, and Sustainability of Health and Care Technologies. *J. Med. Internet Res.* **2017**, *19*, e367. [CrossRef]
13. Liu, L.; Stroulia, E.; Nikolaidis, I.; Miguel-Cruz, A.; Rios Rincon, A. Smart homes and home health monitoring technologies for older adults: A systematic review. *Int. J. Med. Inform.* **2016**, *91*, 44–59. [CrossRef]
14. Murray, E.; May, C.; Mair, F. Development and formative evaluation of the e-Health Implementation Toolkit (e-HIT). *BMC Med. Inform. Decis. Mak.* **2010**, *10*, 61. [CrossRef]
15. Levine, D.M.; Lipsitz, S.R.; Linder, J.A. Trends in Seniors' Use of Digital Health Technology in the United States, 2011-2014 Trends in Seniors' Use of Digital Health Technology in the United States, 2011–2014Letters. *Jama* **2016**, *316*, 538–540. [CrossRef]
16. Cook, E.; Randhawa, G.; Guppy, A.; Sharp, C.; Barton, G.; Bateman, A.; Crawford-White, J. Exploring factors that impact the decision to use assistive telecare: Perspectives of family care-givers of older people in the United Kingdom. *Ageing Soc.* **2018**, *38*, 1912–1932. [CrossRef]

17. Sponselee, A.; Schouten, B.; Bouwhuis, D.; Willems, C. Smart Home Technology for the Elderly: Perceptions of Multidisciplinary Stakeholders. In *Constructing Ambient Intelligence*; Mühlhäuser, M., Ferscha, A., Aitenbichler, E., Eds.; Springer: Berlin, Germanypp, 2007; volume 11, pp. 314–326.
18. McCreadie, C.; Tinker, A. The acceptability of assistive technology to older people. *Ageing Soc.* **2005**, *25*, 91–110. [CrossRef]
19. Peek, S.T.; Wouters, E.J.; Luijkx, K.G.; Vrijhoef, H.J. What it Takes to Successfully Implement Technology for Aging in Place: Focus Groups With Stakeholders. *J. Med. Internet Res.* **2016**, *18*, e98. [CrossRef]
20. Verkerk, M.J. The Triple I model: A translation of Dooyeweerdian Philosophical concepts for Engineers. In *Social change in our technology-based world. Proceedings of the 19th annual working conference of the IIDE.*; Rathbone, M., von Scheele, F., Strijbos, S., Eds.; Rozenberg: Amsterdam, The Netherlands, 2014.
21. Verkerk, M.J.; Holtkamp, F.C.; Wouters, E.; van Hoof, J. Professional Practices and User Practices: An Explorative Study in Health Care. *Philos. Reformatica* **2017**, *82*, 1–25. [CrossRef]
22. Pace, R.; Pluye, P.; Bartlett, G.; Macaulay, A.C.; Salsberg, J.; Jagosh, J.; Seller, R. Testing the reliability and efficiency of the pilot Mixed Methods Appraisal Tool (MMAT) for systematic mixed studies review. *Int. J. Nurs. Stud.* **2012**, *49*, 47–53. [CrossRef]
23. Alwin, J.; Persson, J.; Krevers, B. Perception and significance of an assistive technology intervention—The perspectives of relatives of persons with dementia. *Disabil. Rehabil.* **2013**, *35*, 1519–1526. [CrossRef]
24. Arntzen, C.; Holthe, T.; Jentoft, R. Tracing the successful incorporation of assistive technology into everyday life for younger people with dementia and family carers. *Dement. Int. J. Soc. Res. Pract.* **2016**, *15*, 646–662. [CrossRef]
25. Azad, N.; Amos, S.; Milne, K.; Power, B. Telemedicine in a rural memory disorder clinic-remote management of patients with dementia. *Can. Geriatr. J.* **2012**, *15*, 96–100. [CrossRef]
26. Burstein, A.A.; DaDalt, O.; Kramer, B.; D'Ambrosio, L.A.; Coughlin, J.F. Dementia caregivers and technology acceptance: Interest outstrips awareness. *Gerontechnology* **2015**, *14*, 45–56. [CrossRef]
27. Chiu, T.M.; Eysenbach, G. Theorizing the health service usage behavior of family caregivers: A qualitative study of an internet-based intervention. *Int. J. Med. Inform.* **2011**, *80*, 754–764. [CrossRef]
28. Chou, H.K.; Yan, S.H.; Lin, I.C.; Tsai, M.T.; Chen, C.C.; Woung, L.C. A Pilot Study of the Telecare Medical Support System as an Intervention in Dementia Care: The Views and Experiences of Primary Caregivers. *J. Nurs. Res.* **2012**, *20*, 169–180. [CrossRef]
29. Cristancho-Lacroix, V.; Wrobel, J.; Cantegreil-Kallen, I.; Dub, T.; Rouquette, A.; Rigaud, A.S. A Web-Based Psychoeducational Program for Informal Caregivers of Patients With Alzheimer's Disease: A Pilot Randomized Controlled Trial. *J. Med. Internet Res.* **2015**, *17*, 14. [CrossRef]
30. Czarnuch, S.; Mihailidis, A. The design of intelligent in-home assistive technologies: Assessing the needs of older adults with dementia and their caregivers. *Gerontechnology* **2011**, *10*, 169–182. [CrossRef]
31. Dal Bello-Haas, V.P.M.; O'Connell, M.E.; Morgan, D.G.; Crossley, M. Lessons learned: Feasibility and acceptability of a telehealth-delivered exercise intervention for rurald-welling individuals with dementia and their caregivers. *Rural Remote Health* **2014**, *14*, 11.
32. Ekstrom, A.; Ferm, U.; Samuelsson, C. Digital communication support and Alzheimer's disease. *Dementia (London, England)* **2015**. [CrossRef]
33. Faucounau, V.; Riguet, M.; Orvoen, G.; Lacombe, A.; Rialle, V.; Extra, J.; Rigaud, A.S. Electronic tracking system and wandering in Alzheimer's disease: a case study. *Ann. Phys. Rehabil. Med.* **2009**, *52*, 579–587. [CrossRef]
34. Gibson, G.; Dickinson, C.; Brittain, K.; Robinson, L. The everyday use of assistive technology by people with dementia and their family carers: A qualitative study. *BMC Geriatr.* **2015**, *15*, 10. [CrossRef]
35. Hastall, M.R.; Eiermann, N.D.; Ritterfeld, U. Formal and informal carers' views on ICT in dementia care: Insights from two qualitative studies. *Gerontechnology* **2014**, *13*, 53–58. [CrossRef]
36. Jentoft, R.; Holthe, T.; Arntzen, C. The use of assistive technology in the everyday lives of young people living with dementia and their caregivers. Can a simple remote control make a difference? *Int. Psychogeriatr.* **2014**, *26*, 2011–2021. [CrossRef]
37. Kearns, W.D.; Rosenberg, D.; West, L.; Applegarth, S. Attitudes and expectations of technologies to manage wandering behavior in persons with dementia. *Gerontechnology* **2007**, *6*, 89–101. [CrossRef]

38. Kerssens, C.; Kumar, R.; Adams, A.E.; Knott, C.C.; Matalenas, L.; Sanford, J.A.; Rogers, W.A. Personalized Technology to Support Older Adults With and Without Cognitive Impairment Living at Home. *Am. J. Alzheimers Dis. Other Dement.* **2015**, *30*, 85–97. [CrossRef]
39. Kim, H. Understanding Internet Use Among Dementia Caregivers: Results of Secondary Data Analysis Using the US Caregiver Survey Data. *Interact. J. Med. Res.* **2015**, *4*, 27–38. [CrossRef]
40. Landau, R.; Auslander, G.K.; Werner, S.; Shoval, N.; Heinik, J. Families' and Professional Caregivers' Views of Using Advanced Technology to Track People With Dementia. *Qual. Health Res.* **2010**, *20*, 409–419. [CrossRef]
41. Landau, R.; Auslander, G.K.; Werner, S.; Shoval, N.; Heinik, J. Who should make the decision on the use of GPS for people with dementia? *Aging Ment. Health* **2011**, *15*, 78–84. [CrossRef]
42. Landau, R.; Werner, S.; Auslander, G.K.; Shoval, N.; Heinik, J. Attitudes of Family and Professional Care-Givers towards the Use of GPS for Tracking Patients with Dementia: An Exploratory Study. *Br. J. Soc. Work* **2009**, *39*, 670–692. [CrossRef]
43. Lindqvist, E.; Nygard, L.; Borell, L. Significant junctures on the way towards becoming a user of assistive technology in Alzheimer's disease. *Scand. J. Occup. Ther.* **2013**, *20*, 386–396. [CrossRef]
44. Lundberg, S. The results from a two-year case study of an information and communication technology support system for family caregivers. *Disabil. Rehabil. Assist. Technol.* **2014**, *9*, 353–358. [CrossRef]
45. Mao, H.F.; Chang, L.H.; Yao, G.; Chen, W.Y.; Huang, W.N.W. Indicators of perceived useful dementia care assistive technology: Caregivers' perspectives. *Geriatr. Gerontol. Int.* **2015**, *15*, 1049–1057. [CrossRef]
46. McCabe, L.; Innes, A. Supporting safe walking for people with dementia: User participation in the development of new technology. *Gerontechnology* **2013**, *12*, 4–15. [CrossRef]
47. Mehrabian, S.; Extra, J.; Wu, Y.H.; Pino, M.; Traykov, L.; Rigaud, A.S. The perceptions of cognitively impaired patients and their caregivers of a home telecare system. *J. Med. Device.* **2015**, *8*, 21–29. [CrossRef]
48. Meiland, F.J.M.; Bouman, A.I.E.; Sävenstedt, S.; Bentvelzen, S.; Davies, R.J.; Mulvenna, M.D.; Nugent, C.D.; Moelaert, F.; Hettinga, M.E.; Bengtsson, J.E.; et al. Usability of a new electronic assistive device for community-dwelling persons with mild dementia. *Aging Ment. Health* **2012**, *16*, 584–591. [CrossRef]
49. Mulvenna, M.; Hutton, A.; Coates, V.; Martin, S.; Todd, S.; Bond, R.; Moorhead, A. Views of caregivers on the ethics of assistive technology used for home surveillance of people living with dementia. *Neuroethics* **2017**. [CrossRef]
50. Nauha, L.; Keranen, N.S.; Kangas, M.; Jamsa, T.; Reponen, J. Assistive technologies at home for people with a memory disorder. *Dementia* **2016**. [CrossRef]
51. Newton, L.; Dickinson, C.; Gibson, G.; Brittain, K.; Robinson, L. Exploring the views of GPs, people with dementia and their carers on assistive technology: A qualitative study. *BMJ Open* **2016**, *6*, 7. [CrossRef]
52. Nijhof, N.; van Gemert-Pijnen, J.E.W.C.; Burns, C.M.; Seydel, E.R. A personal assistant for dementia to stay at home safe at reduced cost. *Gerontechnology* **2013a**, *11*, 469–479. [CrossRef]
53. Olsson, A.; Skovdahl, K.; Engstrom, M. Using diffusion of innovation theory to describe perceptions of a passive positioning alarm among persons with mild dementia: A repeated interview study. *BMC Geriatr.* **2016**, *16*, 6. [CrossRef]
54. Pakrasi, S.; Burmeister, O.K.; Coppola, J.F.; McCallum, T.J.; Loeb, G. Ethical telehealth design for users with dementia. *Gerontechnology* **2015**, *13*, 383–387. [CrossRef]
55. Pilotto, A.; D'Onofrio, G.; Benelli, E.; Zanesco, A.; Cabello, A.; Margeli, M.C.; Wanche-Politis, S.; Seferis, K.; Sancarlo, D.; Kilias, D.; et al. Information and Communication Technology Systems to Improve Quality of Life and Safety of Alzheimer's Disease Patients: A Multicenter International Survey. *J. Alzheimers Dis.* **2011**, *23*, 131–141. [CrossRef]
56. Pino, M.; Boulay, M.; Jouen, F.; Rigaud, A.S. "Are we ready for robots that care for us?" Attitudes and opinions of older adults toward socially assistive robots. *Front. Aging Neurosci.* **2015**, *7*, 15. [CrossRef]
57. Pot, A.M.; Blom, M.M.; Willemse, B.M. Acceptability of a guided self-help Internet intervention for family caregivers: Mastery over dementia. *Int. Psychogeriatr.* **2015**, *27*, 1343–1354. [CrossRef]
58. Pot, A.M.; Willemse, B.M.; Horjus, S. A pilot study on the use of tracking technology: Feasibility, acceptability, and benefits for people in early stages of dementia and their informal caregivers. *Aging & mental health* **2012**, *16*, 127–134. [CrossRef]
59. Powell, J.; Gunn, L.; Lowe, P.; Sheehan, B.; Griffiths, F.; Clarke, A. New networked technologies and carers of people with dementia: An interview study. *Ageing Soc.* **2010**, *30*, 1073–1088. [CrossRef]

60. Riikonen, M.; Mäkelä, K.; Perälä, S. Safety and monitoring technologies for the homes of people with dementia. *Gerontechnology* **2010**, *9*, 32–45. [CrossRef]
61. Robinson, L.; Hutchings, D.; Corner, L.; Finch, T.; Hughes, J.; Brittain, K.; Bond, J. Balancing rights and risks: Conflicting perspectives in the management of wandering in dementia. *Health Risk Soc.* **2007**, *9*, 389–406. [CrossRef]
62. Rosenberg, L.; Kottorp, A.; Nygard, L. Readiness for Technology Use With People With Dementia: The Perspectives of Significant Others. *J. Appl. Gerontol.* **2012**, *31*, 510–530. [CrossRef]
63. Schaller, S.; Marinova-Schmidt, V.; Setzer, M.; Kondylakis, H.; Griebel, L.; Sedlmayr, M.; Graessel, E.; Maler, J.M.; Kirn, S.; Kolominsky-Rabas, P.L. Usefulness of a Tailored eHealth Service for Informal Caregivers and Professionals in the Dementia Treatment and Care Setting: The eHealthMonitor Dementia Portal. *JMIR RES. Protoc.* **2016**, *5*, 18. [CrossRef]
64. Solli, H.; Hvalvik, S.; Bjørk, I.T.; Hellesø, R. Characteristics of the relationship that develops from nurse-caregiver communication during telecare. *J. Clin. Nurs.* **2015**, *24*, 1995–2004. [CrossRef] [PubMed]
65. Torkamani, M.; McDonald, L.; Saez Aguayo, I.; Kanios, C.; Katsanou, M.N.; Madeley, L.; Limousin, P.D.; Lees, A.J.; Haritou, M.; Jahanshahi, M. A randomized controlled pilot study to evaluate a technology platform for the assisted living of people with dementia and their carers. *J. Alzheimers Dis.* **2014**, *41*, 515–523. [CrossRef]
66. White, E.B.; Montgomery, P. Electronic tracking for people with dementia: An exploratory study of the ethical issues experienced by carers in making decisions about usage. *Dement. Int. J. Soc. Res. Pract.* **2014**, *13*, 216–232. [CrossRef] [PubMed]
67. Wilz, G.; Soellner, R. Evaluation of a short-term telephone-based cognitive behavioral intervention for dementia family caregivers. *Clin. Gerontol.* **2016**, *39*, 25–47. [CrossRef]
68. Peek, S.T.M.; Luijkx, K.G.; Vrijhoef, H.J.M.; Nieboer, M.E.; Aarts, S.; van der Voort, C.S.; Rijnaard, M.D.; Wouters, E.J.M. Origins and consequences of technology acquirement by independent-living seniors: Towards an integrative model. *BMC Geriatr.* **2017**, *17*, 189. [CrossRef]
69. Olsson, A.; Persson, A.C.; Bartfai, A.; Boman, I.L. Sensor technology more than a support. *Scand. J. Occup. Ther.* **2017**. [CrossRef] [PubMed]
70. Nijhof, N. eHealth for people with dementia in home-based and residential care. PhD Thesis, University of Twente, Enschede, The Netherlands, 2013.
71. Nijhof, N.; van Hoof, J.; Blom, M.M.; van Gemert-Pijnen, J.E.W.C. Smart Living in Dementia Care. In *Handbook of Smart Homes, Health Care and Well-Being*; van Hoof, J., Demiris, G., Wouters, E.J.M., Eds.; Springer International Publishing: Cham, Schwitzerland, 2014; pp. 1–8.
72. Janevic, M.R.; Connell, C.M. Racial, ethnic, and cultural differences in the dementia caregiving experience: Recent findings. *Gerontologist* **2001**, *41*, 334–347. [CrossRef]
73. Tsekleves, E.; Bingley, A.F.; Lujan Escalante, M.A.; Gradinar, A. Engaging people with dementia in designing playful and creative practices: Co-design or co-creation? *Dementia* **2018**. [CrossRef] [PubMed]
74. Brankaert, R.G.A.B. Design for dementia: A design-driven living lab approach to involve people with dementia and their context. Ph.D Thesis, Eindhoven University of Technology, Eindhoven, The Netherlands, 2016.
75. Roelofs, T.S.M.; Luijkx, K.G.; Embregts, P. A person-centered approach to study intimacy and sexuality in residential care facility (RCF) clients with dementia: Methodological considerations and a guide to study design. *NeuroRehabilitation* **2017**, *41*, 359–373. [CrossRef]

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Article

Older Adults' Perceptions of ICT: Main Findings from the Technology In Later Life (TILL) Study

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Abstract: Technology is entwined in 21st Century society, and within the lives of people across all ages. The Technology In Later Life (TILL) study is the first piece of work contributing to the impact, behavior, and perception of technology use, by adults aged ≥70 years, residing in rural and suburban areas. TILL is an international, multi-centred, multi-methods study investigating and conceptualizing how various technologies impact the lives of older adults; residing in urban and rural locations in the United Kingdom (UK) and Canada. This in-depth study recruited 37 participants via a multi-methods approach. Analysis of the findings ascertained two overarching themes: facilitators of technology use (i.e., sharing of information and feeling secure), and detractors of technology (i.e., feelings of apprehension of use). Proposed recommendations include promotion of technology from a strengths-based perspective focusing on positive opportunities technology to improve health and wellbeing, creating a peer support network to assist with learning of new technology, and the need to examine further how intergenerational relationships may be enhanced through the use of technology. The distinction of these themes narrates to the originality of this initial study and milieu of recruited participants, intersecting across the fields of gerontology, geography, social sciences, and gerontechnology.

Keywords: technology; rural ageing; qualitative research methods; gerontechnology; privacy; intergenerational; social connectedness; community networks

1. Introduction

The digital divide is commonly discussed when examining ownership of or access to information communication technologies (ICT), in addition to the possession of the skills and expertise required to use ICT to access information by older adults. Accessibility of ICTs is often dependent upon ICT literacy. For example, having limited knowledge to execute an Internet search may also reduce users' access [1].

The debates surrounding the digital divide have been ongoing for nearly thirty years, in a bid to enhance the quality, access, and equality of ICTs and information, while empowering users from all socio-economic areas [2]. With the former, greater social interaction and engagement of civic involvement occurs, which in turn reduces social connectedness, increases knowledge and skills, and facilitates communities and individuals to better their themselves and their families [3]. Yet, in 2003, the authors of [4] noted that with the rise of ICT and technology developments, there is the possibility that such innovations could increase inequality, rather than improve and restructure exiting concerns.

As the Internet formed part of the earlier debates of the digital divide aiming to understand the diffusion of the internet, access to new technologies was accessible to individuals from higher social denominations and who were educated [5].

Previously, several models and frameworks have proposed a myriad of definitions, and conceptualizations of what constitutes the digital divide. DiMaggio and Hargittai [6] describe the five facets of digital inequality: (1) equipment, (2) autonomy of use, (3) skill, (4) social support, and (5) the purpose for which the technology was used. Meanwhile, Selwyn [7] propounded the digital divide through four stages: (1) formal/theoretical access to ICTs and content, (2) effective access to and use of ICTs and content, (3) engagement with ICTs and content, and (4) outcomes or consequences. Moreover, van Dijk [8] suggested a model comprising of four key facets associated to access: (1) motivational access, (2) material access, (3) skills access, and (4) usage access. Yet, a digital divide index was defined and proposed by the authors of [9], comprising of five elements: (1) infrastructure access, (2) affordability, (3) use, (4) social and governmental constraints/support, and (5) sociodemographic factors. These varying models, definitions, and proposals not only offer, but also broaden perspectives to research conducted over a period of three decades.

However, as early as 2000, scholars [10] questioned whether there was a digital divide at all, and how this digital divide was made up—through income, education, access, skills, and/or based on geographic location (rural vs. metropolitan). For example, Brady notes the following:

"Computers and Web appliances are now relatively cheap, and free Internet access is available in many areas. Even lower income families could find a way to get wired if they viewed it as a high enough priority." (Brady, 2000)

Rooksby and colleagues [10] note this perspective is not significant and fails to recognize differences between and across those who have and those who do not, or those individuals who are rich and poor. Similarly, Compaine [11] supports this notion between the haves and have-nots, while others [12,13] perceive the notion of the digital divide is 'bridging itself' [10], and thus it is the responsibility of governments to offer financial assistance to support access to government information online. For example, Rooksby et al. [10] propose that governments should match funds in conjunction with the private sector to align ICTs, and regional and distribution centres should be developed to facilitate access and to monitor the gaps in Internet access. Over the last two decades, governments across the Western world have been attempting to reduce the digital divide through different initiatives and collaborations. Such initiatives in the UK aimed to tackle issues ranging from accessibility of ICT to infrastructure, roll out, and improvement of broadband. Yet, as we have seen through previous scholarly work, areas of interest have also included income, age, gender, and location; while these factors are still areas of interest, the development of technology since the turn of the twenty-first century has been phenomenal. This is particularly so, when governments are changing their behavior to offering information access and services.

While the digital divide comprises several factors including access, ability, and affordability, for others, additional factors may also play a role in the digital divide including, gender [14], age [15,16], income [17], education [18,19] ethnicity, and geographic location [20].

Literature Review

Across the UK, Internet upgrades have taken place with the notion to "reduce inequalities in Internet access, defined geographically: that is, disparities in access between different regions" [21]. Previously, infrastructure and access have been the primary foci of the digital divide [11,22] and while the provision of equipment is important, having the skills, knowledge, and digital ICT literacy to use ICT must also be considered. The use and deployment of ICT may have a profound effect on their lives of many people across social classes, countries, and socioeconomics. Yet, without the knowledge of how to use ICT, bridging the gap will remain limited, resulting in information inaccessibility, disengagement, and disinterest [23,24].

A growing area of work is the use of the Internet by older adults [1,25–31]. In 2016, more than two-thirds of Americans aged 65 and older used the Internet, and 51 percent had high-speed Internet at home [32]. Zickuhr [30] noted that 69 percent of adults aged over 65 years owned a cell phone, 48 percent owned a desktop computer, 32 percent owned a laptop, 11 percent owned an e-reader, and eight percent owned a tablet [31]. However, within the nontechnological users of the study, 68 percent recognized that their self-confidence was a problem. Furthermore, those individuals also acknowledged that they would benefit from learning how to use ICTs in their daily lives [30]. Anderson and Perrin [32] reported 40 percent of American older adults owned a smartphone in 2016, while smartphone usage was declining in adults aged ≥75 and older.

Currently, research has focused on the existing and prospective role(s) ICTs may have in later-life as a means of reducing social isolation and loneliness [25,28,33–36]. Additionally, and since 2010, this work has aimed to understand the needs and requirements of older adults, identifying that communication across generations is important, while also acknowledging, for some, that having the skills and knowledge to understand how to access ICTs (i.e., Skype) is also an area that needs further exploration.

While contemporary research has explored the digital divide from the standpoint of leisure and engagement by users and non-users of ICT [37], the reduced engagement and interaction by users and non-users may vary based on one's personal choice(s) and interests [38]. However, Ihm and Hsieh [39] note how access to ICTs is greatly reduced in later life compared with in younger users. Thus, this is problematic for older adults who did not have the opportunity to use ICTs in their previous employment and/or careers; thus greatly increasing their limitation to access, knowledge, services, and financial constraints (i.e., online banking) [40].

In a recent study conducted in the Czech Republic, Klimov and colleagues [41] explored whether age impacted on Internet use among 432 older people who were both active and passive users of technology. Respondents' age ranged between 55 and 94 years. Gender was not equal, comprising of 73 percent female and 17 percent male. A total of 15 participants were aged 85+ years, the majority of participants were aged between 65 and 74 years (n = 257), comprising of 188 females. The findings identified that participants between 55 and 74 years do use the Internet, while adults aged 74+ years spend less time using the Internet [41]. Similar findings were identified in earlier studies [31,42,43]. Additionally, respondents reported using the Internet for communication purposes, specifically using email, followed by online banking, Skype communication, and sharing photographs. Similarly, Choi and DiNitto [44] reported that their respective participants engaged in similar Internet-related activities (email/SMS communication, online shopping/banking and paying bills, health related tasks). However, Klimova et al. [41] noted their study was conducted in one specific area of the country and did not explore or take into consideration participants' education levels or socio-economic backgrounds. Conversely, Neves et al. [28] undertook a participatory design approach to developing an "accessible communication app" (page 1) primarily aimed at frail and institutionalized older adults, as a means of reducing social isolation and loneliness. The results from this study identified "that technology adoption is a based on a complex set of interrelated factors: social, attitudinal, physical, digital literacy, and usability" (page 1). Further considerations were noted by Neves and colleagues [28], suggesting there are differences and expectations of communication (i.e., style, feedback, availability) across generations.

Ivan and Hebblethwaite [45] aimed to understand social media use (i.e., Facebook) by grandmothers in Romania and Canada, in a bid to ascertain how intergenerational relationships of grandparent and grandchild are built by sharing photos with one another. Conversely, previous scholarly activity in this domain has explored the relationship between gender and ICT, exploring how and why individuals use ICTs in both younger and older adults [46–49]. The findings by Lian and Yen [48] show how performance and the social influence are strong factors to using ICT by older adults, which in turn are similar to the factors and social influences of younger adults. Yet, the respective study concluded there was no gender difference relating to the barrier and enablers of online shopping.

While we have witnessed a growth of scholarly research focusing on health and rehabilitation within the field of game studies [50–53], what has been lacking from contemporary research is understanding the technology experiences of respective participants recruited to respective studies. Marston, Kroll, Fink, de Rosario, and Gschwind [54] reported technology use by participants who primarily used technology for communicating via email, searching for information, text processing, and online shopping. While some of the participants did report using social media platforms such as Facebook and Google+, Marston and colleagues [54] suggested greater work is needed in the form of in-depth qualitative interviews and focus groups to ascertain the needs and issues surrounding current ageing populations and the impact technology has on their daily lives.

While there is a growing body of work focusing on the impacts of ICTs in later life, there is a need to explore and understand the barriers and enablers of ICTs by adults aged 70> years residing in rural and urban geographical locations to ascertain and understand the needs and requirements of existing age cohorts.

The significance of the Technology In Later Life (TILL) study intersects across the fields of gerontology, social sciences, geography, and gerontechnology, resulting in the contribution of new knowledge and proposed recommendations to advance future work across these multi- and cross-disciplinary fields.

2. Materials and Methods

2.1. Aims and Objectives

The Technology In Later (TILL) project aimed to examine the experiences of older adults aged 65+ years with technology, exploring how they embraced (or did not embrace) various types of ICT, and what the barriers and/or challenges faced by this older generation are in the take-up and continued use of ICTs in later life. Subsequently, the team sought to identify implications of using ICTs for current and future aging populations in rural and urban geographic locations. A multi-methods approach was adopted to enable the project to undertake "the inquiry on the assumption that collecting diverse types of data (quantitative data via one of two online surveys and focus group data) best provides an understanding of a research problem" [55] (pg. 21).

2.2. Participants

Thirty-seven participants were recruited via education facilities, public places (e.g., a library notice board, mailing lists), or seniors' centres such as Age UK Milton Keynes. Participants were included in the study if they used technology (for any amount of time), were 65+ years old, and lived in and around the surrounding respective study sites. There were 20 rural participants (McBride, British Columbia, (BC), Canada n = 10 and Wales, UK n = 10) and 17 urban participants (Regina, Saskatchewan (SK) Canada n = 6 and Milton Keynes, UK n = 11). Table 1a displays the overall demographics of participants and across each the UK and Canada, while Table 1b displays the demographics of participants from the perspective of rural and urban locations. The age range of participants was between 67 and 89 years, with a mean age of 77.

Table 1. Demographics of participants.

a. Demographics of Participants by Country (UK and Canada)

Demographics of Participants	Population (n = 37)	Canada (n = 16)	UK (n = 21)
Mean Age ± SD	77.42 (6.41)	79.31 (5.86)	75.90 (6.56)
Age Range (n)	67.89	70–89	67–89
Gender			
Female	67.6 (25)	87.5 (14)	52.4 (11)
Male	32.4(12)	12.5 (2)	47.6 (10)
Employment Status			
Not currently employed (retired)	86.5 (32)	81.3 (13)	90.5 (19)
Currently employed	13.5 (5)	18.8 (3)	9.5 (2)
Marital status	54.3 (19)	50 (8)	57.9 (11)
Single/Widowed	34.3 (12)	25 (4)	42.1 (8)
Married/Living with partner	11.4 (4)	25 (4)	0
Other			

b. Demographics of participants from rural and urban

Demographics of Participants	Rural (n = 20)	Urban (n = 17)
Mean Age ± SD	77.50 (6.79)	77.31 (6.11)
Age Range (n)	67–89	70–89
Gender		
Female	70 (14)	64.7 (11)
Male	30 (6)	35.3 (6)
Employment Status		
Not currently employed (retired)	90 (18)	82.4 (14)
Currently employed	10 (2)	17.6 (3)
Marital status	40 (8)	73.3 (11)
Single/Widowed	50 (10)	13.3 (2)
Married/Living with partner	10 (2)	13.3 (2)
Other		

2.3. Recruitment

Participant recruitment procedures were tailored as required on a site by site basis. Participants in the Milton Keynes area were recruited from the Age UK Milton Keynes Centre, while for the two sites in South Wales, participants were primarily recruited from the Older People's Forum comprising of 1000+ older people living across Wales. In Canada, participants from the city of Regina were recruited through flyers and posters across the local area, while participants in the town of McBride were recruited through an advertisement posted at a local senior's advocacy centre and in the community monthly newsletter, as well as through a radio interview for a senior's program on a local radio station.

A flyer and poster were created detailing the project study and aims—each tailored to include the contact details for each study site/partner. A mailing list script was created and submitted as part of the recruitment documentation. The mailing list script was primarily utilized by Swansea University. Participants were included in the study if they were users of technology and were ≥70 years old.

2.4. Study Locations

The Technology In Later Life (TILL) project is an international, multi-centred exploratory study comprising of two countries (UK and Canada) and four sites (two rural and two urban). Sites were selected based on the differences in physical environment, size of population, and accessibility to different ICTs. Additional rationale for choosing the selected sites is based on the location of the researchers of this initial study. Milton Keynes, located in the county of Buckinghamshire, was the urban site in the UK, and in 2013, was reported to have a population of 255,700 [56]. The urban site selected in Canada was Regina, the provincial capital of Saskatchewan, which has a population of 230,725 people [57]. The main industries in Regina are mineral resources and agriculture.

The rural locations in the UK consisted of the two small towns of Cwmtwrch and Ystalyfera, located less than 3 miles apart from each other in South Wales some 15 miles north of Swansea. Previously, Ystalyfera was industry-based with a large tin works that was closed 1946. Ystalyfera is located three miles east of Cwmtwrch and the population currently stands at just under 5000 people [58]. Cwmtwrch is a former industrial area, which used to have coal mines and iron works that are now all closed, and the current population is 2074 [59]. Presently, it is now largely agrarian in nature and is on the edge of the Brecon Beacons, one of the UK's national parks. In Canada, the town of McBride, British Columbia (BC) was the selected rural site. McBride, located in the Robson Valley region near the Rocky Mountains, is a small farming and forestry town and has a population of 660 people [60].

2.5. Ethical Approval

Ethics approval was granted by all four institutions by mid-September 2015 and participant recruitment and data collection were conducted between autumn 2015 and February 2016 (Open University: HREC/2015/2028/Marston/1; UNBC: E2015.0714.061.00; Swansea University: Granted-no code given; University of Regina: REB#2015-113). For each phase of data collection, informed consent was obtained. Prior to completing the online survey, participants were required to tick/check the consent box, which enabled them to complete the survey. All participants who completed the online survey also agreed to participate in a focus group discussion. Verbal and written informed consent were completed by each participant prior to the focus group commencing. Prior to the start of the focus groups, each participant signed an informed consent form.

2.6. Procedure

2.6.1. Online Survey

The online survey deployed in the TILL project was created using Google (Docs) survey©, and shared via a link to all participants who had agreed to take part in the study. The online survey was voluntary to complete by each participant across the four sites and was required to be completed prior to attending a scheduled focus group. Participants were required to confirm their consent at the beginning of the online survey by checking/ticking the box.

The survey was a later iteration of an earlier survey [54,60]. The 80-item survey covered eight domains: (1) Technology use; (2) Internet ownership and use; (3) Social networking; (4) Digital device ownership; (5) Purchasing patterns; (6) Quantified Self and lifelogging; (7) Information sharing and privacy issues; and (8) Demographics. A copy of the survey is available in the supplementary data.

Some survey items were amended to reflect minor differences in the British and Canadian English language. For example, in the UK, participants would be asked to "tick the box", whereas a Canadian participant would be asked to "check the box"; or a Canadian participant would use the term "gas", whereas a UK participant would say "petrol".

2.6.2. Focus Groups

Each site aimed to recruit 10 participants and potentially split into two groups of five or six people to ensure the fluidity of discussion, ease of transcribing, and that no one was over shadowed when describing their ICT experiences.

A total of six focus groups were conducted in both the UK and Canada. Sixteen participants were recruited in Canada. In the UK, a total of 21 participants were recruited. Two focus groups were conducted in an urban location (Milton Keynes, Buckinghamshire, UK) and two focus groups were conducted in rural locations (South Wales, UK), comprising of 20 participants residing in rural locations and 17 in the urban location. In Canada, two focus groups were conducted in a rural sites (McBride, BC, Canada), and one focus group was conducted in an urban site (Regina, SK, Canada).

A semi-structured approach was taken, and the questions focused on ICT use/ownership; rationale for using ICTs; social media habits and perceptions; privacy issues and concerns; sharing of information (e.g., why, how, type of content shared), from a traditional (pen/paper) and digital (mobile app/Facebook) standpoint; and what the future holds for ICT in society, health, and ageing populations.

Prior to the focus group discussions, all participants were shown vignettes, which comprised of negative and positive perspectives to using different technologies. The vignettes were developed by the Open University partner for a previously unrelated project and encompassed sketches/content relating to ICT use/experience in different contexts and environments. A full description of the vignettes shown to the participants prior to the focus group discussions commencing can be found at the following website (http://bit.ly/2XH5CFu). The vignettes were shown to the participants comprising of positive and negative perspectives of using different types of technology in different scenarios, yet familiar environments such as a health practitioner surgery, a home, and an office/social environment. The rationale for showing vignettes was to assist the participants in creating a basis for the discussion during the focus group sessions.

2.7. Data Collection and Analysis

Focus group discussions were digitally audio recorded for a minimum of 60 minutes and transcribed by an external company in the UK. A qualitative descriptive approach [61] was conducted, comprising of an investigator triangulation approach to analyzing the focus group data. Meanwhile, data analysis occurred via initial and focused coding and constant comparison, drawing from grounded theory guidelines by Charmaz [62]. For more information relating to data analysis, see the work of [26].

This approach resulted in a rich description of participant experiences. Ongoing peer checking was undertaken by research investigators to ensure the authenticity, credibility, and trustworthiness of the analysis [63–65]. An inductive approach was selected to generate new knowledge from the data [66] and a descriptive cross-sectional study approach was selected, as it is appropriate study design to more broadly describe participant demographics and experience from a quantitative perspective. Qualitative data were classified into categories as a way of describing the role and impact that technology plays in the lives of older adults [67]. Quantitative analysis used SPSS statistics version 24.

3. Results

3.1. Quantitative Data

Findings from the completed online surveys (n = 37) and focus groups will be presented in the following sections, providing insight into technology use by total population, country, and site.

Table 2 displays results focusing on participants use, access, and ownership of computers in their daily lives. The majority of participants owned a personal computer (PC) and the frequencies of participants across each country are nearly equal, but people are slightly more likely to own a PC in rural areas in the UK and in urban areas in Canada. Five participants did state they owned an Apple/Mac computer. The majority of participants accessed their computer in their own home, followed by seven participants located rurally in the UK reported to have accessed their friend's computer and one person living in the urban location. Similarly, six participants in the UK reported to have used a computer owned by an adult child, and a further eight participants reported to have accessed a computer in a public building. However, this was not the case by Canadian participants, who primarily reported exclusively to use their computer in their own home. Most participants have been using computers for over 20 years. This is particularly so for Canadian participants living in rural Canada. Frequency of using a computer showed that the majority of participants used their computer more than once a day, with relatively equal numbers across the UK, Canada, and all locations.

Table 2. Type of computer used, location of use, and length of time used a computer by country (UK and Canada) and location (rural and urban).

Computer Use, Access, and Ownership	**UK (n = 21)**		**Canada (n = 16)**		**Total**
	Rural (n = 10)	**Urban (n = 11)**	**Rural (n = 10)**	**Urban (n = 6)**	
Computer Ownership					
Apple/Mac	1	1	2	1	5
PC	8	5	6	5	24
Unknown	1	2	3	-	6
Other	-	3	-	-	3
Physical Location of accessing Technology					
Own home	9	10	9	6	34
Friend's house	7	1	-	-	8
Adult Child's house	5	1	-	-	6
Public Building	5	3	-	-	8
Length of using a computer					
More than 20 years	3	4	7	3	17
Between 10–19 years	4	3	1	3	11
Between 5–9 years	3	2	1	-	6
Less than 1 year	-	1	-	-	1
Frequency of using a computer					
More than once a day	6	6	6	5	23
About once a day	-	2	1	1	4
More than once a month	-	1	1	-	2
Less than once a month	-	-	1	-	1
More than once a week	4	1	-	-	5

There were several reasons why participants used a computer (Table 3), with the majority reporting email (n = 29), followed by checking facts on the Internet (n = 25), word processing (n = 24), and online shopping (n = 22). There were additional reasons why they used a computer ranging from online banking (n = 18) to using social media (n = 13), playing games (n = 10), and spreadsheets (n = 8), while 15 participants reported using a computer for 'other' reasons. However, participants did not elaborate on these other reasons. Checking facts on the Internet was more popular in Canada (13/16) than in the UK (12/21), and was especially low in rural UK (3/10). Online shopping was especially low in urban Canada (2/6) and highest in urban UK (8/11). Database and spreadsheet use was highest in urban UK (5/11) and non-existent in rural UK (0/10). Social networking on computers was higher in Canada (8/16) than in the UK (5/21) and this was further explored in Table 4, which shows that despite this, those that do use it in the UK are more likely to introduce others to it than those using it in Canada. Most people access it daily and have been using it for between 5 and 10 years' time. The most popular reason for using social media was to stay connected to friends and children/grandchildren (Table 5). Staying connected with children or grandchildren was slightly higher in rural locations than it was in urban locations in both the UK and Canada.

Table 3. Purpose for using a computer by country (UK and Canada) and location (rural and urban).

Purpose of Using a Computer	UK (*n* = 21)		Canada (*n* = 16)		Total
	Rural (*n* = 10)	Urban (*n* = 11)	Rural (*n* = 10)	Urban (*n* = 6)	
Email	6	10	7	6	29
Checking facts on the Internet	3	9	7	6	25
Drawing	-	1	-	1	2
Other	7	3	2	3	15
Word processing	7	8	5	4	24
Online shopping	6	8	6	2	22
Online banking	4	6	4	4	18
Social networking	2	3	4	4	13
Playing games	2	2	4	2	10
Database/Spreadsheets	0	5	2	1	8

Table 4. Social media use by country (UK and Canada) and location (rural and urban).

Use of Social Media	UK (*n* = 21)		Canada (*n* = 16)		Total
	Rural (*n* = 10)	Urban (*n* = 11)	Rural (*n* = 10)	Urban (*n* = 6)	
Do you use social media sites?					
Yes	0	5	4	4	13
No	10	6	6	2	24
Who introduced you to social media sites?					
Spouse/partner	-	-	1	-	1
Adult child	-	2	2	-	4
Friend	2	3	1	1	7
Relative	-	-	2	2	4
Other	-	-	-	1	1
Have you introduced anyone to social media?					
Yes	2	2	1	-	5
No	2	9	7	6	24
Years using social media sites:					
10 years	1	1	3	2	7
More than 5 years	3	3	1	1	8
More than 2 years	-	1	1	-	2
1 year or less	-	-	-	1	1
… <6 month or less	0	1	0	1	2
Frequency of using social media sites					
More than once a day	2	2	3	2	9
About once a day	1	1	1	1	4
More than once a month	-	1	1	-	2
Less than once a month	-	3	1	1	5
More than once a week	1	1	1	1	4
Social media to share information friends/family					
Yes	1	3	4	2	10
No	3	2	2	2	9

Table 5. Purpose for using social media (*n* = 37) by country (UK and Canada) and location (rural and urban).

Reasons for Using Social Media Platforms	UK (*n* = 21)		Canada (*n* = 16)		Total
	Rural (*n* = 10)	Urban (*n* = 11)	Rural (*n* = 10)	Urban (*n* = 11)	
Stay connected with friends	4	3	3	4	14
Stay connected Grandchildren/children	4	2	5	3	14
Share photographs with friends/family	2	4	4	2	12
Share information with friends/family	1	3	4	2	10
To keep up to date with news	4	2	1	1	8
To organize events	1	1	1	1	4
To take part in events	-	1	2	-	3
To express opinions	1	1	1	0	3

Participants across the UK and Canada reported owning a myriad of digital devices, with the majority owning a mobile phone, and in particular participants residing in the urban—UK location, with a very low number in the urban Canadian area (see Table 6). Yet, from a Canadian standpoint, the majority of participants residing in the rural location reported to own a mobile phone. Equal numbers of UK and Canadian participants reported to own an Apple iPad, coupled with participants residing in respective urban locations. Six Canadian participants equally split between rural and urban locations reported to own an Apple iPhone, while one participant residing in the rural location reported to own an Apple iPad. Owning a tablet device was more popular among UK participants residing in the urban location rather than rural and Canadian participants. Owning a Fitbit/pedometer was primarily reported by UK participants living in the urban location (*n* = 2), with a further one participant in the rural location noting their ownership. Overall in the UK urban areas, more devices were owned (25, showing an average of over 2 devices per person; compared with 18 from the 10 rural UK participants; 15 from the 10 rural Canadian participants; and 14 from the 11 urban Canadian participants).

Table 6. Digital devices owned (*n* = 37) by country (UK and Canada) and location (rural and urban)

Digital Devices Owned	UK (*n* = 21)		Canada (*n* = 16)		Total
	Rural (*n* = 10)	Urban (*n* = 11)	Rural (*n* = 10)	Urban (*n* = 11)	
Mobile/cell phone	8	10	6	2	26
Apple iPad	2	3	1	4	10
Apple iPhone	2	0	3	3	8
Samsung phone	0	3	1	1	5
LG phone	0	1	2	4	5
Kindle/e-Book	3	1	1	0	5
Tablet	1	4	1	0	6
FitBit/Pedometer	2	1	-	-	3
Other	0	2	-	-	2

Participants were asked if they shared their information (see Table 7). The majority of participants reported to share their information because of having common interests (*n* = 16), while 11 participants reported to share their information ‘because it is fun’. This rationale was primarily conducted by UK participants living rurally (*n* = 8), compared with none living in the urban area of the UK and only two in rural Canada and one in urban Canada. Sharing information to make sure the recipient is thinking of me was exclusively a UK and almost exclusively an urban UK reason. To increase friendship was noted by seven individuals, but notably not at all in rural Canada. To start or continue a conversation was largely a UK factor and in rural areas, with only one Canadian mentioning it.

Table 7. Self-logging activities by country (UK and Canada) and location (rural and urban)

Sharing Information	UK (*n* = 21)		Canada (*n* = 16)		Total
	Rural (*n* = 10)	Urban (*n* = 11)	Rural (*n* = 10)	Urban (*n* = 11)	
Common interests	4	5	3	4	16
Because it's fun	8	0	2	1	11
Inform people of my activities	1	1	2	4	8
To have other's opinions	2	3	1	2	8
To make sure the recipient is thinking of me	7	1	-	-	8
To increase communication in friendships	2	2	0	3	7
To start/continue a conversation	4	1	0	2	7
I like to share information	1	1	2	0	4
To feel better	2	1	-	-	3
Build my confidence	1	0	1	0	2
Other	0	1	2	0	3

Table 8 notes that friends and family in the UK (*n* = 9) are much more likely to self-log than those in Canada (*n* = 3), especially in urban areas. In addition, self-logging on smart phones is much more prevalent in the UK (*n* = 5) than in Canada (*n* = 1). Similarly, self-logging on the computer is also more prevalent in the UK (*n* = 5) than it is in Canada (*n* = 0). Those in the UK (*n* = 7) are also more likely to consider taking up self-logging than those in Canada (*n* = 1).

Table 8. Self-logging activities by country (UK and Canada) and location (rural and urban).

Self-Logging Activities	UK (*n* = 21)		Canada (*n* = 16)		Total
	Rural (*n* = 10)	Urban (*n* = 11)	Rural (*n* = 10)	Urban (*n* = 11)	
Friends or Family conduct self-logging activities?	6	3	3	0	12
Would you consider taking up self-logging?	5	2	0	1	8
Do you conduct self-logging on a Spreadsheet?	-	4	2	1	7
Do you conduct self-logging on a smart phone	3	2	0	1	6
Do you conduct self-logging on a PC?	-	5	-	-	5
Those self-loggers you know, do they share their data with you?	1	2	-	-	3
Do you conduct self-logging on a tablet?	1	1	-	-	2
Do you enjoy hearing this information	1	1	-	-	2
Do you conduct self-logging using traditional methods (pen/paper)?	-	-	1	0	1

Figure 1 illustrates the myriad of activities conducted and reported by our participants during the focus groups, detailing that our participants do have a wide variety of activities that integrate ICTs and technology into their daily lives.

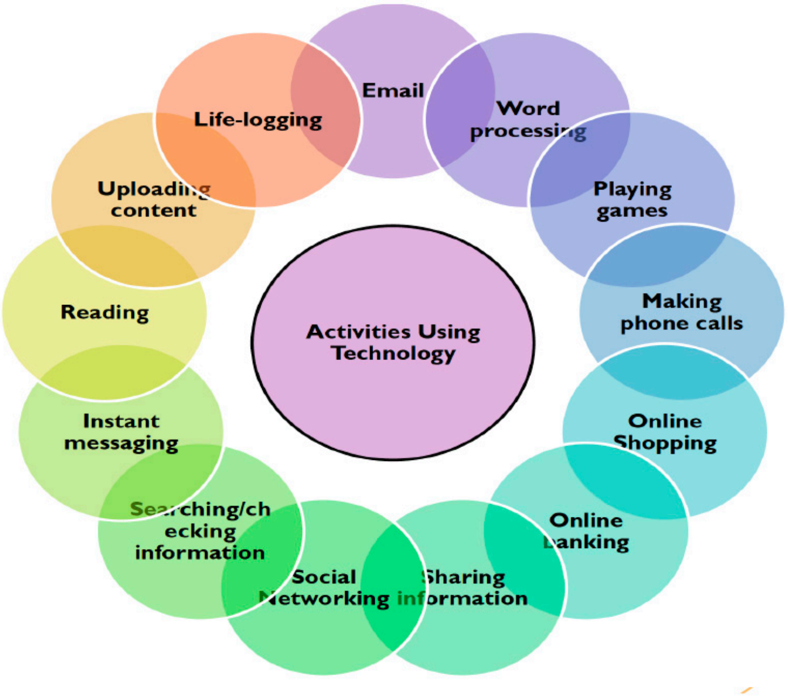

Figure 1. Participant reasons for using technology.

Data analysis of the qualitative data from the focus groups ascertained two primary themes: (1) facilitators of ICT use and (2) detractors to ICT use. Each primary theme had several associated subthemes (see Table 9).

Table 9. The facilitators and detractors of technology use.

Themes	
Primary Themes	**Subthemes**
Facilitators of technology use	• Technology learning opportunities • Having access to technology • Learning and sharing information • Feeling secure
Detractors to technology use	• Feeling apprehensive about technology • Lack of interest in technology use • Difficulty learning how to use technology

The first primary theme, facilitators of technology use, identifies the factors that contributed to the adoption and use of technology. The second primary theme, detractors of technology use, highlights factors that impeded or limited their use of technology. We describe each theme and its corresponding subthemes in detail below (Note: participants are denoted by location and participant number; MK refers to participants from Milton Keynes, R refers to participants from Regina, W refers to participants from Wales, and McB refers to participants from McBride).

3.2. *Facilitators of Technology Use*

Participants identified several facilitators that led them to adopt or continue to use technology in their daily lives, thus demonstrating that technology use can play a positive role for participants across all study sites. Facilitators included technology learning opportunities, having access to technology, learning and sharing information, and feeling secure.

3.2.1. Technology Learning Opportunities

For many participants, having the opportunity to learn how to use technology, whether in the workforce as an employee, or post-retirement in a structured learning environment, facilitated technology use. Having opportunities to learn within the workplace allowed for building skills in an environment where support was available if needed:

> *My first encounter with a computer is obviously in work, latterly in work, and always had the backup support within work as well. If anything went wrong there was always somebody that you could ring and get things out, so that's okay.*
>
> *[MK4, female]*

Some participants described positive experiences with classroom learning geared towards seniors that provided opportunities to learn how to use different devices:

> *I took […] classes … which I found to be very helpful. I think I've had the three iPad classes, so two iPhone classes and several computer classes, they offered years ago, and they were always very, very helpful.*
>
> *[R3, Female]*

Taking initiative to seek out learning opportunities helped to facilitate its use. A participant from Milton Keynes noted that she had not had the opportunity to learn to use a computer in the workplace, and thus took a certificate program to learn the basics:

> *… when computing was brought out and I was teaching, we never did that when we were kids or at school or training. I had to just bite the bullet and just get to it, otherwise I was going to be left behind, very much so. I did all the different things for this certificate, PowerPoint, database, spreadsheets, all the bits like that. You can figure it out. It's not too difficult if you really set to.*
>
> *[MK2, Female]*

3.2.2. Having Access to Technology

For many participants, simply having access to technology, particularly the Internet, served as a motive for its use. For example, when technology was portable, it was perceived as being more accessible than instances when individuals were tied to a desktop. A participant from the Canadian rural site, McBride, found technology to be much more useable once she had access to high speed Internet, something that was introduced in rural areas of Canada much later than in urban areas. She stated the following:

> *I just basically use [my laptop] as a nice portable machine that I can take with me and have lots of information and access to the internet. Because for the longest time I was on dialup and doing these daily emails until about a year and a half ago I could finally get a connection through the new cell tower they put in … so I am on high speed now. It's not really high, high, high speed like you would get in the city but it is like 500 times as fast as dialup was.*
>
> *[McB2, Female]*

With the combination of high-speed Internet access as well as a laptop, this participant found accessing the internet much easier in order to send emails and access information. Indeed, for some of these rural participants, high speed Internet was preferred such that they were willing to pay a higher cost to obtain it: *"And now we have bought an air card at great cost per month so that you are not sitting there for 10 minutes or whatever to get that dialup." [McB3, female]*

Although for some participants, laptops were the preferred means of accessing technology, for others, a desktop, with internet access, sufficed:

> *Yes. I've got a PC that I really like. It's like my right arm, wouldn't be without it. On it every day, twice a day, maybe three times a day, just to find out what emails have come in.*
>
> *[MK1, Female]*

3.2.3. Learning and Sharing Information

In addition to having access to technology in general and Internet use in particular, participants were motivated by a desire to find and share information. In particular, participants were motivated to use technology to find information related to health. A participant from Wales stated the following:

> *I do use the internet to search on health subjects. You can go on, as you say, I use that too, the Mayo Clinic and I use the sites, the National Institute of Health in the US. Well that's because that's what I am familiar with, you know, when I lived there. But I wouldn't go on to some of these forums that you were talking about. They are not very reliable, and they are just people expressing their views. You want evidence to support what is being said.*
>
> *[W3, Female]*

While participants used the Internet to find information, they recognized the need to be careful with regards to the types of information they were accessing and ensuring that the information was reliable. Wearable technology was also utilized as a means of gaining information about health as participants tracked their own health behaviours, such as levels of physical activity or medication use. Participants were interested in monitoring their physical activity levels through technology:

> *"Well, I personally wouldn't mind one of these, where can you get the Fitbit?...I would like to know how many steps I am doing a day so therefore what can I do to improve?"*
>
> *[W2, Female]*

In addition to gaining health information, participants wanted to use technology in order to communicate with others and share information. Participants across the focus groups detailed how they chose to communicate and engage with technology to keep up to date with friends and family. Using videoconferencing software such as Skype or having access to a computer in a public space enabled communication with children or grandchildren who were geographically dispersed. A participant in Milton Keynes spoke about keeping in touch with his daughter in another country by utilizing FaceTime:

> *I've used Skype because my daughter lives in South Africa, but it's an atrocious service because South African broadband is atrocious. We now use Apple FaceTime and that is far superior.*
>
> *[MK3, Male]*

Videoconference platforms enabled easier communication with loved ones at a time when it was convenient for both parties. For example, one participant felt Skype made conversing with loved ones much easier than using a landline:

> *I think it's far easier to use a Skype phone. I just use it because you are always going to be sitting there, waiting for the other person on the other end. And if you have just got a phone, you know ring them up, okay, if they're not answering, they're not answering, end of story sort of thing. Go back later.*
>
> *[W7, Male]*

In addition to videoconference platforms, social media such as Facebook or communication platforms such as Viber enabled participants to communicate through text message and share photographs and videos:

On my phone I use Viber, which is another … Actually, it runs off data; it doesn't run off your ordinary phone. That's very good; that's instant messaging and photographs, pictures, all sorts.

[MK4, Male]

These platforms enabled participants to share their social activities and remain connected. In some cases, participant chose not to share their own information, but enjoyed learning about others:

"Facebook see what's going on, for the gossip. You don't have to participate; you can just be nosey".

[W1, Female]

Technology was valued among participants as a means of learning information that was relevant to them and as a way of communicating with family and friends. Perceiving it as useful for learning and sharing information served as a facilitator for engaging with technology among our participants.

3.2.4. Feeling Secure

In addition to learning and sharing information, some participants felt that technology use offered a sense of security. In many cases, adult children who were concerned about the safety of their parents encouraged its use. Participants reported that adult children were concerned about driving long distances. For example, a participant from McBride stated the following:

I got the cell phone because my kids kept thinking something was going to happen to me. I said, "Well you know if I have a breakdown on the highway, we managed for 70 years for God's sake by just stopping someone and they'd help you. But now, "Oh my God they could murder you." So, this was supposed to be a safety element to keep peace in the family.

[McB1, Female]

While some participants adopted technology for safety when driving long distances, others did so in case of a health emergency:

Oh, well, it was the bright idea of my son. I had a mini stroke. Oh, how old was I? 81, I think. I didn't really know that I'd had one. My daughter was the one who took me into hospital and said, "You've got to be tested." It did turn out that I did have a clot up behind my left ear somewhere, which affects this side of my face and my hand. Ever since, but they're always frightened, my kids now, of a recurrence. So, my son gave me a cell phone, his old one, which I used right away, or more or less. About two years after I had the stroke, I think, they decided that I should have one, because I did get a few [brief] dizzy spells, but that was only the reason. So, now I just use it.

[McB2, Female]

While originally motivated by health reasons and at the encouragement of her children, this participant adopted the technology for use in everyday life. In addition to mobile phone use for safety, some participants considered the usefulness of assistive devices. Wearable technology such as Lifesavers were considered as options if needed. A participant in Wales stated the following:

"Yes, but there are a lot of people out there who actually use these Lifesavers."

[W3, female]

An additional participant in Wales spoke about the use of sensors to monitor movement:

Or mats beside their bed, or mats in front, by the front door, in case they get out of bed and they shouldn't. Or if they are by the front door and they shouldn't be going out. So, there's all that technology and not just the computer and the internet.

[W4, Female]

While these types of technology were not currently being used by the participants, there was awareness that additional options for feeling secure could be available to them if needed.

When participants had easy access to technology, particularly the Internet, and felt that had some skill or understanding with regard to how to use technology, its use was feasible among our participants. They were largely interested in using technology to better understand their own health, and to maintain contact with friends and family. Further, feelings of safety and security served as a final facilitator of technology use.

3.3. Detractors of Technology Use

Participants also identified several detractors of technology use. They did not embrace all aspects of technology and identified several concerns. In particular, participants felt apprehensive about technology, lacked interest in technology, and found it difficult to learn how to use technology.

Feeling Apprehensive about Technology

Participants reported feeling apprehensive about using technology. A lack of understanding of how some technologies worked or how to use technology limited its use among our participants. For example, they expressed concern about being pressured to use technology that they did not feel comfortable with. One participant expressed fear at the rate that technology changed and her ability to keep up with it:

> *I think the scary part now, isn't it, everything is moving very fast in the IT world really? I do think that is an issue. Sometimes you just look in horror at the way that it's moving. In a sense, you keep thinking, "I've got to keep up." Some of it is way, way beyond anything that we would ever ... yes, it's just incredible, absolutely incredible. I find that quite exciting in some ways but staggering and frightening in other ways.*
>
> *[MK4, female]*

While the general pace of development was overwhelming for participants, they also provided specific examples of instances where older adults were required to use technology they may not be comfortable with. Participants described being required to order prescriptions online rather than through the telephone, which they were accustomed to doing. One participant exclaimed,

> *People are being quite inextricably pushed towards using the internet. I mean I turned up at the doctors, only to pick up a prescription, which was unusual. And there was a notice up saying, "On December 1st ... " And I had always ordered prescriptions ... through the prescription line. That was changing from December 1st ... In actual fact you had to turn over because there was no longer a telephone prescription line.*
>
> *[W5, Female]*

Later in the conversation, the same participant expressed her concerns with forcing people to use technology they may not be comfortable with. With removal of the telephone prescription line, some older adults may be forced to go to their physician's office in person, which may be difficult for them:

> *In actual fact, what you are actually going to do is, you are going to handicap the less mobile, older people, who maybe might need a taxi or a bus and walk. Because there's no bus right outside our surgery, and that's not just our surgery, there are a lot. It is penalising people who are not able to use the internet.*
>
> *[W6, Female]*

While using technology in new ways caused apprehension among participants, they also felt uncomfortable when pressured to upgrade their current technology. A participant in Regina felt pressure from her adult children to adopt more recent technology despite her satisfaction with her current capabilities:

> *I have a cell phone, but I don't text because the one I had that I bought six years ago has a, b, c, like. So, I am going to get a new one this year because after lots of pressure from my children, "Oh come on mum," so I have a nice programme right that's just phoning and it's about $240 a year. I mean that's 20 bucks a month without texting so that's pretty good. I can still take pictures with it too.*
>
> *[R2, Female]*

Participants also reported feeling apprehensive regarding asking for help for using technology because of barriers with regards to experience and language use:

> *I went to some store and they made you feel like you're stupid. They will not answer your questions and you don't really know what to ask but you try to ask something, and they say . . . .*
>
> *[R1, Female]*

In addition, some participants were apprehensive about using social media platforms. Many participants wanted to maintain their privacy and were reluctant to use these platforms:

> *I've got a Facebook account, but I don't use it, because too much privacy and my wife has got thousands of friends who tell them that "Yes, I've had a cup of tea. I've eaten my sandwich." The whole world lives like that.*
>
> *[MK3 Male]*

Negative experiences with social media owing to lack of understanding of how it worked led to increased feelings of apprehension and, in turn, avoidance of these platforms:

> *Facebook, I went onto for a short period, but, like a complete wally, I didn't realise that unless you set up the privacy settings properly, everything you say is broadcast to the world. I fell out with my daughter quite badly over something [. . .] "Right, I'm coming off that," because there was so much garbage coming on.*
>
> *[MK4, Male]*

Because of this apprehension, some participants took care to avoid sharing much detail about themselves when they did use social media:

> *I do use Facebook because I've got a lot of friends who send me messages and say, "Like," or, "Don't like," and small comments, but I never give any information about myself—I mean detailed information.*
>
> *[MK2, Male]*

Similarly, a participant in McBride noted that while she enjoyed reading about others on Facebook, she avoided posting any information about herself because of concerns about privacy:

> *Yes. I think about it and I am very careful about opening things because you can get a virus or whatever. I try to be very careful and yes, I am concerned about privacy. That is one reason I do not, very seldom will I answer on Facebook. I read what goes on, but I do not participate because of privacy.*
>
> *[McB1, female]*

In addition to being apprehensive about social media use, participants reported apprehension about privacy and information sharing in terms of banking:

> *Well you have to be very careful with your banking. I do my banking online which I find very, very convenient. But I am always kind of concerned about that, but I think, "Well there's so little in there that who'd be interested anyway." So, I feel I am pretty safe.*
>
> *[McB1, female]*

Media reports of Internet scams also lent themselves to feelings of apprehension with regard to technology use. One participant talked about recent media reports and how they may affect older adults:

> *I think it is interesting, and I think for older people when they hear so many different things, particularly about this week and some other banks—there were 900 scams in the last week in Santander, 900. That makes you panic, doesn't it? I think for older people, I think IT is so important for them and yet they hear so many of the negatives, which are frightening for them. It's that balance, isn't it, of the two things of helping them to say, "Yes, if you do this, you're okay, but there is this danger really"?*
>
> *[MK4, female]*

A range of concerns were identified that led to feelings of apprehension among participants of this study, which impacted the degree to which they embraced technology in their day to day lives.

3.4. Lack of Interest in Technology Use

While in some cases, feelings of apprehension acted as deterrents of technology use, in other cases, there was a lack of interest in learning about or using technology. Again, social media arose as an example of a use of technology in which some participants lacked interest. A participant from Regina spoke about using email, but avoiding social media:

> *I'm not involved in any of that social media, I find the email keeps me more than busy. I'm always getting people to want me to be on Facebook or whatever but there's no way I have time for that.*
>
> *[R1, Female]*

In some cases, in person, face-to-face communication was preferred over social media use, further highlighting a lack of interest in social media use:

> *[...] I do not do Facebook. I decided a few years back I just didn't want to spend any more time on the computer. I see social networks as being getting together with people like this and talking over a table more so than on Facebook. I find it too impersonal and that might just be my old-fashioned ways, but I would much rather talk to people face to face rather than on the computer.*
>
> *[McB1, Male]*

Participants viewed technology use as anti-social, despite the opportunities it provided for keeping in touch with loved ones. As such, they had little interest in engaging with it.

One participant noted that, when riding the bus, she was surrounded by people using their devices:

> *I'm sitting on the bus; every single person on that bus is doing this—every single person. They have forgotten how to communicate one with another. Communication verbally.*
>
> *[MK6, female]*

This participant further lamented that a focus on devices minimized opportunities for face-to-face communication or conversation, and often its use was observed in inappropriate places:

> *I think mobile phones are an [expletive], antisocial, because no matter where you go you've got people doing this, doing this. Even in front of me, a woman in front of me in Milton Keynes Theatre the other week had her mobile phone on, and I had to tap her on the shoulder and tell her to turn it off.*
>
> *[MK6, Female]*

Similarly, participants did not always perceive wearable technology to be useful or of interest. A participant from Milton Keynes tried using a pedometer to keep track of physical activity, but soon lost interest: "I got fed up with it ... According to what I was walking and doing, yes, you're okay, but that was as much as it did." [MK3, male]

Overall, some participants were not interested in technology until it was deemed to be of value. Social media, non-face-to-face communication, and fitness trackers did not provide tangible benefits versus the investments required to use them.

Difficulty Learning how to Use Technology

Learning how to use a new piece of technology or software can be difficult for anyone, and across our focus groups, our participants talked about the challenges they faced in learning how to use technology. For example, for some participants, switching between platforms was difficult and represented a significant learning curve.

> *But I think the problem comes that there is nobody teaching people, and what to use, because I changed to Apple last year because my wife bought it for my birthday and that took me a learning curve. I think if somebody had never seen the technology, you're lost. You get problems, like [when] my laptop went to Windows 10 that clashes with Norton's, the utility software, so you have to take Norton's off.*
>
> *[MK3, Male]*

Furthermore, language or terminology posed a notable barrier to learning and understanding how to use technology. Clarifying the difficulty in terminology one participant commented,

> *[...] it is really important to realise that older people in particular I think, and I hate to be ageist, but it is a different language that we didn't learn in school. And anyone under 30 or 35 learned those terms and we don't know.*
>
> *[McB2, Female]*

Learning how to use peripheral devices such as a USB (Universal Serial Bus, a computer port which used to connect external equipment to a computer). An was also a concern. For example, one participant wanted to back-up photographs, using a USB stick, with additional memory, because,

> *My computer needs to be replaced and I've got to figure out a way to get all the pictures off of it and put them on disc so that I can get a new computer. So that's my next thing that I have to do. I have a lot of pictures; I think they're on my iPad now. I took them off my phone, they're on my iPad and I have to connect the iPad to the computer and put more pictures on the computer before I get rid of them, before I put them on disc, so I have to do that. One thing I can't do is put pictures; I haven't learnt how to put pictures on a memory stick. That would be helpful I think [...] I can put them on a memory stick, but I don't know how to do that.*
>
> *[R3, Female]*

Moreover, one participant adopted a trial and error approach to learning to use technology, which enabled them to read an e-Book. Trial and error was preferred because asking children or grandchildren for assistance is not always easy. The terminology used by younger generations was unfamiliar to the participants. Further, the speed at which the instructions or demonstrations are delivered also caused the respective participant additional problems. The learning process unfolded like this,

> *I learned how to download books and I am really enjoying that as I go to bed at night and read, I thought, "I'm not going to like this to hold instead of a book." But I find it is really, really great. And I am using that a lot. I am having some difficulty, I have to learn; well I am always learning, always learning but I have to do it trial and error because when I ask the grandchildren to show me something, they go so damn fast you can't remember or follow what instructions they give you anyway.*
>
> *[MK1, female]*

One participant reported that she had to ask for assistance at an Apple store to gain access to her email account. The respective quote illustrates how non-technical users may become confused with terminology. Yet, asking for assistance from younger generations who (in some instances) may have grown up with technology and may find it difficult to relate on a personal level and communicate using terminology that would be understood and what can be accessed by different platforms:

> *I've got Apple... I took my iPad; I've got it with me. I took it all the way up to Apple because I wanted to get back into Google account. He couldn't do it. I can't understand why. Google is in America. Why do they not have somebody that talks to you? You have all these little bits of messages on the thing, like I was trying to do . . . .I went to the Apple store and saw a man. In the end, he set me up an iCloud account with Google, but I want to get back onto emails; I want to get . . . I've got a new Google thing, but I can't get in because it keeps saying, "Password is wrong, account is wrong," and I'm, "Argh." (Laughter).*
>
> *[MK5, female]*

While participants actively engaged with technology in a variety of ways, they also identified several factors that limited their use. Feeling uncertain about how to use technology, lacking interest in particular aspects of technology, as well as difficult learning how to use technology and understanding the language all detracted from further engagement with technology among our participants.

4. Discussion

This paper has presented findings from the Technology In Later Life (TILL) project—an international, multi-centered study, focusing on the use, behavior, and impact of technology by older adults residing in rural and metropolitan locations across two countries.

Quantitative data revealed a myriad of reasons (Figure 1) why adults aged ≥70 years adopt and engage technology into their lives, whether they are living in a rural or urban geographic location. Overall, over half of participants owned a mobile phone, though many more owned one in the UK (n = 18) than in Canada (n = 8), with just under ome-third owning an Apple iPad, while very few only used and owned a device to self-monitor or track one's activity (e.g., Fitbit or pedometer). Canadian participants used social media more than UK participants. Those in rural locations of both UK and Canada use social media more than those in urban areas to stay connected with grandchildren or children.

Qualitative data analysis identified two primary themes: (1) facilitators of technology use, and (2) detractors of technology use; with seven subthemes, surrounding learning, access, sharing of information, positive and negative emotional wellbeing, justification of technology use, and competency of technology skills. While some participants spoke about their use and engagement with technology, initially through the workplace, for other respondents, this was not the case, and for some it was through intergenerational relationships with family members.

Participants perceive the Internet positively, especially those residing in a rural location; however, some participants did not see the point in social media platforms, and thus did not have a profile/account. This perspective was justified because there are more interesting things to do with their time, such as talking to people face-to-face, or the essence that social media can enable people to share information (i.e., photographs) without one's permission.

While some participants chose to track or self-log, these participants enjoyed knowing how many steps they had walked per day, they did not always understand how to use the technology or how to access information on how to use the technology. For example, one participant was unsure what the 'heart' icon was used for on their mobile phone. Yet, the same participant noted their medication was logged. This suggests that the barrier to using mobile apps (mApp) is not necessarily a dislike for their use, but rather a lack of knowledge on 'how' to use the app. With improved access to information on the benefits of and instructions for use of an app, uptake by older adults may be increased. This is not to state that participants did not own devices; participants noted they owned many devices (see Table 6), with a mobile/cell phone been the most popular type and the least owned devices being a Fitbit/pedometer.

Despite identifying the facilitators of technology use, the factors that limited or discouraged them from using technology were also identified. In many cases, participants explained a simple lack of interest in technology use. In general, participants reported feeling apprehensive about the rate of technological change and some felt they had difficulty keeping up. Concerns about sharing too much information and the potential to be an invasion of privacy also lent itself to feelings of apprehension; especially if one did not realise that privacy settings were needed to ensure all information shared was kept between friends.

Privacy issues relating to older adults and their use of social media and technology have been understudied, yet across existing literature, we are starting to see how social media can play a positive element in life to maintain relationships with others [68,69]. However, this may not always be the case, as demonstrated by some participants in this study who chose not to use social media because it caused upset within families and friendship circles. Additionally, Table 4—Sharing Information illustrates the knowledge and experiences of study participants relating to self-logging, whether their friends or family members share data with them, and how often information is shared. Overall, many of the UK rural and urban participants reported to enjoy receiving this information.

Participants discussed how the use of technology may actually have a negative impact on society, resulting in an increase of social isolation. Furthermore, some participants perceived the use of technology was anti-social. In existing literature, researchers have been proposing the use of technology as a means of reducing isolation and enhancing social connectedness [25,70–73]. However, this was not the case for participants living in Milton Keynes—an urban area. In contrast, a participant from McBride, a rural location, discussed how she did not communicate with her family members as often as those who were using social media.

Enhancing social inclusion is integral to promoting positive ageing in place and reducing social isolation in later life. The findings from the TILL project show a positive trend towards age in place. For example, ensuring sound Internet services, provision, and infrastructure coupled with ICTs and associated technologies, such as social media platforms (i.e., Facebook), can facilitate individuals to share health-related information. Moreover, older adults have the opportunity to share photographs and narratives through different mediums (social media—Facebook), WhatsApp or mobile apps (mApps), which in turn may reduce social isolation. However, as evidenced here in the findings, our participants showed a mixed response to ICTs within their lives, owing to privacy concerns, interaction, learning new information, and jargon. To increase numbers of older adults who use technology in later life, in addition to making technology available, attention must be placed on developing age-appropriate education on strategies to use existing and new technologies. Participants in this study saw the benefits to using ICTs and digital devices; being able to share information; search for information; appeasing safety concerns of their children; and communicating with friends, children, and grandchildren. Therefore, ICTs can enable enhanced social inclusion and interaction, which in turn strengthens individuals, families, and communities [3].

Those participants in rural locations of both the UK and Canada use social media more than those in urban areas to stay connected with grandchildren or children. While participants explained, during the focus groups, concerns over privacy in social media; overall, all participants responded positively to hearing shared news and information from friends' families, and nearly half of the participants had been using social media platforms such as Facebook for at least five years or more. Thus, this ability to stay digitally connected with friends, grandchildren, or children offers an additional means of communication. We can assume, based on previous research [10], those participants living in rural locations have less opportunity to regularly meet family members than those who live in metropolitan areas. This is particularly so for those family members who are geographically dispersed. Furthermore, while this work contributes to existing scholarly activity, it is also distinctive because of the study design and nature of the TILL study, and given the mere fact that social isolation and loneliness are key topics within the UK government; who has appointed Tracey Couch to the position of Minister for loneliness [74]. While it is beyond the scope of this paper, loneliness can and does play an integral role in ageing populations and could be exacerbated more so in rural locations than metropolitan. However, it should be noted that a person could still live in a metropolitan area and be lonely.

Primarily, participants in this study use technology in later life to communicate with family, in particular their adult children and grandchildren. Participants perceived technology as a digital 'gathering place', and technology is especially important when their family members are living in different geographic locations—be it overseas or in different parts of the country. Almost all participants in the urban sites used their computer for email, followed closely by using the internet to check facts, though this was much more common in urban areas of the UK and least common in rural areas of the UK. Social media/networking was mainly used in urban Canada and urban UK, with no rural participants in the UK and only 4 out of 10 in rural Canada using it. Given how technology was perceived by adults aged over 70 years, a range of purposes were identified for primary use, including reducing social isolation, safety reasons, sharing information, and undertaking tasks for community groups; one of the key differences between rural and urban participants was the rationale for owning a mobile/cell phone. Participants living in rural communities in both the UK and Canada used this type of technology for safety (when travelling to the city), while urban participants in both countries were more concerned about their privacy of data. Social media/networking is also one area where there is room for growth in connecting friends and family; the use of personal fitness trackers to enhance leisure, competitive virtual gaming (e.g., collecting digital badges or competing against friends in distances walked), and continued group sharing of information/communication [75] can all reduce social isolation.

While the TILL project follows similar and ongoing narratives in contemporary research, it is a distinctive initial study because of the study design—aims and objects, and focusing on a population of society that has garnered little attention from scholars. Yet, it is building on existing research [10,28,31–33,35,36,39,41,42,44,54,76]. On the basis of the findings of the work presented in this paper, we propose several recommendations aimed at policy makers, local and national organizations, stakeholders, and academics.

4.1. Recommendations

(1) Researchers, stakeholders, governments, and industry should focus on the strengths and opportunities, as opposed to focusing on simply overcoming the negative perceptions, attitudes, and barriers that ICT and associated technologies can bring to older adults, communities, and society. For example, the phenomenal development of mHealth Apps, which have enabled users to self-monitor their health and fitness [77]. While researchers and industry should demonstrate to individuals how such apps can enhance one's life, rather than taking a deficit approach, how they plug a gap, would be appropriate given the narratives the older people gave in the focus groups;

(2) Training and education opportunities (age appropriate) should include peer-to-peer learning and support and support from peers, sharing information on mHealth Apps/mApps and Internet sites they use and why is often how using ICT is maintained among this age group. Having such support readily available in locations where computers can be shared, such as libraries or cafes, or where mobile phones can be looked at in comfort and safety are crucial;

(3) Create online support including both practical and emotional support by peers to include different terminologies, needs, and requirements;

(4) Employees across society who are working in computer shops or General Practitioner (GP) or primary care surgeries should consider how barriers or detractors to understanding technology specific language or technical jargon may impact the older adult's abilities to engage with technology. Thus, integrating awareness training across varying environments should be

considered as a government policy initiative, similar to existing awareness training conducted in employment. However, it is likely that a one-size-fits-all will not be suitable, and extensive consultation would be needed.

For further research to explore these findings in wider contexts, we suggest the following:

(1) Engage with different age cohorts to ascertain ICT and technology use, behaviour, and perception for future populations;
(2) Explore how intergenerational relationships work with older populations adopting and engaging with ICT across different regions/provinces and countries (Reference redacted for reviewing);
(3) Government agencies need to collect more detailed information on ICT use and ownership across all age cohorts, and not simply group all persons aged 65 years and older into the same age cohort. New questions may be added to existing surveys to reflect ICT and technological advances such as smart phones and mobile apps, and wearable health technologies to support age in place.
(4) Explore how ICT and associated technologies can facilitate positive age in place across the UK, Canada, and wider afield.

While we have proposed these recommendations, the TILL study does have limitations, yet we have identified areas for future work to grow and add new discussions to this work.

4.2. Limitations, Strengths, and Future Work

Several limitations should be considered regarding the TILL study. Each study site aimed to recruit 10 participants; however, the region of Regina was unable to recruit the full participant sample, and this may have been related to the recruitment processes allowed at that University. While this study took a geographic location approach, there is the limitation of not exploring ethnicity and gender, which may have also yielded further insights and perceptions. Future work should explore these factors regarding the digital divide, and technology adoption, building on the work of [17,18]. Although the sample size is small, the findings show a myriad of facilitators and detractors encountered and experienced by the respective participants.

The authors believe this is the first piece of work that has been conducted and culminates in this distinctive approach to data collection. Thus, the strengths and significance of this work not only contribute to furthering the discourse and debate surrounding technology use in later life in fields of gerontology, social sciences, and gerontechnology, but also has the capability of contributing to the field of public health. Given the national agenda and importance set by the UK government, loneliness can impact and carry associated health benefits to existing and future ageing populations.

Future work should include a lager sample size, with diverse populations including participants from indigenous populations, minority, and ethnic communities in addition to gender analysis. Encompassing additional locations from across the two countries would also provide a greater insight into the perception of ICTs in the lives of older adults, while also considering extending the sites to encompass countries from other geographic regions may provide different perspectives and insights. Furthermore, though we have offered several recommendations aimed at the non-academic community, we believe charities, stakeholders, policy makers, healthcare practitioners, and administrators should be aware of the issues facing ageing populations. Future work could explore the perceived perceptions encountered by patients and ICTs by employees, while also exploring the perception of ICTs within different settings (i.e., primary and secondary healthcare facilities) by staff.

5. Conclusions

On the basis of the study design of the Technology In Later Life (TILL) study, the findings intersect at the fields of gerontology, geography, and gerontechnology. In particular, the authors have identified the barriers and challenges to using and adopting ICTs by adults aged 65+ years and over living in different geographic locations. The findings are distinctive based on the participants' perceptions of

ICTs and use of associated technologies, in a bid to provide older adults with different opportunities to ensure social connectedness and sharing of information, and to complement one's hobbies and interests. The authors have proposed a series of recommendations aimed at widening this research to encompass wider stakeholders, policy makers, support networks (i.e., carers), and health practitioners; in a bid to ensure digital solutions are accessible for all in society and to facilitate positive age in place. Conducting this study in the UK and Canada has provided significant depth to understanding the milieu of the recruited participants in the Technology In Later Life (TILL) project, and offers future studies the opportunity to learn and build upon the findings and proposed recommendations presented here, which in turn offer a significant contribution to several scholarly fields.

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References

1. Berry, R. Older People and the Internet: Towards a 'System Map' of Digital Exclusion. ILC-UK. Available online: http://www.ilcuk.org.uk/index.php/publications/publication_details/older_people_and_the_internet (accessed on 1 June 2011).
2. D'alessandro, D.M.; Dosa, N.P. Empowering children and families with information technology. *Arch. Pediatrics Adolesc. Med.* **2001**, *155*, 1131–1136. [CrossRef]
3. Katz, J.E.; Rice, R.E.; Aspden, P. The Internet, 1995–2000 Access, civic involvement, and social interaction. *Am. Behav. Sci.* **2001**, *45*, 405–419. [CrossRef]
4. Gunkel, D.J. Second thoughts: Toward a critique of the digital divide. *New Media Soc.* **2003**, *5*, 499–522. [CrossRef]
5. Rogers, E.M. *Diffusion of Innovations*; Simon and Schuster: New York, NY, USA, 2010.
6. DiMaggio, P.; Hargittai, E. *From the 'Digital Divide' to 'Digital Inequality': Studying Internet Use as Penetration Increases*; Center for Arts and Cultural Policy Studies, Woodrow Wilson School, Princeton University: Princeton, NJ, USA, 2010.
7. Selwyn, N. Reconsidering political and popular understandings of the digital divide. *New Media Soc.* **2004**, *6*, 341–362. [CrossRef]
8. van Dijk, J.A. Digital divide research, achievements and shortcomings. *Poetics* **2006**, *34*, 221–235. [CrossRef]
9. Barzilai-Nahon, K. Gaps and bits: Conceptualizing measurements for digital divide/s. *Inf. Soc.* **2006**, *22*, 269–278. [CrossRef]
10. Rooksby, E.; Weckert, J.; Lucas, R. The Rural Digital Divide. *Rural Soc.* **2002**, *12*, 197–210. [CrossRef]
11. Compaine, B.M. *The Digital Divide: Facing a Crisis or Creating a Myth?* MIT Press: Cambridge, MA, USA, 2001; ISBN 0262531933.
12. Leigh, A.; Atkinson, R.D. *Clear Thinking on the Digital Divide*; Progressive Policy Institute: Washington, DC, USA, 2001.
13. Arrison, S. What digital divide? *Tech News*. 13 March 2002. Available online: https://www.cnet.com/news/what-digital-divide/ (accessed on 3 July 2019).

14. DiMaggio, P.; Hargittai, E.; Celeste, C.; Shafer, S. From unequal access to differentiated use: A literature review and agenda for research on digital inequality. *Soc. Inequal.* **2004**, *1*, 355–400.
15. Basu, P.; Chakraborty, J. New technologies, old divides: Linking internet access to social and locational characteristics of US farms. *GeoJournal* **2011**, *76*, 469–481. [CrossRef]
16. Loges, W.E.; Jung, J.Y. Exploring the digital divide: Internet connectedness and age. *Commun. Res.* **2001**, *28*, 536–562. [CrossRef]
17. Dutton, W.; Sweet, P.L.; Rogers, E.M. Socio-economic status and the diffusion of personal computing in the United States. *Soc. Sci. Comput. Rev.* **1989**, *7*, 259–271. [CrossRef]
18. Losh, S.C. Gender, educational, and occupational digital gaps 1983–2002. *Soc. Sci. Comput. Rev.* **2004**, *22*, 152–166. [CrossRef]
19. Hoffman, D.L.; Novak, T.P.; Schlosser, A. The evolution of the digital divide: How gaps in Internet access may impact electronic commerce. *J. Comput. Mediat. Commun.* **2000**, *5*, 3. [CrossRef]
20. Hindman, D.B. The rural-urban digital divide. *J. Mass Commun. Q.* **2000**, *77*, 549–560. [CrossRef]
21. Berry, C.; Berry, R. Ideas, interests and information. *Public Policy Res.* **2006**, *13*, 119–125. [CrossRef]
22. Dutton, W.H.; Gillet, S.E.; McKnight, W.; Peltu, M. Briding broadband Internet divides: Reconfiguring access to enhance communicative power. *J. Inf. Technol.* **2004**, *19*, 28–38. [CrossRef]
23. Mun-cho, K.; Jong-Kil, K. Digital divide: Conceptual discussions and prospect. In *The Human Society and the Internet: Internet Related Socio-Economic Issues, Proceedings of the First International Conference, Seoul, Korea, 4–6 July 2001*; Kim, W., Ling, T.W., Lee, Y.J., Park, S.S., Eds.; Springer: New York, NY, USA, 2001.
24. Aqili, S.; Moghaddam, A. Bridging the digital divide: The role of librarians and information professionals in the third millennium. *Electron. Libr.* **2008**, *26*, 226–237. [CrossRef]
25. Barbosa Neves, B.; Franz, R.; Judges, R.; Beermann, C.; Baecker, R. Can Digital Technology Enhance Social Connectedness Among Older Adults? A Feasibility Study. *J. Appl. Gerontol.* **2019**, *28*, 49–72. [CrossRef]
26. Genoe, R.; Kulczycki, C.; Marston, H.; Freeman, S.; Musselwhite, C.; Rutherford, H. E-leisure and older adults: Findings from an international exploratory study. *Ther. Recreat. J.* **2018**, *52*, 1–18. [CrossRef]
27. Neves, B.B.; Amaro, F.; Fonseca, J.R. Coming of (Old) Age in the Digital Age: ICT Usage and Non-Usage among Older Adults. *Soc. Res. Online* **2013**, *18*, 1–14. [CrossRef]
28. Neves, B.B.; Franz, R.L.; Munteanu, C.; Baecker, R. Adoption and feasibility of a communication app to enhance social connectedness amongst frail institutionalized oldest old: An embedded case study. *Inf. Commun. Soc.* **2018**, *21*, 1681–1699. [CrossRef]
29. Ofcom. Adults' Media Use and Attitudes. 2017. Available online: https://www.ofcom.org.uk/__data/assets/pdf_file/0020/102755/adults-media-use-attitudes-2017.pdf (accessed on 2 July 2019).
30. Zickuhr, K. *Generations 2010*; Pew Internet and American Life Project; Pew Research Center: Washington, DC, USA, 2010.
31. Zickuhr, K.; Madden, M. *For the First Time, Half of Adults Ages 65 and Older Are Online*; PEW Internet American Life Project; Pew Research Center: Washington, DC, USA, 2012.
32. Anderson, M.; Perrin, A. Tech Adoption Climbs among Older Adults. Pew Research Center, 2017. Available online: http://www.pewinternet.org/2017/05/17/tech-adoption-climbs-among-older-adults/ (accessed on 2 July 2019).
33. Beacker, R.; Sellen, K.; Crosskey, S.; Boscart, V.; Barbosa Neves, B. Technology to Reduce Social Isolation and Loneliness. In Proceedings of the 16th international ACM SIGACCESS conference on Computers & accessibility-ASSETS '14, Rochester, NY, USA, 22 October 2014; pp. 27–34.
34. Damodaran, L.; Gilbertson, T.; Olphert, W.; Sandhu, J. Digital Inclusion—The Vision, the Challenges and the Way Forward. *Int. J. Adv. Internet Tehnol.* **2015**, *8*, 78–92. [CrossRef]
35. Damodaran, L.; Olphert, W. *How Are Attitudes and Behaviours to the Ageing Process Changing in Light of New Media and New Technology? How Might These Continue to Evolve by 2025 and 2040?* Future of an ageing population: Evidence review; Government Office of Science: London, UK, 2015.
36. Sims, T.; Reed, A.E.; Carr, D.C. Information and Communication Technology Use Is Related to Higher Well-Being among the Oldest-Old. *J. Gerontol. Ser. B Psychol. Sci. Soc. Sci.* **2017**, *72*, 761–770. [CrossRef] [PubMed]
37. Mitzner, T.L.; Boron, J.B.; Fausset, C.B.; Adamas, A.E.; Charness, N.; Czaja, S.J.; Dijkstra, K.; Fisk, A.D.; Rogers, W.A.; Sharit, J. Older Adults Talk Technology: Technology Usage and Attitudes. *Comput. Hum. Behav.* **2010**, *1*, 1710–1721. [CrossRef] [PubMed]

38. Yu, R.P.; Ellison, N.B.; McCammon, R.J.; Langa, K.M. Mapping the two levels of the digital divide: Internet access and social network site adoption among older adults in the USA. *Inf. Commun. Soc.* **2016**, *19*, 1445–1464. [CrossRef]
39. Ihm, J.; Hsieh, Y. The implications of information and communication technology use for the social well-being of older adults. *Inf. Commun. Soc.* **2015**, *18*, 1123–1148. [CrossRef]
40. Barnard, Y.; Bradley, M.D.; Hodson, F.; Lloyd, A.D. Learning to use new technologies by older adults: Perceived difficulties, experimentation behaviour and usability. *Comput. Hum. Behav.* **2013**, *29*, 1715–1724. [CrossRef]
41. Klimova, B.; Poulova, P.; Simonova, I.; Prazak, P.; Cierniak-Emerych, A. Internet use by the older adults in the Czech Republic. *E a M Ekonomie a Management* **2018**, *21*, 220–232. [CrossRef]
42. van Boekel, L.C.; Peek, S.T.; Luijkx, K.G. Diversity in older adults' use of the Internet: Identifying subgroups through latent class analysis. *J. Med. Internet Res.* **2017**, *19*, e180. [CrossRef] [PubMed]
43. Smith, A. Older Adults and Technology Use. 2014. Available online: http://www.pewinternet.org/2014/04/03/olderadults-and-technology-use/ (accessed on 9 June 2017).
44. Choi, N.G.; DiNitto, D.M. Internet use among older adults: Association with health needs, psychological capital, and social capital. *J. Med. Internet Res.* **2013**, *15*, e97. [CrossRef] [PubMed]
45. Ivan, L.; Hebblethwaite, S. Grannies on the net: Grandmothers' experiences of Facebook. *Rom. J. Commun. Public Relat.* **2016**, *18*, 11–25.
46. Habib, L.; Cornford, T. Computers in the home: Domestication and gender. *Inf. Technol. People* **2002**, *15*, 159–174. [CrossRef]
47. Hanson, V.L. Influencing technology adoption by older adults. *Interact. Comput.* **2010**, *22*, 502–509. [CrossRef]
48. Lian, J.-W.; Yen, D.C. Online shopping drivers and barriers for older adults: Age and gender differences. *Comput. Hum. Behav.* **2014**, *37*, 133–143. [CrossRef]
49. Helsper, E.J. Gendered Internet Use across Generations and Life Stages. *Commun. Res.* **2010**, *37*, 352–374. [CrossRef]
50. Marston, H.R.; Freeman, S.; Bishop, A.K.; Beech, C.L. Utilization of digital games for older adults aged 85+ years: A scoping review. *Games Health J.* **2016**, *5*, 157–174. [CrossRef]
51. Bleakley, C.M.; Charles, D.; Porter-Armstrong, A.; McNeill, M.D.J.; McDonough, S.M.; McCormack, B. Gaming for health: A systematic review of the physical and cognitive effects of interactive computer games in older adults. *J. Appl. Gerontol.* **2015**, *34*, NP166–NP189. [CrossRef] [PubMed]
52. Marston, H.R.; Smith, S.T. Interactive videogame technologies to support independence in the elderly: A narrative review. *Games Health J.* **2012**, *1*, 139–152. [CrossRef]
53. Hall, A.K.; Chavarria, E.; Maneeratana, V.; Chaney, B.H.; Bernhardt, J.M. Health benefits of digital videogames for older adults: A systematic review of the literature. *Games Health J.* **2012**, *1*, 402–410. [CrossRef]
54. Marston, H.R.; Kroll, M.; Fink, D.; de Rosario, H.; Gschwind, Y.J. Technology use, adoption and behaviour in older adults: Results from the iStoppFalls Project. *Educ. Gerontol.* **2016**, *4296*, 371–387. [CrossRef]
55. Creswell, J.W. A Framework for Design. In *Research Design Qualitative Quantitative and Mixed Methods Approaches*, 2nd ed.; Sage Publications: Thousand Oaks, CA, USA, 2003; pp. 3–26.
56. Council, M.K. Population Statistics. 2018. Available online: https://www.milton-keynes.gov.uk/your-council-and-elections/statistics/population-statistics (accessed on 8 January 2019).
57. City of Regina Regina History & Facts, 2019. Available online: https://www.regina.ca/about-regina/regina-history-facts/ (accessed on 2 July 2019).
58. City Population Information. YSTALYFERA Community in Wales. 2018. Available online: http://www.citypopulation.info/php/uk-parishes-wales.php?adm2id=W04000629 (accessed on 8 January 2019).
59. City Population Information. CWM-TWRCH Ward in Wales. 2018. Available online: http://www.citypopulation.info/php/uk-wards-wales.php?adm2id=W05000295 (accessed on 8 January 2019).
60. Marston, H.R. Older Adults as 21st Century Game Designers. *Comput. Games J.* **2012**, *1*, 90–102. [CrossRef]
61. Sandelowski, M. What's in a name? Qualitative description revisited. *Res. Nurs. Health* **2010**, *33*, 77–84. [CrossRef] [PubMed]
62. Charmaz, K. *Constructing Grounded Theory*, 2nd ed.; Sage: Thousand Oaks, CA, USA, 2014.
63. Giorgi, A. Description versus Interpretation: Competing Alternative Strategies for Qualitative Research. *J. Phenomenl. Psychol.* **1992**, *23*, 119–135. [CrossRef]
64. Guba, E.G.; Lincoln, Y.S. *Fourth Generation Evaluation*; Sage Publishing Inc: Thousand Oaks, CA, USA, 1989.

65. Milne, J.; Oberle, K. Enhancing rigor in qualitative description: A case study. *J. Wound Ostomy Cont. Nurs.* **2005**, *32*, 413–420. [CrossRef]
66. Patton, M.Q. *Qualitative Evaluation and Research Methods*, 2nd ed.; Sage: Newbury Park, CA, USA, 1990.
67. Elo, S.; Kyngas, H. The qualitative content analysis process. *J. Adv. Nurs.* **2008**, *62*, 107–115. [CrossRef] [PubMed]
68. Greenwoord, S.; Perrin, A.; Duggan, M. Social Media Update 2016. Pew Research Center, Internet & Technology, 20 November 2016. Available online: https://www.pewinternet.org/2016/11/11/social-media-update-2016/ (accessed on 1 November 2017).
69. Madden, M. Older Adults and Social Media. Pew Research Center, 27 August 2010. Available online: http://pewinternet.org/Reports/2010/Older-Adults-and-Social-Media.aspx (accessed on 2 July 2019).
70. Chayko, M. *Superconnected: The Internet, Digital Media, and Techno-Social Life*, 2nd ed.; Sage Publications, Inc.: Thousand Oaks, CA, USA, 2017; ISBN 9781506394855.
71. Masi, C.; Chen, H.Y.; Hawkley, L.; Cacioppo, J.T. A meta-analysis of interventions to reduce loneliness. *Personal. Soc. Psychol. Rev.* **2011**, *15*, 219–266. [CrossRef]
72. Khosravi, P.; Rezvani, A.; Wiewiora, A. The impact of technology on older adults' social isolation. *Comput. Hum. Behav.* **2016**, *63*, 594–603. [CrossRef]
73. Findlay, R.A. Interventions to reduce social isolation amongst older people: Where is the evidence? *Ageing Soc.* **2003**, *23*, 647–658. [CrossRef]
74. UK Government. PM Launches Government's First Loneliness Strategy. 2018. Available online: https://www.gov.uk/government/news/pm-launches-governments-first-loneliness-strategy (accessed on 5 March 2019).
75. Vooris, R.; Blaszka, M.; Purrington, S. Understanding the wearable fitness tracker revolution. *Int. J. Social. Leis.* **2019**, 1–17. [CrossRef]
76. de Veer, A.J.E.; Fleuren, M.A.H.; Bekkema, N.; Francke, A.L. Successful implementation of new technologies in nursing care: A questionnaire survey of nurse-users. *BMC Med. Inf. Decis Mak.* **2011**, *11*, 67. [CrossRef]
77. Marston, H.R.; Hall, A.K. Gamification: Application for Health and Health Information Technology Engagement. In *Handbook of Research on Holistic Perspectives in Gamification for Clinical Practice*; Novak, D., Tulu, B., Brendryen, H., Eds.; Medical Information Science Reference: Hershey, PA, USA, 2015.

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Perspectives of Healthcare Professionals on Meaningful Activities for Persons with Dementia in Transition from Home to a Nursing Home: An Explorative Study

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Abstract: Meaningful activities can enhance quality of life, a sense of connectedness, and personhood for persons with dementia. Healthcare professionals play an important role in maintaining meaningful activities, but little is currently known about the impact of the transition from home to nursing home on these activities. This study explored the experiences of professionals in four Dutch nursing homes, identifying facilitators and barriers to the maintenance of meaningful activities during the transition. A qualitative explorative design was used. Data were collected using focus groups and analyzed using thematic analysis. Twenty-two professionals participated in four focus groups, and three themes were identified: (1) a lack of awareness and attention for meaningful activities; (2) activities should be personalized and factors such as person characteristics, interests, the social and physical environment, and specific information such as roles, routines, activities, and personal issues play an important role in maintaining activities; (3) in the organization of care, a person-centered care vision, attitudes of professionals and interdisciplinary collaboration facilitate maintenance of meaningful activities. Healthcare professionals felt that meaningful activities are difficult to maintain and that improvements are needed. Our study provides suggestions on how to maintain meaningful activities for persons with dementia prior, during and after the transition.

Keywords: meaningful activities; transition; dementia; nursing home

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1. Introduction

Meaningful activities are commonly mentioned in relation to quality of life and management of the behavioral and psychological symptoms of dementia [1]. The use of the term meaningful activity is widely spread, although in current literature, a clear definition of meaningful activity is lacking. In this study, meaningful activities are defined as all activities or occupations that are significant or meaningful for the person and reflect someone's current and past interests, routines, habits, and roles and are adjusted to someone's abilities [1,2]. A wide range of activities can be seen as meaningful activities, such as reminiscence, music, family, and social activities and individual activities related to routines and habits, for instance, domestic tasks [3]. For persons with dementia, meaningful activities can enhance wellbeing [4], provide a sense of connectedness to self, others, and the environment [5], and a sense of personhood [6]. Despite these benefits, engaging in meaningful activities can be difficult for persons with dementia, difficulties that are often related to the progress of dementia. One major and often inevitable challenge can be the transition to a nursing home.

Moving to a nursing home is a major life event [7], and adjustment to a nursing home is difficult both for persons with dementia and their family members [8]. Most studies that have focused on the transition period and the factors influencing this transition period have described the perspectives of family members of persons with dementia [8,9] or focused on supporting family members [10]. A recent study investigated adjusting to residential aged care facilities from the perspectives of persons with dementia, family members, and facility care staff and identified meaningful activities as critical for facilitating adjustment to life in the facility [11]. A study by Rijnaard et al. [12] showed that engagement in activities and preservation of one's habits and values in nursing homes can help persons with dementia to feel at home.

Although the importance of meaningful activities for persons with dementia in nursing homes is known, little is known about factors influencing meaningful activities and maintenance of these activities in the transition period. One study of cognitively intact older persons showed a decline in meaningful activities when moving to a nursing home [13]. Tak et al. [14] have shown that while nursing home residents with dementia had a wide variety of hobbies and activities prior to moving to a nursing home, their current involvement in activities was limited and did not always match their interests. Further, the study of Davison et al. [11] found that although some residents continued with previous hobbies, many residents and families found activities inadequate to meet residents' needs for stimulation and interest. In this study, staff found it difficult to find activities that meet individual interests, preferences, and capacities of persons with dementia and to incorporate meaningful activities in day-to-day-life. A range of factors are associated with activity involvement in the nursing home and relate to the person's interests, competences, abilities, the (social and physical) environment, and other factors related to the organization of care [15]. Healthcare professionals play an important role in individually tailoring activities for persons with dementia by focusing on the individual's preferences, interests, remaining abilities, memories or personal history [2]. This study explores the experiences of healthcare professionals in Dutch nursing homes in relation to (1) maintaining meaningful activities when persons with dementia move from home to a nursing home, (2) working together as a multidisciplinary team to maintain meaningful activities, and (3) the experienced barriers and facilitators.

2. Materials and Methods

This study has a qualitative explorative design and used focus groups as a data collection method. Focus groups were used to gain an in-depth insight into the experiences of healthcare professionals regarding meaningful activities for persons with dementia in transition from the home to a nursing home, and the factors experienced as barriers and facilitators. Furthermore, focus groups were used because, in comparison with individual interviews, this method offers participants the opportunity to share their ideas and to interact and complement each other [16]. In this study, the transition period is seen as the period prior to, during, and the period following admission and therefore also includes the adjustment period [7].

2.1. Setting, Study Sample, and Recruitment

The participating care organization has nine nursing home locations in the region of the Hague, the Netherlands, which provide small-scale dementia living facilities within the environment of a larger nursing home. Six to eight persons live together in a group, with in total about 100 persons with dementia per nursing home location. Residents share a living room, and each has their own bedroom. Activities are integrated in daily care (e.g., cooking, household activities) or offered in groups (e.g., gym, dancing). Daily care is provided by a multidisciplinary team that consists of nurse aides, registered nurses, psychologists, elderly care physicians, occupational therapists, and physiotherapists.

The inclusion criteria in this study required that the participating healthcare professionals were regular members of a multidisciplinary team and were employed in a dementia care unit. All teams were recruited by a researcher via email, through which a multidisciplinary team member in a dementia care unit was invited to explore the possibility if several multidisciplinary team members could participate in the focus group at their location. The member of the team who was approached by the researcher contacted the multidisciplinary team members also by email or face-to-face to see if they could participate in the focus group. Participation was on a voluntary basis.

2.2. Data Collection

The focus groups were semistructured and had the following structure: (1) welcome, (2) focusing exercise, (3) main subject, and (4) completion. During the welcome, participants introduced themselves, and approval was obtained for audio recording. This was followed by a focusing exercise to introduce the topic of meaningful activity. The aim of this focusing exercise was to get the conversation going between the group members by introducing the topic [16]. Participants were asked to write examples of meaningful activities and what they believe makes an activity meaningful on Post-It notes, after which, discussion of their views took place. A different color of Post-It was used for each discipline in order to compare views per discipline. As the main subject of the focus group, various topics were discussed related to assessment and maintenance of meaningful activities during the transitional period. Opinions and experiences were shared concerning current practice, barriers and facilitators, and collaboration as a multidisciplinary team. The topic list for the main subject was derived from the experiences of the researcher (author 1) and an occupational therapist (author 3). The focusing exercise and main subject are listed in Table 1. During completion, all participants were able to contribute any last thoughts and ask questions about the study.

Table 1. Focusing exercise and main subject.

Head Topic	Sub Topic
What is a meaningful activity?	Can you give an example of a meaningful activity? What do you believe makes an activity meaningful?
How are meaningful activities assessed?	Opinions and current practice: What do you consider barriers and facilitators? How do you collaborate as a multidisciplinary team in the assessment of meaningful activities?
How do you maintain meaningful activities during the transition from home to nursing home?	Opinions and current practice: What do you consider barriers and facilitators? How do you collaborate as a multidisciplinary team in maintaining meaningful activities?

All participants gave oral consent for audio recording of the focus groups and anonymous use of data. The focus groups were moderated by a researcher (author 1) and an occupational therapy student (author 2). The researcher is an experienced group facilitator, is employed in the organization as a lecturer practitioner, and has worked with multidisciplinary teams to maintain meaningful activities. Both moderators encouraged participation and discussion from all participants in the group interview.

2.3. Data Processing and Analysis

The focus groups were analyzed by thematic analysis. Thematic analysis is a commonly used method to identify, analyze, and report patterns (themes) within data [17]. During the first step, familiarization with the data, author 2 listened to the audio recordings and transcribed the focus groups using the topic list. Author 1 then listened to the audio recordings and read the transcripts, comparing them to the audio recordings in an effort to identify any inaccuracies. The second step was to develop a coding frame, in which author 2 selected fragments from the transcripts and organized them based on the topic list. All the fragments were then read and coded by authors 1 and 2 and discussed based on the questions: 'What is the fragment about?' and 'What does this fragment mean?'. The coding process was data-driven, meaning that the codes were based on the data, which resulted in a long list of specific codes [17]. The third step was to organize the codes into themes and subthemes; to facilitate this process, authors 1 and 2 used visual methods, such as tables, to structure their thinking process. In the fourth step, author 3 independently reviewed the themes, subthemes, and extracted data, reflecting on the coding process. Questions raised were discussed by authors 1, 2, and 3, and agreement was reached. The final step was to define and rename the themes.

Authors 1 and 5 together reviewed the data, and three overall themes and several subthemes were identified and renamed. These themes were then verified by all other authors. Nvivo (version 12) was used for the coding and theme process, facilitating the structuring of the transcript into fragments, codes, subthemes, and themes. Anonymity and confidentiality were guaranteed, and the names of people, appearing in the quotes, were deleted from the written texts or were anonymized. A member check was conducted on the findings; the participants found the research findings reflecting their meanings and perceptions [18].

3. Results

Four nursing homes indicated an interest in participating in the study. The remaining five declined to participate due to a shortage of staff related to the vacation season. In total, 22 healthcare professionals participated in four focus groups. The focus groups had a broad composition and included a range of professionals comparable to the typical multidisciplinary team in a Dutch nursing home, represented in the following disciplines: five psychologists, four physiotherapists, three nurse aides, one registered nurse, one hostess (a paid assistant without nurse training), one activity therapist, three occupational therapists, two team managers, one physician, and one elderly care physician. The number of participants in the four focus groups varied between three and seven: Two focus groups had six participants, one had seven, and one had three. In total, 4 men and 18 women participated. Work experiences in the care for persons with dementia varied: Four participants had 0–2 years' experience, nine participants 2–10 years, and seven participants more than 10 years, while we had no data from two participants. Six participants were 20–35 years of age, nine participants 35–50, three participants 50–65, and we had no data from four participants. The focus groups convened from 10 July to 24 July 2018. Two of the focus groups required half an hour, and two required one hour.

Three themes were identified in the data which, according to the healthcare professionals, influenced the maintenance of meaningful activities as persons with dementia transitioned from home to a nursing home. These themes were (1) attention and awareness, (2) personalized meaningful activities, and (3) the organization of care.

3.1. Attention and Awareness

During the focusing exercise, healthcare professionals were asked to give examples of meaningful activities for persons with dementia. Five of the eight disciplines mentioned "moving and/or walking", "music", and "kitchen activity and/or cooking" as meaningful activities. A wide variety of examples were given, both between and within the disciplines, varying from leisure activities to activities related to routines, roles and habits. Not every activity was considered especially meaningful by all disciplines.

Participants were also asked which factors gave meaning to an activity. The items "based on interests" and "mood enhancing" were mentioned by six disciplines and "adapted from past activities" and "personalized activities" by five disciplines. In each focus group, all attendees could agree with the items mentioned by a different discipline.

Healthcare professionals in all focus groups reported that meaningful activities receive little attention and constitute a minor aspect of the transition period, except when this presents a problem or leads to behavioral problems in the person with dementia. Nevertheless, they believe that greater attention for this subject could be beneficial.

> *"We can definitely improve care for persons who become distressed in their new environment. For example, if a person appears to have behavioral problems or aggression following admission, we need to identify factors appropriate to that person" (Team manager, focus group 4)*

In addition, the professionals argued that persons without behavioral problems also deserve attention, because these individuals may be at risk "of quietly disappearing into the crowd or of being overlooked". In general, professionals endorsed the value of meaningful activities in increasing quality of life and providing a sense of identity and meaning.

> *"But it is also important to understand the patterns of someone's home life before admission and how we can help that individual to maintain that life in the nursing home. This will necessarily differ because a nursing home is not someone's original home, but we should try to identify useful elements. So that someone still feels "I matter", "I'm involved" and "I'm important"." (Psychologist, focus group 3)*

Healthcare professionals report a lack of awareness amongst colleagues and family members regarding meaningful activities. For family members, it can be difficult to recognize which activities could be meaningful and how these activities can be maintained, an issue probably related to the fact that family members have experienced the decline and loss of activities firsthand and have consequently come to believe that the person with dementia cannot regain activities. Another issue is that some family members consider that older persons no longer need to undertake activities. A final reason family members may be reluctant to share in activities and routines could be embarrassment related to the behavior of the person with dementia. The participating professionals proposed that additional information could be helpful for family members. In addition to creating awareness among family members, improved awareness among healthcare professionals and giving priority to meaningful activities were considered important, especially in the transitional period characterized by other urgent considerations (e.g., medical problems and issues).

> *"There is insufficient awareness and professionals ask too few questions related to meaningful activities. In essence, there is often too little awareness of its importance. The question is why someone is here; and that is not because they once had nice hobbies. The medical condition receives primary attention." (Psychologist, focus group 2)*

Healthcare professionals suggest that more awareness and attention could be created by integrating meaningful activities into standard care. During these procedures, it is important to personalize meaningful activities, a theme elaborated below.

3.2. Personalizing Meaningful Activity

Healthcare professionals stated that both general and personalized activities are available in nursing homes. General activities are offered in groups and have a specific program or are performed in the living room. These activities are usually developed for and are intended to meet the needs of residents but are not personalized. Although these general group activities are valuable, the participants suggested that a combination of personalized and (group) activities would be optimal.

> *"I think there should be a combination. People can sometimes no longer properly express their wishes, or family members find it difficult to be specific. Sometimes it is good to offer general activities for people to enjoy, but that is not enough; it is also important to define what someone wants and needs." (Occupational therapist, focus group 3)*

In general, professionals felt that activities decline after moving to a nursing home. Nonetheless, some people become more active following admission due to clear structure in their day and greater stimuli (see theme three). A range of factors were mentioned as influencing the performance and maintenance of meaningful activities in the transition from home to a nursing home. Factors mentioned included the cognitive and physical abilities of the person with dementia, a change in interests, and the changing environment (both in terms of the building itself and social factors). As a consequence of the decline in the cognitive and physical abilities of persons with dementia, professionals thought it important to adjust activities to meet abilities. Persons with dementia can experience frustration and loss of motivation when offering them activities that they previously performed. In addition, interest and motivation can change as a result of the disease or the change in environment. Activities previously performed at home may no longer be meaningful after transition to a nursing home.

> *"Certain activities can be sustained, but in my experience if someone no longer finds an activity meaningful they will not want to do it anymore, such as peeling potatoes, for example." (Nursing aide, focus group 3)*

Healthcare professionals often experience barriers to maintaining meaningful activities related to a lack of materials and to personal issues stemming from the move, reduced accessibility to and from the unit, and a different room layout and outside area.

> *" … for example, when someone is used to a small living area and has everything close to hand. This is completely different in a nursing home with a long corridor leading to the living room". (Physiotherapist, focus group 4)*

A facilitator of a successful transition is the possibility of continuing socially meaningful activities, for example, birthdays and holidays, and the involvement of family members is considered important in preserving someone's living patterns.

Healthcare professionals argued that specific changes are needed to maintain meaningful activities. They state that understanding the reason someone performed a given activity can be important to find an appropriate alternative activity adjusted in a way that is meaningful.

> *"What did the activity represent and what did it mean to someone. For example, going outside gave a sense of freedom, so how can you now encapsulate this sense of freedom in a still achievable activity". (Psychologist, focus group 2)*

Another facilitator supporting the maintenance of meaningful activities is finding meaning in 'little things', such as the daily routines someone was used to before moving to a nursing home. Specific details of a person's life history are collected during the period immediately following admission, and these can help in the search for possible activities, although additional information is often needed. The healthcare professionals stated that information on the final period at home is especially important.

> *"At admission we ask questions about hobbies. But you should also look more specifically at a person's role at home and the activities they undertook when still at home". (Physiotherapist, focus group 3)*

The last facilitator to be mentioned was the need for reflection on the implementation of an activity in daily nursing home practice. If the activity is easy to implement, it is more likely that the activity will take place. The focus groups mentioned additional organizational issues, which are discussed in the next theme.

3.3. Organization of Care

This theme includes several subthemes, with facilitators and barriers defined based on the data from the focus groups: (1) person-centered care vision and attitudes of professionals, (2) interdisciplinary collaboration, and (3) requirements (See Table 2).

Table 2. Facilitators and barriers to maintaining meaningful activities in the transition period as experienced by healthcare professionals.

Facilitator	Barrier
Theme 1: AWARENESS	
Multidisciplinary team meetings promote greater awareness by professionals by asking questions such as: What is meaningful for this person? What are the things this person wants to do?	A lack of awareness of meaningful activities among professionals
Greater attention in standard procedures for meaningful activities during the transition period	A lack of awareness by family members: little belief that activities can be regained, and a view that older persons do not need to maintain activities
Theme 2: PERSONALIZED MEANINGFUL ACTIVITY	
Questions such as: What makes you happy? "What is important for a day to be a good day?"	Insufficient specific knowledge of activities, roles and habits before moving to the nursing home
Both general and personalized activities are offered	Only general activities available, rather than asking which activities are preferred
Family involvement	Lack of specific information about activities from family members
Environment provides the possibility to perform activities	Environment: accessibility of the unit, change of environment (moving) can change routines of daily living. Materials unavailable and personal issues related to moving. Change of room layout
Determining why an activity is performed, finding satisfaction in small things and the opportunities for implementing the activity in daily routines and nursing home daily practice	Factors relating to the person with dementia: advanced dementia, apathy, frustration
Theme 3: ORGANISATION OF CARE	
Subtheme person-centered care vision and attitudes of professionals	
Professionals seek opportunities, are flexible, apply fresh thinking, stimulating persons with dementia and experimenting	Adopting tasks and care
Structuring the day, a single team approach	Holding on to structures and routines from the perspective of the organization
Multidisciplinary team meeting, focusing on meaningful activities and well-being	
Subtheme: Interdisciplinary collaboration	
Goal setting, paying attention to specific conditions	Non-specific goals/information not aligned
Interdisciplinary collaboration: no specific division of roles	Few exchanges between professionals
Presence of professionals at the care location. An involved manager who thinks in possibilities	Few possibilities for exchanges except in multidisciplinary team meetings
Possibility of acclimatizing to the new environment	No exchanges with previously involved professionals from other organizations
Subtheme: requirements	
Care plan access for all involved in care Presence of hostess Permanent team	Time, shortage of staff Temporary workers

In three focus groups, the participants felt that a person-centered focus in the attitude of professionals and organization of care in the nursing home is needed in order to realize meaningful activities. Attitudes focused on the questions a person may have, including asking a person what is important to them, contribute to personalized meaningful activities. Recently, a more person-centered approach was implemented in the multidisciplinary team meetings in the care organization. Following this change, the professionals noticed that more questions were being asked in the multidisciplinary team meeting related to meaningful activities. Although the overall opinion was that meaningful activities deserve greater attention, the multidisciplinary team meetings were mentioned in all focus groups as a facilitator of this idea. In general, an organization in which professionals seek opportunities, are flexible, and apply fresh thinking will be supportive of maintaining meaningful personalized activities.

By contrast, in three focus groups, the participants argued that adopting tasks and structures and routines from the perspective of professionals and the organization could represent a threat to the maintenance of meaningful activities.

> *"When someone enters a nursing home, it is often said that they must first 'get used to' the new environment and 'settle down' for a couple of weeks. Actually, you are allowing someone to become hospitalized during those two weeks. There is a danger in doing nothing for too long, with the result that routines and habits are lost." (Psychologist, focus group 1)*

Although to facilitate person-centered care, a flexible approach to work was considered important, also, a single team approach was seen as a facilitator by two focus groups. This issue is further elaborated in the subtheme of interdisciplinary collaboration.

Many different healthcare professionals are involved in the assessment and realization of meaningful activities. For example, information is gathered during planned conversations with family members and with the person with dementia, but also during care moments and conversations throughout the day. Two focus groups felt that when this information is not integrated, it can act as a barrier to the maintenance of meaningful activities. Several situations were mentioned whereby this information could be aligned, both formal and informal. One was related to the multidisciplinary team meeting and another to the possibility of working together as a single team in the nursing home. No contact outside of formal meetings was mentioned as a barrier.

> *"The lines of communication between all disciplines are short (hostess). We really feel it is one team (psychologist). And because the lines are short, professionals are also prepared to ask more of each other (physiotherapist)." (Focus group 4)*

Goal setting can facilitate the process of finding alignment. Although the finding and formulation of goals can be complicated, the overall opinion was that they are important in realizing meaningful activities and are helpful in making a plan specific and explicit.

> *"The plan is often unclear, as are the conditions which must be met. For example, omeone likes Elvis's music, but can they put on the music themselves, is equipment available, who is responsible for it and how does someone react to the music." (Psychologist, focus group 1)*

In all focus groups, clear responsibilities were considered important due to the many different disciplines involved, so working together as a team was viewed as essential. It is important to know who is responsible for what and to undertake regular evaluations of agreements.

> *"Available care is developed around the residents. Each discipline carries out its own assessment and we jointly discuss how they can be combined and implemented, resulting in a cooperative, dynamic process. There are no clear boundaries as to who should do what, as the focus is on the integrated package (nurse). We are integrating more of our work (psychologist). The ball keeps rolling because everyone cooperates and feels jointly responsible" (nurse)." (All focus group 4)*

A factor experienced as a barrier was the lack of input from professionals involved prior to admission to the nursing home, for example, the care professionals at the daycare center or those providing home care. One focus group mentioned as a facilitator the possibility for a person with dementia to acclimatize to their new situation, for example, by visiting the nursing home before moving in.

Various requirements are mentioned in the maintenance of meaningful activities. The facilitators were access to care plan for all involved in care, the presence of a hostess, and a permanent team in the nursing home. The barriers to this included time, shortage of staff, and temporary workers.

4. Discussion

This qualitative, explorative study identified three themes important to the maintenance of meaningful activities for persons with dementia during the transition from home to a nursing home. The first theme was awareness and attention for meaningful activities during the period of transition on the part of healthcare professionals and family members. The second theme involved how to adapt and personalize an activity to a new environment and to adapt the activity so that it remains meaningful. The participating healthcare professionals argued that specific information is needed on the involvement of family members and the activities, roles, and routines someone preformed in the period before moving to a nursing home. In addition, various factors that may influence the performance of activities have to be taken into account (person characteristics, activity, and environment). The third and last theme embodied what is needed in the organization of care in order to maintain meaningful activities.

The healthcare professionals consulted in this study reported that meaningful activities are difficult to maintain during the transition from home to a nursing home and are maintained less often than desired. These conclusions correspond to the findings of an earlier study which reported that residents of nursing homes are generally inactive and consequently have low overall activity levels [19]. Currently, no studies specifically describe investigations of how to adjust activities to remain meaningful in the transition from home to a nursing home. There are, however, studies that focus on how to moderate activities. For instance, Regier et al. [20] described a model for caregivers illustrating how to design activities that maximize engagement. In this model, the remaining cognitive and physical functional abilities are aligned to interests and environmental characteristics. These factors are similar to those found in our study, in which healthcare professionals mentioned that various factors are important in the maintenance of meaningful activities related to the remaining cognitive and physical abilities of the person with dementia, the possible change in interests, and the changing environment (both the building and social) due to moving. In addition, the motivation underlying an activity and a person's life history are important to the personalization of a meaningful activity and to adaptations of an activity to the new environment. Du Toit, Shen, and McGrath [21] also stressed the importance of a deep understanding of why activities were undertaken in order to promote person-centered care. Viewing person-centered care as the foundation can help in finding an alternative activity that matches the values or needs embedded in the previous activity. Especially as dementia progresses, an individual may no longer be able to engage in their valued meaningful activity, even when using compensation strategies or adaptive tools or equipment [5]. In our study, we found that specifically assessing someone's activities before admission to a nursing home, determining the underlying meaning of activities for the person with dementia, and involving family members in any assessment may all contribute to identifying and maintaining meaningful activities. In this study, healthcare professionals experienced a lack of attention and awareness among healthcare professionals within their nursing home organizations, which could have an influence on the identification and maintenance of meaningful activities in transition from home to a nursing home. The participating professionals expressed the view that a transition in living environment could have an impact on maintaining activities for persons with dementia. Although a more structured environment and daily care might be beneficial for some individuals, most people risk losing activities. There is little research at present on the impact of a transition from home to a nursing home on meaningful activities.

The findings reported in the present study suggest that adaptations will be required in order to ensure that personalized meaningful activities remain meaningful in a new environment.

Interdisciplinary collaboration, with healthcare professionals in the nursing home and professionals involved prior to the admission, was found to be a facilitator in the organization of care, permitting the realization of meaningful activities for persons with dementia in the transition from home to a nursing home. In a systematic review [22], interdisciplinary interventions were found to have a positive effect on patient outcomes in nursing homes. To improve transitional care focused on maintaining meaningful activities, an interdisciplinary approach, both with professionals in the nursing home and professionals involved prior to the admission, is therefore recommended.

Strengths of this study included the participation of a variety of different disciplines in the focus groups, which led to a better understanding of the facilitators and barriers healthcare professionals experience in daily practice. The focus groups consisted of persons working together on a daily basis, which allowed for an in-depth discussion about their own situation and work process. Professionals in the organization that provided the focus groups were familiar with meaningful activities, and a person-centered care approach has recently been implemented. This allowed the professionals to draw on their own experience in the maintenance of meaningful activities and to reflect on and formulate facilitators and barriers. A limitation of the study was that it was conducted in four nursing homes allied to the same care organization, a factor that may conceivably have influenced the diversity of the information provided by the healthcare professionals. Another limitation was that author one, who moderated the focus groups, also worked in the organization. Although we cannot rule out that this had an effect on the participants' responses in the focus groups [18], we do not have any indication for different responses in the focus groups because of the affiliation of the researchers. Further, the cooperation with researchers that are well experienced in Dutch nursing home care but outside this organization reduced the risk of overly biased results.

5. Conclusions and Recommendations for Practice and Research

To the best of our knowledge, this is the first study which explored the experiences of healthcare professionals regarding the maintenance of meaningful activities for persons with dementia during the transition from home to a nursing home. Providing personal meaningful activities for persons with dementia is a challenge for healthcare professionals and healthcare organizations [11,14,19]. Furthermore, there is a lack of guidelines [11] and interventions [8,10] focusing on the transition from home to a nursing home for persons with dementia. The findings of this study provide valuable insights, both for professionals and organizations, on how to maintain meaningful activities during this transition. Several recommendations could be made for healthcare professionals and organizations based on the findings in the present study. Training of healthcare professionals can contribute to awareness of the importance of meaningful activities in the transition period, knowledge of the factors influencing the maintenance, risks of losing meaningful activities, and possibilities to maintain meaningful activities. The results of the study highlight the need for the development of an interdisciplinary multicomponent intervention and guidelines aimed at supporting persons with dementia and their families during this important transitional period. Further research should focus on how interventions could help persons with dementia and family members to maintain their lives as fully as possible during the transitional period and how activities can be adapted to remain meaningful for them, despite progression of the disease and changing environments.

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References

1. Travers, C.; Brooks, D.; Hines, S.; O'Reilly, M.; McMaster, M.; He, W.; MacAndrew, M.; Fielding, E.; Karlsson, L.; Beattie, E. Effectiveness of meaningful occupation interventions for people living with dementia in residential aged care: A systematic review. *JBI Database Syst. Rev. Implement. Rep.* **2016**, *14*, 163–225. [CrossRef] [PubMed]
2. Han, A.; Radel, J.; McDowd, J.M.; Sabata, D. The Benefits of Individualized Leisure and Social Activity Interventions for People with Dementia: A Systematic Review. *Act. Adapt. Aging* **2016**, *40*, 219–265. [CrossRef]
3. Harmer, B.J.; Orrell, M. What is meaningful activity for people with dementia living in care homes? A comparison of the views of older people with dementia, staff and family carers. *Aging Ment. Health* **2008**, *12*, 548–558. [CrossRef] [PubMed]
4. Smit, D.; de Lange, J.; Willemse, B.; Twisk, J.; Pot, A.M. Activity involvement and quality of life of people at different stages of dementia in long term care facilities. *Aging Ment. Health* **2016**, *20*, 100–109. [CrossRef] [PubMed]
5. Han, A.; Radel, J.; McDowd, J.M.; Sabata, D. Perspectives of People with Dementia About Meaningful Activities: A Synthesis. *Am. J. Alzheimers Dis. Other Demen.* **2016**, *31*, 115–123. [CrossRef]
6. Milte, R.; Shulver, W.; Killington, M.; Bradley, C.; Ratcliffe, J.; Crotty, M. Quality in residential care from the perspective of people living with dementia: The importance of personhood. *Arch. Gerontol. Geriatr.* **2016**, *63*, 9–17. [CrossRef]
7. Afram, B.; Verbeek, H.; Bleijlevens, M.H.; Hamers, J.P. Needs of informal caregivers during transition from home towards institutional care in dementia: A systematic review of qualitative studies. *Int. Psychogeriatr.* **2015**, *27*, 891–902. [CrossRef]
8. Sury, L.; Burns, K.; Brodaty, H. Moving in: Adjustment of people living with dementia going into a nursing home and their families. *Int. Psychogeriatr.* **2013**, *25*, 867–876. [CrossRef]
9. Pritty, B.; De Boos, D.; Moghaddam, N. Factors influencing the transition experience of carers for persons with dementia, when the person with dementia moves into residential care: Systematic review and meta-synthesis. *Aging Ment. Health* **2019**, 1–10. [CrossRef]
10. Muller, C.; Lautenschlager, S.; Meyer, G.; Stephan, A. Interventions to support people with dementia and their caregivers during the transition from home care to nursing home care: A systematic review. *Int. J. Nurs. Stud.* **2017**, *71*, 139–152. [CrossRef]
11. Davison, T.E.; Camões Costa, V.; Clark, A. Adjusting to life in a residential aged care facility: Perspectives of people with dementia, family members and facility care staff. *J. Clin. Nurs.* **2019**. [CrossRef]
12. Rijnaard, M.D.; van Hoof, J.; Janssen, B.M.; Verbeek, H.; Pocornie, W.; Eijkelenboom, A.; Beerens, H.C.; Molony, S.L.; Wouters, E.J. The Factors Influencing the Sense of Home in Nursing Homes: A Systematic Review from the Perspective of Residents. *J. Aging Res.* **2016**, *2016*, 6143645. [CrossRef]
13. De Vriendt, P.; Cornelis, E.; Vanbosseghem, R.; Desmet, V.; Van De Velde, D. Enabling meaningful activities and quality of life in long-term care facilities: The stepwise development of a participatory client-centred approach in Flanders. *Br. J. Occup. Ther.* **2018**, *82*, 15–26. [CrossRef]
14. Tak, S.H.; Kedia, S.; Tongumpun, T.M.; Hong, S.H. Activity Engagement: Perspectives from Nursing Home Residents with Dementia. *Educ. Gerontol.* **2015**, *41*, 182–192. [CrossRef]
15. Smit, D.; de Lange, J.; Willemse, B.; Pot, A.M. Predictors of activity involvement in dementia care homes: A cross-sectional study. *BMC Geriatr.* **2017**, *17*, 175. [CrossRef]
16. Green, J. *Qualitative Methods for Health Research*; SAGE: London, UK, 2018.
17. Braun, V.; Clarke, V. Using thematic analysis in psychology. *Qual. Res. Psychol.* **2006**, *3*, 77–101. [CrossRef]
18. Tong, A.; Sainsbury, P.; Craig, J. Consolidated criteria for reporting qualitative research (COREQ): A 32-item checklist for interviews and focus groups. *Int. J. Qual. Health Care* **2007**, *19*, 349–357. [CrossRef]
19. Den Ouden, M.; Bleijlevens, M.H.; Meijers, J.M.; Zwakhalen, S.M.; Braun, S.M.; Tan, F.E.; Hamers, J.P. Daily (In)Activities of Nursing Home Residents in Their Wards: An Observation Study. *J. Am. Med. Dir. Assoc.* **2015**, *16*, 963–968. [CrossRef]

20. Regier, N.G.; Hodgson, N.A.; Gitlin, L.N. Characteristics of Activities for Persons with Dementia at the Mild, Moderate, and Severe Stages. *Gerontologist* **2017**, *57*, 987–997. [CrossRef]
21. Du Toit, S.H.J.; Shen, X.; McGrath, M. Meaningful engagement and person-centered residential dementia care: A critical interpretive synthesis. *Scand. J. Occup. Ther.* **2019**, *26*, 343–355. [CrossRef]
22. Nazir, A.; Unroe, K.; Tegeler, M.; Khan, B.; Azar, J.; Boustani, M. Systematic review of interdisciplinary interventions in nursing homes. *J. Am. Med. Dir. Assoc.* **2013**, *14*, 471–478. [CrossRef]

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Article

Using Citizen Science to Explore Neighbourhood Influences on Ageing Well: Pilot Project

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Abstract: Outdoor and indoor environments impact older people's mobility, independence, quality of life, and ability to "age in place". Considerable evidence suggests that not only the amount, but also the quality, of public green spaces in the living environment is important. The quality of public green spaces is mostly measured through expert assessments by planners, designers and developers. A disadvantage of this expert-determined approach is that it often does not consider the appraisals or perceptions of residents. Daily experience, often over long periods of time, means older residents have acquired insider knowledge of their neighbourhood, and thus, may be more qualified to assess these spaces, including measuring what makes a valued or quality public green space. The aim of this Australian pilot study on public green spaces for ageing well was to test an innovative citizen science approach to data collection using smart phones. "Senior" citizen scientists trialed the smart phone audit tool over a three-month period, recording and auditing public green spaces in their neighbourhoods. Data collected included geocoded location data, photographs, and qualitative comments along with survey data. While citizen science research is already well established in the natural sciences, it remains underutilised in the social sciences. This paper focuses on the use of citizen science with older participants highlighting the potential for this methodology in the fields of environmental gerontology, urban planning and landscape architecture.

Keywords: citizen science; built environment; older people; urban neighbourhoods; GIS; spatial; Australia

1. Introduction

The design and delivery of quality public green spaces that promote health and wellbeing, social engagement with others and engagement with the environment is a key challenge in our rapidly growing, and increasingly population-dense cities. As cities become denser, incorporating quality public green spaces becomes more important than ever [1–4]. A greater understanding of how these spaces should be designed is needed to support the physical, mental and social health of individuals. By 2030 two-thirds of the world's population will be living in cities and, in many of these cities, at least a quarter of the population will be aged 65 plus years [5]. Cities, particularly our inner-city built environments, are spaces that are usually imagined, planned and structured with a younger, working age demographic in mind. This project was conducted in South Australia—chiefly in Greater Metropolitan Adelaide. South Australia (SA) is the oldest of the mainland states of Australia, with 37.8% of its population aged 50 + years [6]. Thus, planning our cities and neighbourhoods for an older population is an extant reality; yet older people are not typically incorporated into the mainstream of thinking and planning around urban development, public open and green space environments.

For the purposes of this project, public green spaces included any public or civic space that included forms of vegetation (grass, trees, gardens, formal planting and/or natural bushland) that are maintained by local, state or federal governments or private organisations but are accessible to all members of the public. Public green spaces include parks, gardens, reserves, sporting fields, walking trails, riparian areas such as riverbanks, trees and verges as part of streetscapes, and courtyards or 'green walls' that form parts of public buildings. These public green spaces vary in size, presentation, quality and purpose and have a diversity of vegetation cover and species.

This pilot study aimed to test a new smart phone-based audit tool using an innovative methodology—citizen science—in order to explore how and why older people engage with public green spaces. The pilot project presented in this paper was built upon the premise that it is important to understand the relationship between older people and these public green spaces beyond simple utilisation of the physical space. While the fabric of the physical space (such as the housing environment, surrounding neighbourhood, public buildings as well as the public green spaces) is important, we also need to consider the interplay of these built environment elements with health, wellbeing, social connectedness and civic engagement, as well as mediums for maintaining autonomy and independence. We need to imagine how the built environment, including public green spaces, can become enablers of ageing well, and this needs to be examined from the insider perspective of the older person.

2. Background

Standards and guidelines have been developed to address principles to improve public spaces, neighbourhoods, buildings and constructions to ensure that older people can fully utilise those spaces. The World Health Organization (WHO) has developed a guideline for achieving "age-friendly cities", or cities that encourage "active ageing by optimizing opportunities for health, participation and security in order to enhance quality of life as people age" [7]. The guideline focuses on eight main topic areas that must be addressed: public spaces and buildings, transportation, housing, social participation, respect and social inclusion, civic participation and employment, communication and information, and community support and health services [7]. Outdoor and indoor environments are considered to have major impacts on older people's mobility, independence and quality of life in cities, and particularly on their ability to "age in place" (or to live as long as possible in one's own home). The guideline specifies 11 areas to be addressed in the topic of "outdoor spaces and buildings" including pleasant and clean environments, the importance of green spaces, somewhere to rest, age-friendly pavements, safe pedestrian crossings, accessibility, secure environment, barrier-free buildings, and adequate public toilets [7].

Local governments around the world have developed their own policies, plans, programs and services to improve the "age-friendliness" of their cities by adopting the WHO guideline [7]. Researchers have previously conducted studies to audit neighbourhoods [8,9], and developed tools to conduct the audits [10]. It is, however, questionable whether this expert-determined approach reflects the appraisals or perceptions of the older residents about their own environment. As older people have a tendency to live in the same place, often over long periods of time, they are likely to have first-hand or insider knowledge about their neighbourhood, and thus, may be more qualified to assess these spaces and understand what makes a valued or quality public green space [11,12]. Citizen science, an emerging methodological approach in the social sciences, offers insightful opportunities for creating strong appraisals of age friendly adaptations of the built environment. This enables developers, planners and academics to better understand what really makes a community or neighbourhood age friendly from the perspective of the older person who uses that space.

In recent years, we have witnessed important shifts in the relationship between science and society. The discussion has moved away from a classical "public understanding of science" approach, aiming at transferring knowledge about scientific processes to the public, to a "science in society" approach where the public is engaged in the production of science. One practical approach to engaging citizens in the scientific process is co-design, and another is "citizen science" [13].

The term citizen science is used in different ways. For the purpose of this research, we view citizen science as a partnership between professional researchers and volunteers in which the volunteers implement tasks which have traditionally been implemented by scientists [14,15]. This cooperation is meant to serve two goals. First, it should create new scientific insights, most importantly by gathering large-scale or hidden data, which the researchers alone could not access or generate. Second, the partnership should produce an educational outcome for the participants, such as increasing knowledge and scientific interest.

Citizen science employs a cooperative approach to research. There are three possible models of cooperation that have been identified: (1) contributive, (2) collaborative, and (3) co-created [15,16]. In the contributive model, volunteers (the citizen scientists) contribute to data collection only. This may also be called "crowd sourcing" data. Note that this is different from researchers merely collecting data from or about participants. In the collaborative model, the citizen scientists may also be engaged in data analysis and interpretation. In the co-created model, the citizen scientists are involved in all stages of the scientific process, including assisting in defining the research questions and developing the research design [14–16].

In this project, instead of basing the evaluation of public green spaces on the researcher's value judgement, we trialed the citizen science approach with a co-created model. As citizen scientists, older people not only collected data but were also engaged in preliminary analysis of the data and, most importantly, contributed feedback and ideas on the methods, process, audit tool and the design of the proposed larger project.

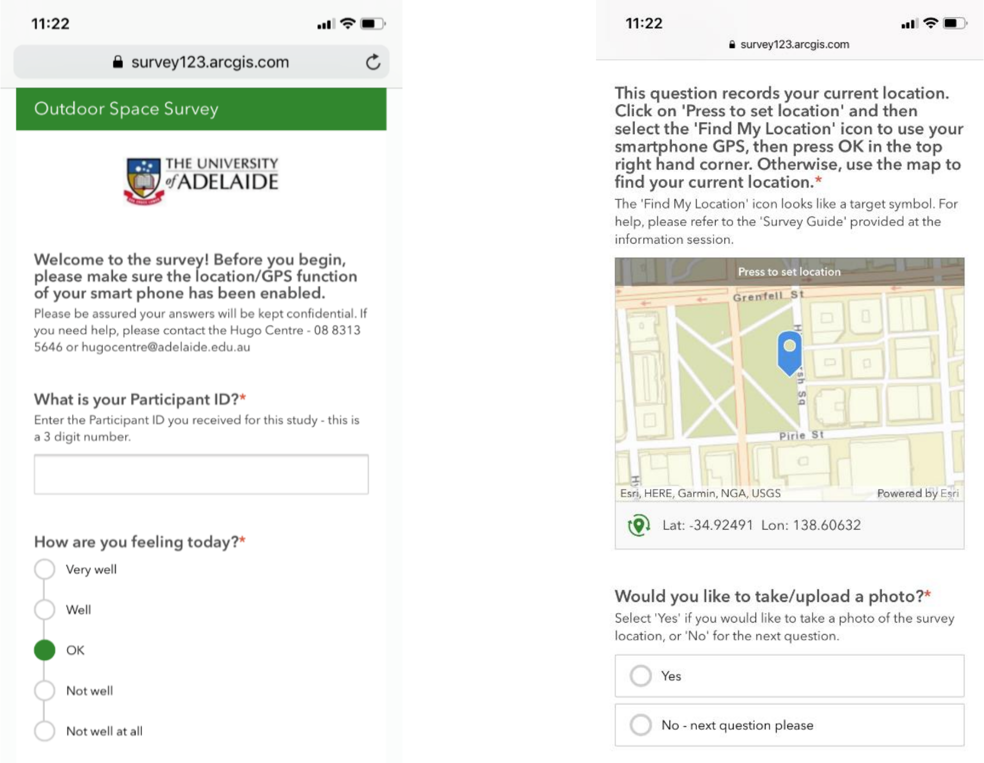
3. Materials and Methods

3.1. Development of Audit Tools

As well as trialing the citizen science approach to evaluate public green spaces, the pilot project developed and tested audit tools to be used by the citizen scientists to evaluate these spaces around their own neighbourhoods.

Two main audit tools were developed: (1) an online tool for a smart phone and (2) a field note booklet used in conjunction with a disposable digital camera that replicates the smart phone audit tool. The audit tools were developed through a combination of previous work by the research team in the field of built environment (yet to be published) and review of current literature. The tools developed for the pilot have not been tested for reliability or validity at this stage as this work is ongoing. Development of the audit tools included a set of printed instructions—including some safety tips regarding using a mobile phone while walking, and privacy legislation regarding taking photographs. The audit tools were trialed by the research team during development before participants were recruited to take part in the pilot study. Participants selected either the mobile-based or paper-based tool depending on their preference and comfort with, and access to, the appropriate technology.

The online tool was hosted on the ESRI platform, Survey123™ [17]. The audit tool allowed participants to record their experiences and perceptions in using public spaces in the course of their normal day-to-day activities, chiefly by responding to Likert scale questions relating to several key areas. They are: (1) the state of their general health and well-being at the time of the audit; (2) the space itself, including overall visual perception, state of cleanliness, feeling of safety/security, user friendliness, comfort, noise and busyness, lighting quality, and greenness; (3) the nature of the visit to the space, including purpose of visit (e.g., to relax, to meet with people, to exercise), average frequency of visits, length of time of this visit, mode of travel (e.g., walking, driving or by public transport); and (4) facilities available in that location (e.g., public toilets, seating, shade, drinking water availability). Critically for data analysis, the ESRI Survey123™ audit tool includes a location finder question, allowing each audit to be geocoded. The tool also allowed for uploading two photographs and a 250-character open text box for additional comments about the audit as additional qualitative data (see Figure 1). Each time a citizen scientist submitted the audit survey, the data were sent to the Hugo Centre’s ESRI online cloud-based service. This enabled the research team to validate the quality and frequency of the audits completed in real-time and offer individual support to participants regarding use of the auditing tool.



Welcome to the survey! Before you begin, please make sure the location/GPS function of your smart phone has been enabled.
Please be assured your answers will be kept confidential. If you need help, please contact the Hugo Centre - 08 8313 5646 or hugocentre@adelaide.edu.au

What is your Participant ID?*
Enter the Participant ID you received for this study - this is a 3 digit number.

How are you feeling today?*
○ Very well
○ Well
● OK
○ Not well
○ Not well at all

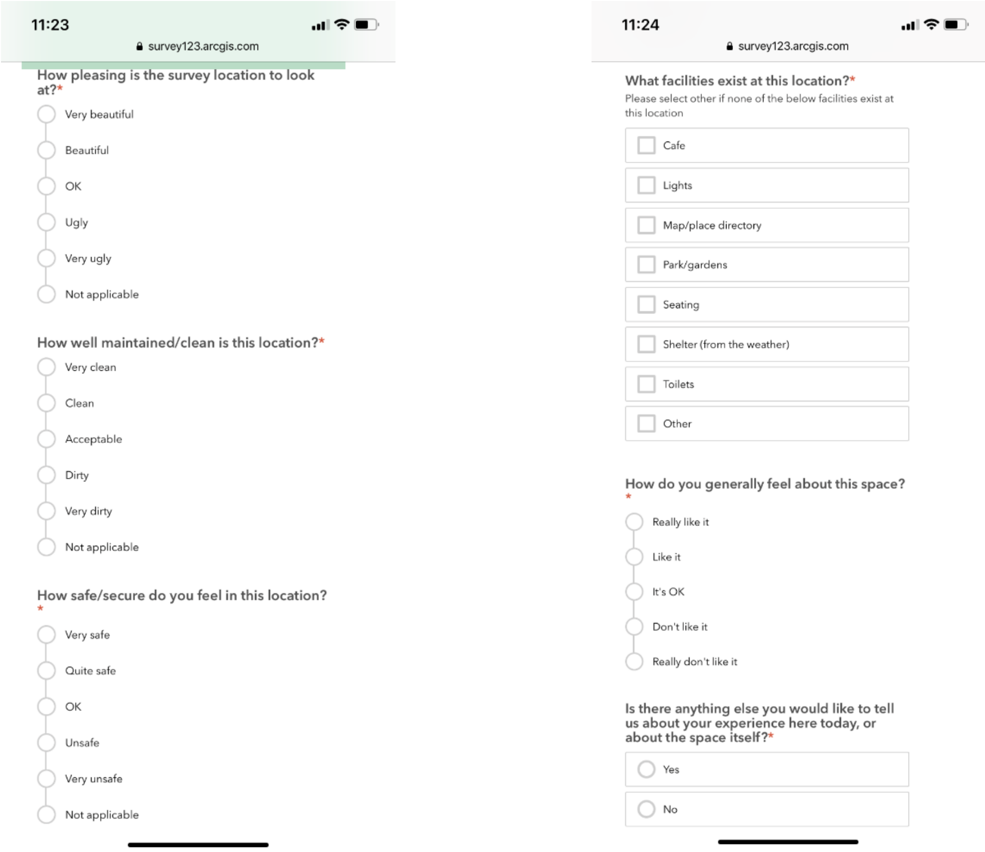
This question records your current location. Click on 'Press to set location' and then select the 'Find My Location' icon to use your smartphone GPS, then press OK in the top right hand corner. Otherwise, use the map to find your current location.*
The 'Find My Location' icon looks like a target symbol. For help, please refer to the 'Survey Guide' provided at the information session.

Lat: -34.92491 Lon: 138.60632

Would you like to take/upload a photo?*
Select 'Yes' if you would like to take a photo of the survey location, or 'No' for the next question.
○ Yes
○ No - next question please

a b

Figure 1. *Cont.*



11:23
survey123.arcgis.com

How pleasing is the survey location to look at?*

○ Very beautiful
○ Beautiful
○ OK
○ Ugly
○ Very ugly
○ Not applicable

How well maintained/clean is this location?*

○ Very clean
○ Clean
○ Acceptable
○ Dirty
○ Very dirty
○ Not applicable

How safe/secure do you feel in this location?
*

○ Very safe
○ Quite safe
○ OK
○ Unsafe
○ Very unsafe
○ Not applicable

c

11:24
survey123.arcgis.com

What facilities exist at this location?*
Please select other if none of the below facilities exist at this location

☐ Cafe
☐ Lights
☐ Map/place directory
☐ Park/gardens
☐ Seating
☐ Shelter (from the weather)
☐ Toilets
☐ Other

How do you generally feel about this space?
*

○ Really like it
○ Like it
○ It's OK
○ Don't like it
○ Really don't like it

Is there anything else you would like to tell us about your experience here today, or about the space itself?*

○ Yes
○ No

d

Figure 1. Outdoor Space Audit Tool (screen capture from a smart phone): (**a**) shows the opening screen of the audit tool; (**b**) shows the location data and photograph questions; (**c**) and (**d**) show examples of the questions from the audit tool.

3.2. Recruitment and Training

Older citizen scientists were recruited through advertisements in the "Weekend Plus" magazine, an online weekly magazine produced by the Office for Ageing Well (Previously the Office for the Ageing) available to South Australians eligible for a Seniors Card. Recruitment also took place through the newsletter of the Adelaide City Council (ACC) and on the "Plug-In" community website of the Council of the Ageing (COTA) SA. The latter was the most successful recruitment route with most senior citizen scientists becoming part of the research team through the COTA site. Human research ethics approval was obtained from the Human Research Ethics Committee, South Australian Department for Health and Wellbeing, approval number HREC/18/SAH/42.

Thirty-two participants expressed an initial interest in becoming citizen scientists, with 20 signing up for a training workshop. Due to a variety of personal circumstances (illness, travelling and timing of the workshops), only 15 citizen scientists completed the training. Most (12) took part in a 90-min face to face workshop, with two receiving training over the phone and one face to face individually as they were unable to attend the workshop. All participants were provided with an easy to use, brief manual as a follow-up to training. Participants were also offered email and phone support from the research team to deal with any issues during the audit process as well as tailored individual support based on real-time validation of the frequency and usage of the audit tool.

Before citizen scientists were introduced to the audit tool, they were asked to complete an introductory survey, also hosted in the Survey123™ platform. This survey, which collected user demographic information, was opened for data collection at the commencement of each training session and was secured thereafter given that it contained personal information related to the citizen scientist. At completion of the introductory survey, citizen scientists were assigned an ID for use with data collection. This further anonymized the audit data collection process but allowed demographic data to be linked with audit data.

During induction, for those who selected the online audit tool, the link to the survey was placed on the citizen scientist's mobile phone home screen for ease of access– giving the impression of an "app". Those using the paper-based audit tool were given a booklet where each audit could be completed on one page to make field observations more convenient. They were also provided with a digital camera with which to visually record their location and reply-paid envelopes for returning audit sheets and the camera. Capturing data in situ gave citizen scientists the opportunity to provide "real-time" data which limited the introduction of recall bias to the study.

3.3. Deployment

Citizen scientists were given between six and ten weeks to conduct audits, using the tools provided, of any public green spaces they visited as part of their daily activities. We did not assign any specific spaces to go to; the idea was to let the citizen scientists conduct the audit without changing their normal routines. This ensured that audits mainly took place within the "life spaces" of citizen scientists, places and spaces that were part of their everyday lives and that were meaningful to them. There was no restriction as to how many audits to complete or where to complete them. Some citizen scientists took the audit tool with them when they travelled and even conducted audits outside South Australia. There were four email reminders sent during the data collection period to encourage citizen scientists to continue with their audits, wish them Happy Christmas and inform them of the closing date for audit uploads as the end of the data collection period approached.

3.4. Interviews and Co-Analysis

When the data collection period ended, each citizen scientist was invited to take part in a 1:1 interview with the research team during which several elements of the project were discussed. As well as exploring the data itself, the research team was interested in each citizen scientist's views of the process regarding recruitment, use of the online or paper audit tool, survey content, and thoughts on how the data could or should be analysed. Along with autonomy and direction over data collection, it is this element of engagement which sets citizen science apart from usual data collection. One could argue that respondents are generally part of the research process since the submission of their data is the substance of this type of research; however, participation in decision-making around data collection interpretation and analysis is not a usual component of research.

At the interview, each participant was given a folder which contained three sections: the first was the aggregated, de-identified data from all participants; the second was their collated individual data; and the third was each individual audit they had carried out. During the interview, it was then easy to compare the individual's collated data with the aggregated dataset from all participants, drawing conclusions about consistent trends and outliers in the data. Discussing individual audits provided an opportunity to gain a deeper understanding of the thought processes and differing interpretations of public green spaces made by the citizen scientists. As this was an iterative process, it allowed the research team to build a deeper understanding of the data set.

3.5. Analysis

Audit data consisted of three key elements: (1) spatial data; (2) preliminary demographic survey and Survey 123™ audit data and (3) recorded and transcribed interview data. Analysis of data consisted of three different approaches:

1. Spatial data, based on geocoded audit points (linked to the home address of each citizen scientist from the preliminary demographic survey) extracted from ArcGIS Online, was analysed using ESRI's spatial analysis software (ArcMap 10.6.1). In particular, mapping of spatial data focused on

creating spider maps for individual participants (where their home address formed the centroid point and the audit locations formed points linked to this centroid) as these were considered the most appropriate way to view the life spaces of individual citizen scientists. Spatial audit data were also viewed by demographic variables for potential themes; for example comparing audits for people who lived alone, by age or gender, and by audit variables, for example: measuring distance from home location to audit sites for public green spaces accessed by walking, or comparing location attributes where the length of visit was stated as less than 15 min.

2. Quantitative data from both the preliminary demographic survey with each citizen scientists and the public green space audits were analysed using SPSS Statistics Version 26. Due to the small number of participants, this provided descriptive statistics only.
3. Qualitative data in the form of the photographs and open-ended text comments from the public green space audits and the transcribed interviews with citizen scientists were analysed using an inductive thematic approach using NVivo 12. An inductive approach to thematic analysis allows research findings to emerge from the frequent, dominant or significant themes inherent in raw data. This was considered particularly important for use with open text comments on the audits and with exploring the photographs where citizen scientist responses were organic and not guided by interviewer questions or interests.

4. Results

4.1. Study Participants

Of the 15 Citizen Scientists taking part in the pilot study, 12 were female and three were male; they ranged in age from 60 to 84 years with four aged 70 + years and the remainder aged 60–69 years. Three lived alone and ten lived with a partner or spouse while one citizen scientist lived with relatives other than a partner or spouse. Thirteen of the citizen scientists were living in the Greater Adelaide metropolitan region at the time of project; with two living in rural towns outside the city region. All were retired at the time of the pilot study. Thirteen were still driving and 12 considered their self-rated health to be good or very good.

In total, 15 participants submitted 264 audits over a three-month period; this varied from 6 to 47 audits for individual citizen scientists, with an average of 17.6 audits. Some citizen scientists began data collection in October 2018 with a rolling recruitment and induction until mid-December 2018. Data collection halted on 31 January 2019. Follow-up interviews were conducted with 12 participants in February and early March 2019, with three citizen scientists unavailable for interview at this time due to travel commitments or illness.

4.2. Use of the Audit Tool

All citizen scientists were regular and confident users of smart phones prior to the pilot study. Two participants elected to use the paper-based version of the audit tool even though they owned smart phones, while the remaining 13 elected to use their smart phones to do the audit. Of the two citizen scientists who chose to use the paper-based version, one (female, aged 83) chose this method because she was a keen photographer and preferred to take photographs for the audits with her digital camera. The second (female, aged 62) was not confident using her older mobile phone and was concerned her limited data allowance would not cope with the audit tool requirements. Both of these citizen scientists posted the audit forms back to the research team to be entered into the online system. One uploaded her audit photographs into Google Drive™ while the other brought the camera in and researchers retrieved the photographs. At the post-audit interview both said they would have been happy to enter their own data into an online system via their home computer had this been an available option, emphasizing their comfort levels with technology.

The research team allowed two hours for training workshops and 90 min for 1:1 training either face to face or via the telephone. This included time to go through the consent process for research, provide some background information on citizen science methods and approaches, uploading the online audit tool to participants' smart phones, completing the background survey, going through the audit questions and options for answers, and some time to practice using the audit tool. In fact, the workshops were completed in less than one hour, with less than 30 percent of this time needed to install and trial the online audit tool to a level where participants felt confident using it. The three participants unable to attend the workshop who were trained over the phone or face to face managed to work through the information and training in less than 45 min.

All participants were offered telephone and email backup assistance during the data collection process. Only two queries were received from participants during the data collection period, both related to online connectivity and data usage rather than issues with the online audit tool itself. In addition, at the post-audit interviews, three citizen scientists suggested they had been unsure they were "doing it right" as the audit tool did not indicate to the user that uploads had been successful after pressing the submit button. However, it should be noted that data collected in the audit process had a very high completion rate (there were no skipped questions in any audits) and there were also high rates of photograph uploads and free text comments. Of the 264 audits, over 99 percent had at least one photograph uploaded (with just over 40 percent having a second photo), 95 percent had correctly used the geocoded location finder, and over 73 percent (n = 195) included a short, open-ended comment.

Post-audit interviews were structured so that citizen scientists were first asked about the usability of the audit tool. Overall, citizen scientists liked the questions that had been included in the survey. The only question that was generally thought irrelevant asked "how are you feeling today?" The general sentiment here was that if they were not feeling okay they would not be out doing an audit. The most difficult aspect of using the audit tool appears to have been using the "target" GPS locator. While most audits were geocoded correctly, users were unsure at the time of the audit that they were correct, and this seemed to cause a slight anxiety for a few citizen scientists. However, most agreed that, overall, the technology had been simple to use, the audits were easy and quick to complete, and they felt confident that unassisted training via an online video or training package and/or with a training manual would have been possible. Over half said they had enjoyed the immediacy of the data collection process (audits done in situ and data uploaded straight away) but some would have preferred to complete the audits in situ and then upload data later using Wi-Fi.

In the post-audit interviews, citizen scientists were also asked to comment on the amount of direction they were given in terms of what to audit and where. Some felt that they had understood the brief very well and were confident that they had managed to capture the themes of the pilot study. Others felt that they would have liked more direction regarding what to audit. Suggestions for more guidance included having a "checklist" of potential audit sites for future projects, others felt being able to view de-identified data through access to the project's ArcGIS website, or being able to connect with other citizen scientists in the pilot, would have encouraged them to consider other spaces they could audit.

4.3. Overview of Audit Data

While the analysis of the audit data was not the focus of the pilot study, it does provide some insight into the approaches to data collection taken by citizen scientists. Audits were carried out in a wide variety of places under the broad remit of public green spaces. Half of all audits were carried out within 1.6 km (straight line distance) of the citizen scientist's home, with the rest being a mixture of regular activities or outings as part of everyday life (walks with friends, visiting relatives, being on holidays or socializing with others). As such, it is considered that all audits reflected the natural life spaces of citizen scientists. Only 11 audits (0.4%) were classed as "other" or not being "a green space" (described by the categories of "very green", "somewhat green", "mixed bare and green", "mostly bare" on the Likert Scale response). These included spaces such as cafés, the theatre or library, and shopping precincts. Of the other 253 audits, 70 percent, were considered very green or somewhat green. These public green spaces varied from more formal parks, gardens and streetscapes in local neighbourhoods (as seen in Figure 2a) to more natural forest or bushland settings (see Figure 2b).

a b

Figure 2. Examples of public green space images uploaded with audits. Figure (**a**) shows a more formal park space while (**b**) highlights some of the more natural "bushland" spaces.

Several key design elements of public green spaces were identified in the analysis of both audit free text comments and photographs through inductive coding using NVivo12. Seating received the most references (97), followed by street trees (96), natural bushland (93), park trees (87) and water (in terms of creeks, lakes, rivers and the ocean) (51). Citizen scientists were asked several questions about the spaces they were auditing, including "Why have you come to this location?"; "How long do you usually spend here?" and "How did you get here?". By far the common response to the first of these questions was "On my way to somewhere else" ($n = 128$), with the next three most common responses being "To relax" ($n = 58$), "To exercise" ($n = 54$) and "To meet others" ($n = 52$). In accordance with the responses to this first question, the most frequent response to "How long do you usually spend here" was "Less than 15 min" ($n = 99$) followed by "15 to 30 min" ($n = 48$). When looking at mode of transport in relation to both of these responses the most usual form of mobility by far was "walked" ($n = 132$). These responses, along with the fact that just over half of all audits were less than 1.6 km from home, suggests audit data relates to local neighbourhood engagement, which was reinforced in some of the open comments associated with the audits:

> "*I frequently pass these places when out walking or on my way to the shops or library. A combination of council and resident plantings make the route very pleasant to use*" *[ID133]*

> "*My streetscape. I walk down this street a number of times a day on the way to shops and or beach nearby*" *[ID186]*

In terms of creating a series of neighbourhood audits indicative of use of local public green spaces, open text comments appeared to reflect on the attributes of their local neighborhoods, the elements of good design that appealed to them and the impact the built environment had on their sense of wellbeing, as highlighted by these comments:

> *"I go out of my way to ride down this road- trees, birds and plants along tram line give street a calming uplifting effect" [ID199]*

> *"The building design enables conversation. Easy to hear!" [ID193]*

> *"I choose this bus stop in preference to others purely because of the trees, grass, flowers and birds" [ID133]*

4.4. Participant Reflections on Senior Citizen Science

The post-audit interviews with participants also offered the opportunity to reflect on the citizen science process. The most common response to the question regarding the most enjoyable aspect of the experience was that our citizen scientists took greater notice of their physical surroundings as a result of the audit process; in particular, photographing these public green spaces seemed to be the catalyst for a closer examination at their everyday life spaces.

> *"It really brought home to me how I choose my routes and my activities according to how much green space I can walk through or stop and have a rest in" [ID118]*

> *"Yes, it did make me think a little bit more about the environment and how it can be made more conducive to people walking and doing recreational activities" [ID101]*

> *"I think it was that thing of being more aware of your physical environment – like if I was with a friend and he or she would be saying 'hurry up' and I'd say 'no look at this . . . ...yes it heightens your awareness" [ID110]*

As part of this reflection, citizen scientists also offered suggestions on design of the larger project. These suggestions fell into three clear themes: (1) more engagement by citizen scientists in co-designing the audit tool and methodology; (2) providing a greater range of roles for citizen scientists beyond data collection, including elements of data cleaning, analysis, co-design workshops and activities that use the audit results (for example re-development of case study sites in the community or working with design students to create models of innovative public green spaces) and (3) creating a variety of ways to engage citizen scientists in the whole project– for example, through e-newsletters; an interactive web page that includes chat functions and de-identified aggregated data; short text messages updating citizen scientists on data collection progress (both individual and team progress), and opportunities to provide feedback on publications, reports and other forms of dissemination.

5. Discussion

A pilot study on the use of a citizen science approach to explore influences of neighbourhoods, particularly public green spaces, on daily lives of older people has been conducted. An on-line audit tool installed on the smart phones of older people, as citizen scientists, was developed by the research team and trialed by 15 trained citizen scientists. The citizen scientists were involved not only in data collection but also in data interpretation and preliminary analysis, as well as contributing to a review of the audit tool and overall study. Several themes on the use of citizen science for understanding the life spaces of older people have emerged.

5.1. Comfort Levels with New Technology

Older people, as citizen scientists, demonstrated high comfort levels with technology and therefore comfort with technology should not be underestimated among an older population when designing research projects. This small pilot study showed that participants were capable and eager to use technology to engage with science; although it is important to still have alternative means for all older people to fully participate in citizen science. While restricted to a small participant group, this confidence with digital technology was evident through several components of this study. Firstly, the high selection rate for using the online audit tool with a smart phone, where even participants who used a paper-based version of the audit tool had smart phones and all participants were comfortable communicating with the research team by email during the audit process. Secondly, the training process required much less time and interaction than anticipated, with a high rate of participants suggesting at the post-audit interview that they would have been comfortable carrying out training via a video and/or using a training manual. Thirdly, the small number of participants who requested assistance throughout the data collection period suggests participants were comfortable with the technology and audit process.

While this study is indicative of the increasing comfort levels older adults have with technologies, it also highlights the improved user friendliness of new technologies and tools such as the Survey123™ audit tool. High levels of compliance in audit submissions (no skipped questions) and high rates of uploading of photos and optional open-ended text comments suggest the audit tool platform is both user friendly and suitable for the general public. However, there were some issues with the audit tool that need to be addressed. For example, the need to manually geocode current location, either by pressing the target button to find current location, or by manually moving the map to show locate current location, can mean one of the most critical elements of the data collection tool (knowing where the audit has been conducted) may become unreliable. Secondly, a simple message to let users know that the audit data has been successful submitted would give users more certainty that their audit was complete. However, while there are some minor issues with the Survey123™ platform the advantages of in situ data collection, time and date stamped geocoded data, being able to include both photographic and free text data, and the fact that the software is available in over 30 languages makes this an ideal tool for use with older citizen scientists.

Of course, this pilot engaged a small, self-selected group of adults interested in participating in citizen science and may not represent the general older population. Further work needs to be done with wider groups of older adults, including those with reduced mobility, greater frailty and/or poorer health, and from different cultural backgrounds to test both the potential and reliability of the audit tool. Understanding the relationship between ageing and the built environment—particularly the potential value of age friendly environments—is critical for all older adults, not just those who are technology adept, fit and active. Further pilots are being planned using the audit tool with more frail older populations under different circumstances—for example in The Netherlands and Poland we are hoping to trial the audit tool in 2020 by pairing frail older adults with gerontology students in order to audit local neighborhoods for age friendliness.

5.2. The Audit Tool as a Medium to Reflect on Public Green Spaces

Citizen scientists felt they had thought more deeply and reflected on their own engagement with the built environments they lived and interacted in through the audit process. We feel the audit tool gave older people a medium to look critically at their neighbourhoods and lived environments in order to reflect on and understand more fully what components of their neighbourhoods they liked and did not like, and not only what they utilised but also where and why. While the audit tool alone allowed for the collation of data on this usage, along with pictures and qualitative expressions of their neighbourhood public green spaces, it was the follow-up interview that offered the opportunity to reflect on this more fully, by looking at the neighbourhood audits as a whole, highlighting both spatial and behavioural patterns of usage.

Of note for this pilot, these patterns of interaction with public green spaces in local neighbourhoods may be seen as transition points or "green corridors"—a conduit to everyday life rather than necessarily destinations in themselves. This was aptly summed up by one citizen scientist: *"I'm passing in transit. I have been thinking that this is my contact with many green spaces rather than visiting. I will record more of these"* [ID102]. This suggests how we could think about the design of neighbourhood public green corridors—with better pathways, more opportunities to sit and rest, points of interest along the way (through art, play, exercise equipment, or mediums for interaction with others). This may create spaces that act as links for community points of interest and activity (shops, public amenities, libraries and other public facilities, transport links and so forth); encouraging older people to use public green spaces for social and civic engagement, incidental exercise and as a way of engaging with nature without necessarily being destinations in themselves.

5.3. The Value of Citizen Science

This pilot highlights that even a small number of citizen scientists can tell us a lot about the built environment they interact in because of the high volume of audits they can produce in a short amount of time. With very few prompts, 15 citizen scientists produced 264 neighbourhood audits in this pilot study, with most saying they felt they could have completed more in the same time frame with more reminders. This is far beyond the scope of a small university-based research team alone and highlights the effectiveness of citizen science for data collection. The added value of using an online tool is that data collection could be carried out anywhere and is not limited to the geographical location of the university-based research team. Citizen scientists could theoretically be based anywhere in the world and submit geocoded, date and time stamped audits online in their own language, enabling data to be collected from a wide variety of locations simply and effectively.

The over-riding reflection on citizen science for participants in this pilot study was that it was an engaging use of their time where they felt they were contributing something of value to science as well as potentially improving outcomes for the neighbourhoods in which they lived. They appreciated the opportunity to examine their own data, the de-identified aggregated dataset and to reflect on the research tools and processes through the post-audit interviews. Participants showed a keenness to be further engaged with future citizen science projects beyond just data collection, indicating that whenever possible they would like to be involved in all stages of future research projects. Citizen science projects should make the most of this enthusiasm and engage citizen scientists early in the process. As with all research teams, citizen scientists bring different skill sets and interests to projects and these assets should be utilised to the project's advantage by offering a range of activities to be engaged in, including data cleaning and analysis; co-design and planning of improved neighbourhood spaces, and presentation and dissemination of research outcomes.

6. Conclusions

Citizen science is a valuable tool for the social sciences, in particular for exploring the built environment and life spaces of older people. While the tools used in this pilot study have not yet been tested for reliability or validity, the outcomes of the pilot study show that further testing and retesting of the audit tools is a worthwhile future exercise. Further work also needs to be done of trialing the audit tool with different population groups, including frailer and less mobile older people and older people from different cultural backgrounds and in different geographical locations.

While this pilot study has focused on public green spaces it is felt that a citizen science approach using an audit tool that focuses more broadly on age friendly neighbourhoods would provide an opportunity to evaluate age friendly communities from the perspective of older people. The number of age friendly neighbourhoods and communities have expanded rapidly worldwide in the past 10 years; yet little work has been done in this time evaluating the differences age friendliness makes to the lives of those living in these communities. Such an audit tool offers opportunities to collect and collate data from the unique perspective of older people in these communities. Most importantly, the insider knowledge of older people about their own neighbourhoods has shown to be a valuable contribution to social science through the conceptual learning and deeper observation that citizen science offers. As cities and neighbourhoods around the world continue to adopt age friendly principles for the built environment, citizen science projects such as this pilot study offer sound approaches to evaluating and understanding the value of these approaches for creating better places to age well.

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H.B., V.S., F.M.C.-B., L.W.; writing—review and editing, H.B., V.S., F.M.C.-B., J.L.; Project administration, F.M.C.-B.; Funding acquisition, H.B.

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References

1. Mensah, C.A.; Andres, L.; Perera, U.; Roji, A. Enhancing quality of life through the lens of green spaces: A systematic review approach. *Int. J. Wellbeing* **2016**, *6*, 142–163. [CrossRef]
2. Kabisch, N.; Qureshi, S.; Haase, D. Human-environment interactions in urban green spaces: A systematic review of contemporary issues and prospects. *Environ. Impact Assess. Rev.* **2015**, *50*, 25–34. [CrossRef]
3. Grose, M. Changing relationships in public open space and private open space in suburbs in South-Western Australia. *Landsc. Urban Plan.* **2009**, *92*, 53–63. [CrossRef]
4. Hoopera, P.; Boruffb, B.; Beesleya, B.; Badlandc, H.; Giles-Coric, B. Testing spatial measures of public open space planning standards with walking and physical activity health outcomes: Findings from the Australian national liveability study. *Landsc. Urban Plan.* **2018**, *171*, 57–67. [CrossRef]
5. United Nations. *Population 2030: Demographic Challenges and Opportunities for Sustainable Development Planning (ST/ESA/SER.A/389)*; Development of Economic and Social Affairs, Population Division: New York, NY, USA, 2015.
6. ABS. 2016 Census QuickStats. Australian Bureau of Statistics. Available online: https://quickstats.censusdata.abs.gov.au/census_services/getproduct/census/2016/quickstat/4GADE?opendocument (accessed on 2 October 2019).
7. WHO. *Global Age-Friendly Cities: A Guide*; World Health Organization: Geneva, Switzerland, 2007.
8. Bentley, R.; Jolley, D.; Kavanagh, A.M. Local environments as determinants of walking in Melbourne, Australia. *Soc. Sci. Med.* **2010**, *70*, 1806–1815. [CrossRef] [PubMed]
9. Sugiyama, T.; Francis, J.; Giles-Corti, B. Neighbourhood park attributes (attractiveness, size and distance) associated with residents' leisure-time walking. *J. Medicine Sport* **2010**, *12*, e57. [CrossRef]
10. Hoffimann, E.; Campelo, D.; Hooper, P.; Barros, H.; Ribeiro, A.I. Development of a smartphone app to evaluate the quality of public open space for physical activity. An instrument for health researchers and urban planners. *Landsc. Urban Plan.* **2018**, *177*, 191–195. [CrossRef]
11. Wahl, H.W.; Oswald, F. Theories of environmental gerontology: Old and new avenues for person-environmental views of aging. In *Handbook of Theories of Aging*, 3rd ed.; Bengston, V.L., Settersten, R.A., Jr., Eds.; Springer: New York, NY, USA, 2016; pp. 621–641.
12. Lawton, M.P. Environment and other determinants of well-being in older people. *Gerontologist* **1983**, *23*, 349–357. [CrossRef] [PubMed]
13. Heiss, R.; Matthes, J. Citizen science in the social sciences: A call for more evidence. *GAIA-Ecol. Perspect. Sci. Soc.* **2017**, *26*, 22–26. [CrossRef]
14. Ankeny, R.; Barrie, H. Learning Not Just from but with Citizens: The Importance of Co-Design in Health-Related Social Research. *Am. J. Bioethics* **2019**, *19*, 54–56. [CrossRef] [PubMed]
15. Bonney, R.; Phillips, T.B.; Ballard, H.L.; Enck, J.W. Can citizen science enhance public understanding of science? *Public Underst. Sci.* **2016**, *25*, 2–16. [CrossRef] [PubMed]
16. Bonney, R.; Ballard, H.; Jordan, R.; McCallie, E.; Phillips, T.; Shirk, J.; Wilderman, C.C. *Public Participation in Scientific Research: Defining the Field and Assessing Its Potential for Informal Science Education*; A CAISE Inquiry Group Report; Center for Advancement of Informal Science Education (CAISE): Washington, DC, USA, 2009. Available online: http://files.eric.ed.gov/fulltext/ED519688.pdf (accessed on 6 October 2019).
17. ESRI. Survey123 for ArcGIS. Available online: https://survey123.arcgis.com/ (accessed on 2 October 2019).

healthcare

MDPI

Review

Mobile Self-Monitoring ECG Devices to Diagnose Arrhythmia that Coincide with Palpitations: A Scoping Review

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Abstract: The use and deployment of mobile devices across society is phenomenal with an increasing number of individuals using mobile devices to track their everyday health. However, there is a paucity of academic material examining this recent trend. Specifically, little is known about the use and deployment of mobile heart monitoring devices for measuring palpitations and arrhythmia. In this scoping literature review, we identify the contemporary evidence that reports the use of mobile heart monitoring to assess palpitations and arrhythmia across populations. The review was conducted between February and March 2018. Five electronic databases were searched: Association for Computing Machinery (ACM), CINHAL, Google Scholar, PubMed, and Scopus. A total of 981 records were identified and, following the inclusion and exclusion criteria, nine papers formed the final stage of the review. The results identified a total of six primary themes: purpose, environment, population, wearable devices, assessment, and study design. A further 24 secondary themes were identified across the primary themes. These included detection, cost effectiveness, recruitment, type of setting, type of assessment, and commercial or purpose-built mobile device. This scoping review highlights that further work is required to understand the impact of mobile heart monitoring devices on how arrhythmias and palpitations are assessed and measured across all populations and ages of society. A positive trend revealed by this review demonstrates how mobile heart monitoring devices can support primary care providers to deliver high levels of care at a low cost to the service provider. This has several benefits: alleviation of patient anxiety, lowering the risk of morbidity and mortality, while progressively influencing national and international care pathway guidelines. Limitations of this work include the paucity of knowledge and insight from primary care providers and lack of qualitative material. We argue that future studies consider qualitative and mixed methods approaches to complement quantitative methodologies and to ensure all actors' experiences are recorded.

Keywords: cardiology; wearable devices; community care; primary care; technology; clinical care; scoping review

1. Introduction

In the past two decades, there has been a phenomenal increase in the take-up of wearable mobile devices, with many facilitating the measurement of a variety of health outputs. While many of these devices are basic, there are a number of devices that offer clinician-level diagnostic evaluations. According to Public Health England (PHE), in the United Kingdom (UK), there are 1.4 million people or 2.5% of the population who have atrial fibrillation (AF) [1]. Given the rise of these estimated projections in addition to PHE purporting AF increases with age, in particular, with 80.5% of the English population aged 65 years and over experiencing AF and a further 985,000 people living in England, UK, with undiagnosed AF, equating to 425,000 people [1]. Moreover, there are global implications: the United Nations (UN) estimate that there will 8.6 billion people by 2030, increasing to 9.8 billion in 2050 [2]. Consequently, there is an opportunity to determine whether mobile devices can provide a timely and cost-effective solution to identify the risk of AF.

The purpose of this review is to explore the current trends in the use of wearable stand-alone devices capable of recording the electrical activity of the heart electrocardiogram (ECG/EKG) used for the detection of cardiac arrhythmias associated with palpitations.

People describe palpitations as a feeling that their heart is pounding or fluttering or that their heartbeat is irregular [3,4]. These feelings can last from a few seconds to several minutes and patients often perceive them as a serious cause for concern [3,4]. There are many reasons for palpitations including changes in emotional or psychological state, the use of hormones, prescribed and illegal drugs, excessive alcohol, smoking, strenuous exercise, and excessive consumption of caffeinated drinks. In most cases, palpitations invariably raise a person's anxiety, leading to increased visits to their General Practitioner (GP) or hospital. Furthermore, it has been established that palpitations are connected to greater morbidity, a higher risk of stroke, heart failure and an increase in risk of mortality [5–9]. In the UK, the internationally recognised organisation "The Arrhythmia Alliance note four out of 100 people aged ≥65 years are affected by AF one of the most common types of arrhythmia (AR)" [3]. Patients present with varying symptoms including palpitations, shortness of breath or chest pains. However, some people may not display any symptoms, but other indications will lead to detection [3]. Repeated visits to the GP lead to the phenomenon of the 'worried well': patients who may feel they are wasting health practitioners' time and adding unnecessary costs on to the health service. However, people's quality of life (QOL) is severely affected by this health complaint. If AR is suspected, the current recommended advice is to monitor a patient either in a hospital environment or to wear a 24-h ECG device such as Holter monitor [3,4]. The recent development of substantially cheaper wearable technologies provides a challenging alternative to the traditional approach.

Given the rise in ageing populations, a reduction in health care services and additional strains on the delivery of primary care, there is a greater need to explore alternative, accurate and cost-effective solutions to detect and diagnose AF. Mobile ECG devices are worth considering because they can reduce the diagnosis time and have the potential to be cost effective, while enabling heart activity to be monitored over a prolonged period [10]. By contrast, the traditional alternatives are uncomfortable to use and can only be worn for a very limited amount of time or, in the case of implanted loop recorders, they require invasive surgery [11]. Moreover, since 2010, wearable devices such as Fitbit devices, Jawbone UP, Garmin Vivofit and Misfit Shine have increasingly been used to monitor and analyse one's daily activity through self-tracking users' progress over time. Usually, goal-oriented [12] tasks over a set period are agreed by the user (i.e., walk 10,000 steps per day). In addition, these devices often offer rudimentary Heart Rate (monitoring). The user can then review their progress, share their data with their friends, family and health practitioner (i.e., physician, nurse or consultant). Contemporary evidence provides an insight into the use of mobile heart monitoring via wearable devices to measure heart rate and rhythm [9,13–15]. Cheung, Krahn, and Andrade [9] discuss the current and ongoing developments of wearable devices, which have entered the consumer market at a phenomenal rate. Consequently, physiological data, sleep patterns, Heart Rate (HR) and much more have been tracked. Cheung, Krahn and Andrade described the various wearable devices that have the ability to track HR and AR [9]. Nonetheless, Cheung, Krahn and Andrade note that one of the limitations of wearable devices is the level of accuracy, which has only been evaluated on small sample sizes of patients presenting with unique symptoms [9]. Furthermore, Cheung, Krahn and Andrade argue that the suitability of wearable devices for detecting or for the treatment of AF within clinical settings remains unanswered [9].

1.1. Overview of Mobile ECG Devices

There are several mobile ECG devices available on the market. Firstly, the HeartCheck™ ECG Pen [16] has received Food and Drug Administration (FDA) approval for monitoring AR. The user/patient does not require a prescription to access/use the device and has Internet access to a qualified physician. The HeartCheck™ device is easily transportable given the size of the device—similar to a pen—and enables the user/patient to take their reading(s) anywhere [15]. Quinn et al. [17] conducted a clinical trial with the HeartCheck™ ECG Pen involving 22 primary care clinics, 2054 participants aged 65 years and older (mean age = 73.7 ± 6.9). Participants had to be attending clinics/appointments on a regular basis and were required to undertake three different types of screening methods in the trial. The first screening method was a 30-s radial pulse check and the second a single-lead ECG. The third consisted of a screening blood pressure machine with AF detection. Participants who presented positively with one or more tests were then required to undergo a 12-lead ECG with or without 24-h Holter. Participants with confirmed AF received a 90-day follow up. The overall findings [16] showed the single-lead ECG and the blood pressure devices to have superior specificity in comparison to the pulse check. Fifty-six (2.7%) participants were confirmed with AF: 12 newly diagnosed and 44 previously diagnosed.

The EMAY mobile ECG device [18] is available to purchase from Amazon for £79.00. The company states the device is 'intended for initial evaluation' and 'not for medical diagnostic use' [18]. The EMAY device is used by both hands when taking a reading and can be used anytime and anywhere. The EMAY website notes patients with a myriad of health conditions such as chronic disease, coronary heart disease, diabetes, hypertension, myocarditis, obesity, chest pain, palpitations and dyspnea can use the device [18]. Additional information on the EMAY website states several 'cardiac situations that could be detected' that include missed beat, tachycardia, bradycardia, arrhythmia, Accidental Ventricular Premature Beats (VPBs), VPB trigeminy, VPB bigeminy, VPB couple, VPB runs of 3, VPB runs of 4, VPB RonT, ST elevation, and ST depression [18]. To date the clinical trials website returned no registered clinical trials using the EMAY mobile ECG device [19].

The Beurer ME 90 Bluetooth® mobile ECG device purports to accurately monitor and record users/patients heart rhythm on the go, or at home. This device is compatible with iOS 8.0, Android 4.4, Bluetooth 4.0 or above platforms. The device is categorised as a medical device and users/patients have the ability to transfer recordings over Bluetooth. The Beurer ME 90 Bluetooth® has a USB portal and has storage for 36 recordings. The device is CE marked and is covered by German health insurance and pharmaceutical legislation [20]. To date, the clinical trials website returned no registered clinical trials using the Beurer ME 90 Bluetooth®. The device is available to purchase from Amazon DE for €137.72 or through a third party for approximately £134.55.

The AliveCor Kardia Mobile ECG device is available to purchase directly from the company website or via other third-party websites for £99.00. The AliveCor device is available on both Android and iOS platforms and it is noted the device should not be used with pacemakers or ICDs [21]. AliveCor state that the device can detect AF instantly and is CE marked with positive National Institute for Health Care Excellence (NICE) advice. AliveCor Kardia [21] declare the device has been clinically proven and is used by leading cardiologists. Users/patients can track their weight and blood pressure within one app and has the option to take unlimited EKG recordings. Users can take a recording in 30 s using their thumbs pressing down on the pads. Users have additional options to pay for a premium membership, which enables them to receive unlimited history and storage of EKG, and monthly reports. To date, the company website reports a total of 69 peer-reviewed articles [22] using the AliveCor mobile ECG device within a myriad of varying health cohorts and chronic diseases.

1.2. Background Literature

Limited studies have examined how wearable devices perform compared to the Holter ECG. For example, Pevnick et al.'s [23] retrospective paper explores existing wearable devices, which have been designed specifically to measure activity, heart rate (HR) and heart rhythm. However, this paper provides limited information and lacks critical insight into the deployment of mobile ECG monitoring in primary care settings. Furthermore, it does not account for the perspective of health practitioners, physicians, and cardiologists. Likewise, their proposed frameworks and taxonomies lack clarity and theoretical underpinning, resulting in a paucity of in-depth knowledge and experience of these devices. In the UK, the National Institute for Health Care Excellence (NICE) [10] provides health information guidance, policy and practice, procedures, and standards. This guidance is informed on evidenced-based studies for clinical practitioners, public health practitioners, and social care institutions employed across the National Health Service (NHS). In 2015, The Newcastle and York External Assessment Centre and the Medical Technologies Evaluation Programme, NICE [10], conducted a literature search to identify evidence-based research and the cost effectiveness of the AliveCor ECG device and the AliveECG App. A total of eight databases were searched, resulting in 1033 records retrieved. After screening, four papers were identified that met the review's inclusion criteria: Lau et al. [24], Lowres et al. [25], Haberman et al. [26] and Tarakji et al. [27]. The review acknowledged that there were other mobile ECG devices available. For example, Dicare m1CC Colour portable ECG recorder (Dimetek), MD100A ECG reader (Choice Medical), MD100E ECG reader (Choice Medical), and HCG-801 ECG reader (Omron). Moreover, the review reported further information from 'Specialist commentator comments' and the 'Patient and carer perspective' of The Arrhythmia Alliance and the Atrial Fibrillation Association, respectively. While the commentary in the briefing can be taken positively; it is unclear why the review focused specifically on the AliveCor ECG device and the AliveECG app [22].

The Zenicor mobile ECG device was developed by the Swedish-based Zenicor Medical Systems AB. [28]. The Zenicor ECG device enables readings to be taken by the user/patient by placing their thumbs on two electrodes for 30 s. This device supports a web-based service that enables the analysis, interpretation, presentation, and processing and storage of the ECG recordings, to the care provider. The Zenicor ECG device is CE marked and is ISO (International Organization for Standardization) 13485 rated [29]. The Zenicor Medical Systems AB website lists three pieces of evidence-based research (published in English) of the Zenicor mobile ECG device. These studies were conducted by Hendrikx et al. [13], Usadel et al. [14], and Dahlqvist et al. [15]. Each used the Zenicor ECG mobile device to explore AR. Both Hendrikx et al. [13], and Dahlqvist et al. [15] recruited participants aged 18≥ years. Usadel et al. [14] focused on AR in children aged between 5 and 17 years. Hendrikx et al. [13] conducted a prospective, observation, cross-sectional study within a hospital's clinical physiology department. Hendrikx et al. [13] recruited 108 participants, who had been referred to clinicians for ambiguous palpitations, or experiences of dizziness. In total, 95 patients (42 men and 53 women) were assessed with a mean age of 54.1 years. All the participants were given a 24-h Holter ECG in addition to the Zenicor EKG handheld (for 30 s). Readings were taken twice a day when the participants were experiencing symptoms. The results from the 24-h Holter ECG ascertained two patients with AF and a third with atrioventricular (AV), a further three patients displayed paroxysmal supraventricular tachycardia (PSVT), and another patient presented with AV-block-II. Hendrikx et al. [13] concluded the use and deployment of the Zenicor EKG handheld to be more effective than the 24-h Holter ECG in detecting AF and PSVT, specifically with patients experiencing ambiguous symptoms.

The study by Usadel et al. [14] examined patients aged 0–17 years, who have or did not have congenital heart defects, pacemaker/ICD or AF and compared a lead-12 ECG with the Zenicor EKG handheld. Recordings and the transmission of data were completed successfully by the Zenicor EKG device with thorough and consistent data readings. The P wave detection was reported to be challenging, with 82 participants displaying heart rhythm disturbances. The detection of sensitivity via the Zenicor EKG handheld identified 92% of participants diagnosed with supraventricular tachycardia, while abnormal ECGs were identified with 77 and 92% sensitivity and specificity, respectively. In conclusion, Usadel et al. [14] noted that the use of the Zenicor EKG device with children was appropriate. Moreover, they suggested that the device was a suitable tool for detecting and excluding tachycardia in children. Dahlqvist et al. [15] evaluated the Zenicor EKG handheld to ascertain whether AF and cardiac autonomic dysfunction can be diagnosed in children with univentricular hearts. A total of 27 patients were recruited and used the Zenicor EKG handheld over a period of 14 days, while a manual AF analysis was conducted. The results from this study identified asymptomatic AF in one patient while HRV was also identified in some patients. Dahlqvist et al. [15] concluded that the use of the Zenicor EKG handheld device was a useful tool for detecting AF and cardiac autonomic dysfunction.

Reed et al. conducted a randomised control trial (RCT) [30] across multiple sites in the UK, deploying the AliveCor ECG device to ascertain symptomatic rhythm detection in patients attending the emergency department. Reed et al. [30] recruited 242 participants over a period of 18 months, with 125 allocated to the intervention group and 117 to the control group. The findings from the RCT were positive and the primary outcome of identifying symptomatic rhythm detection was identified in 69 participants in the intervention group, and 11 participants in the control group. The length of time to identify the primary outcome was 9.5 days for those participants assigned to the intervention group and 42.9 days for those participants assigned to the control group. Symptomatic cardia was detected in 11 intervention group participants and in one person in the control group. During the RCT phase, a total of seven questions were posed to participants assigned to the intervention group to ascertain patient engagement and usability of the AliveCor ECG device. Overall, the results showed positive responses to engaging and using the ECG device. The majority of participants (70%) reported to have never using a mobile ECG device; 21.6% of participants strongly agreed that the AliveCor ECG device will be useful in diagnosing their symptoms; 22.4% reported positively to recording their heart tracing based on their initial experiences upon entering the emergency department. Furthermore, 28.0% of participants reported having no problems or concerns when they sent a heart trace to the study team, while 32.0% of participants strongly agreed with having no problems recording a trace. Reed et al. [30] reported that their study demonstrated the cost benefits of using the AliveCor ECG device relating to primary, community and secondary care for both the intervention and control groups. The authors identified a £108 cost saving for participants in the intervention group. While no cost saving was identified for the control group, further analysis found that the cost saving per symptomatic rhythm diagnosis was less per patient in the intervention group (£474) compared to the control group (£1395). Reed et al. [30] argue that their findings are generalizable from emergency medicine to general practice, across a myriad of health care systems. However, Reed et al. [30] study reported findings based on the use and deployment of one particular ECG device. While they did not state the justification(s) for choosing the AliveCor ECG device over other devices available on the market, the results have demonstrated the positive effects of using a mobile ECG device.

Acknowledging the growing popularity of mobile heart monitoring (including ECG) devices, a search of the clinicaltrials.gov website [31] was undertaken. The website displays information concerning clinical trials that are either completed, active, recruiting, not recruiting or unknown. Three individual searches were conducted using the search terms ‘Alivecor [32] ECG device’, ‘Zenicor ECG device’ and ‘atrial fibrillation and wearable devices’. The device terms were used because of the studies referred to earlier. The latter term was used to capture any other device(s). Regarding the Alivecor [32] ECG device, 25 registered trials between the years 2013 and 2019 were identified. The majority of the 25 studies were conducted in the USA (n = 17). The remainder were conducted in Canada (n = 2), Hong Kong (n = 2), UK (n = 1), Belgium (n = 1), India (n = 1), and the Netherlands (n = 1). Five trials between 2012 and 2019 were identified involving the Zenicor ECG device [33]. The majority had been conducted in Sweden (n = 3), but also included one in Germany (n = 1) and one conducted in multiple locations (Denmark, Sweden and Austria). The final search using the terms ‘atrial fibrillation and wearable devices’ (e.g., Garmin Smart Watch, Amiigo Watch and Wristband, and iRhythm Zio XT Patch) yielded a further 17 trials between 2012 and 2019 [34]. Five trials were conducted in the USA (n = 5), two in Canada (n = 2), two in Finland (n = 2), two in Israel (n = 2), and one each in Belgium (n = 1), China (n = 1), Germany/Switzerland (n = 1) Singapore (n = 1), Spain (n = 1) and in the UK (n = 1), respectively. The HeartCheck™ device was used in one RCT study conducted in Canada [35].

Although this complex and rapidly changing field represents an attractive prospect for the diagnosis of heart and circulatory disease, there are few reviews that look at mobile self-monitoring ECG devices designed to diagnose cardiac arrhythmia that coincide with cardiac event-related conditions such as palpitations. This paper reviews the contemporary literature and examines whether the evidence obtained from studies with such devices can support primary care providers to deliver high levels of care at a low cost to the service provider. Although the causes of palpitations are variable, they are occasionally a manifestation of potentially life-threatening arrhythmia (AR). Under conditions where abnormal heart rhythms and cardiac symptoms are irregular and infrequent, such mobile self-monitoring ECG devices have potential as event monitors during symptoms such as palpitations. Cheung, Krahn, and Andrade [9] argued that one of the limitations of wearable device studies was their reliance on small sample sizes involving patients presenting with unique symptoms.

This review is distinctive and timely in that it provides an insight into an increasingly complex field that combines the precision demanded by the medical profession with wearable technology that has advanced rapidly with the development of miniaturised, and increasingly accurate, sensors. The authors believe it is the first review of its kind to explore contemporary evidence surrounding the use of mobile ECG devices and, consequently, contributes to the field of primary care and medicine. The authors aim to offer further evidence for the support of such devices in a community setting and to answer the question of what contemporary evidence reports the use of mobile ECG monitoring to assess palpitations that occur with AR across populations.

2. Methods

A scoping review strategy was selected to chart this important and complex subject. Arksey and O'Malley [36] propose that scoping reviews provide a clear and thorough method for providing an overview of significant and quickly developing areas of research. Furthermore, Arksey and O'Malley [36] note the aim of this type of review is 'to illustrate the field of interest in terms of the volume, nature and characteristics of the primary research' (p. 30).

In order to chart the emerging nature of the rapidly developing area of mobile heart measuring devices, a scoping review was deployed using Arksey and O'Malley's [36] framework. This framework gives both an overview of the topic and facilitates an examination of the breadth and depth of knowledge of the subject. One of the framework's strengths is that it allows the authors to draw conclusions about the overall state of research activity and make recommendations for future research.

2.1. *Objectives*

This review was guided by Arksey and O'Malley's five-stage framework [36], which includes (a) establishing the research question, (b) the identification of pertinent studies, (c) the choice of studies, (d) mapping the data and (e) collating, summarizing and reporting the findings.

2.2. *Search Strategy*

The search strategy consisted of a systematic search of five electronic databases. The databases examined were the Association for Computing Machinery (ACM, New York, NY, USA), CINHAL, Google Scholar, PubMed, and Scopus. The date criterion of the search was for material published between January 2010 and February 2018. The search was conducted between February and March 2018.

Each database underwent individual search strategies and the limiters were 'English' and 'humans'. Articles, their references (BibTeX format) and, where possible, the CSV files were exported into Dropbox and Mendeley. An inclusion and exclusion criteria were developed and deployed. The complete search criteria are given in Table 1.

Table 1. Criteria for study selection.

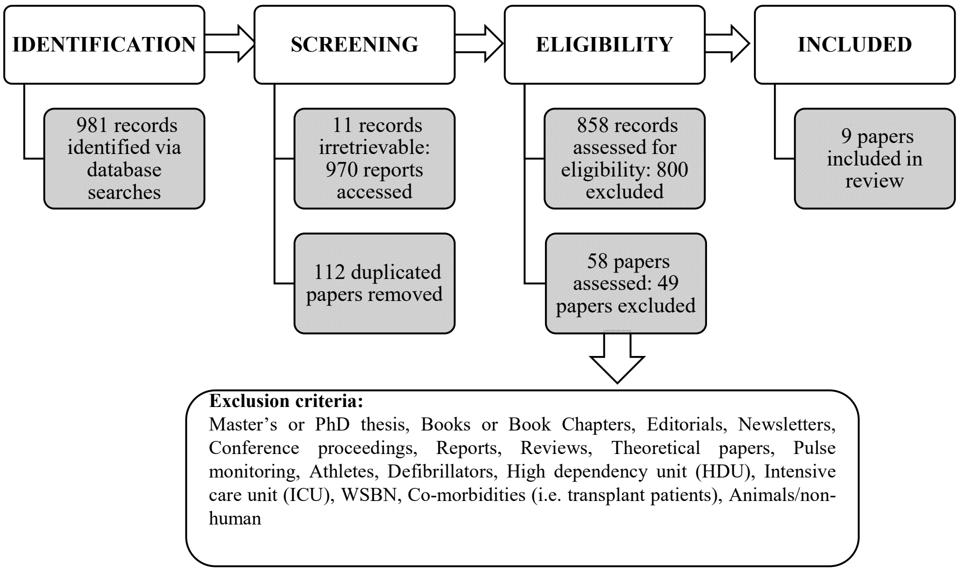
Inclusion	Exclusion
Mobile apps (mApps)	Master's and PhD thesis
Electrocardiogram (ECG/EKG)	Conference proceedings
Cardiogram	Book Chapters
Wearables	Reports
Atrial Fibrillation (AF)	Reviews
Heart	Pulse monitoring
Human	Theoretical papers
ECG Wearable Devices/Patches	Athletes
Mobile Health (mHealth)	Defibrillators
Security/Privacy	Intensive care unit (ICU) or high dependency unit (HDU)
Smart Fabric/textiles	WSBN
Papers published in Journals	Animals/non-human
Commercial technologies	Co-morbidities (i.e., transplant patients)
Purpose-built technologies	Newsletters
Encryption	Editorials
Big Data	PhD, MSc & BSc Thesis
Human	
Study designs: (randomised control trial (RCT), Exploratory, Cohort, Prospective, Feasibility)	

2.3. Selection Criteria

Studies were included if they met the inclusion criteria (Table 1). Titles of papers and abstracts were initially screened for suitability and, where necessary, the full paper was then reviewed. The final decision was determined by two authors (H.M. and D.B.). Both H.M. and D.B. reviewed all articles from each database separately and then collectively. Where additional discrepancies were highlighted, H.M. and D.B. reviewed and discussed the respective paper(s) before a final decision was made. Both abstracts and full texts were retrieved to determine whether they met the inclusion/exclusion criteria. Both H.M. and D.B. jointly decided the final selection of papers for inclusion.

3. Results

The initial search yielded 981 records across the five databases. However, 11 records were not available (six from CINHAL and five from Google Scholar). Consequently, 970 records were accessed, and 112 duplicates removed. The remaining 858 records were then judged against the inclusion/exclusion criteria (see Table 1). Subsequently, 800 records failed the inclusion criteria and were excluded from the review. The remaining 58 papers were subjected to a full text assessment and a further 49 papers were excluded (Figure 1). Nine papers met the inclusion criteria of the review.



Exclusion criteria:
Master's or PhD thesis, Books or Book Chapters, Editorials, Newsletters, Conference proceedings, Reports, Reviews, Theoretical papers, Pulse monitoring, Athletes, Defibrillators, High dependency unit (HDU), Intensive care unit (ICU), WSBN, Co-morbidities (i.e. transplant patients), Animals/non-human

Figure 1. Diagram showing the review process.

3.1. General Characteristics of Studies

Analysis of the final nine articles found that they were all published between 2015 and 2017 and the majority were located in the PubMed database (n = 5). The sample size varied across all articles from 25,415 participants in the study published by Arronsson et al. [37] to 22 participants in the study published by Doliwa et al. [38]. The total sample includes 27,346 participants with a mean age of 57.18 ± 7.42, and the median age is 64.45. Five studies reported the percentage or number of female participants [37–42], while three studies recruited only male participants [26,43,44]. Three studies were performed in Europe: Arronsson et al. [37], Doliwa, Rosenqvist and Frykman [38], and Halcox et al. [42]. Five studies were conducted in the USA: Boudreaux et al. [39], Turakhia et al. [44], Haberman et al. [26], Hickey and Freedson [41] and McManus et al. [43]. The remaining study was conducted in Africa by Evans et al. [40]. Study design varied, with three studies reporting an observation cohort study Arronsson et al. [37], Halcox et al. [42], Haberman et al. [26]. Two studies reported on an experimental study approach: Evans et al. [40] and McManus et al. [43]. Hickey and Freedson [41] reported an experimental comparative study design. A further two studies reported a prospective observation study design: Boudreaux et al. [39] and Halcox et al. [42]. One study, Doliwa, Rosenqvist and Frykman, reported an experimental RCT design [38].

3.2. Themes

A total of six primary themes and the 24 secondary themes which were identified through the review process. The secondary themes detail the type of assessments used in the studies.

3.3. Primary Themes

A total of six primary themes (purpose and objectives, environment, population, wearable devices, assessment, and study design) were identified and are explained in the proceeding sections.

The purpose and objectives theme comprised five secondary themes: detection, feasibility, comparison, cost effectiveness and study protocol. The Halcox et al. [42] study does not directly report the purpose of the study. However, critical examination of the complete paper revealed, that Halcox et al. [42] compared the AliveCor device with the delivery of routine care [42].

Four studies, Arronsson et al. [37]; Boudreaux et al. [39]; Turakhia et al. [44] and McManus et al. [43] used the detection of AF to assess the ECG device. Evans et al. [40] explored the feasibility of the AliveCor ECG device. The study by Boudreaux et al. [39] compared the energy expenditure (EE) during a particular activity (i.e., resistance training). Haberman et al. [26], and Doliwa et al. [38]

compared the AliveCor mobile ECG device against the traditional method of a 12-lead ECG. Cost effectiveness (CE) was also assessed by Arronsson et al. [37]. We have included the McManus et al. study protocol that outlines a single-centre, prospective randomised control trial (RCT) that deployed the AliveCor ECG device over a 30-day period [43]. This study protocol reported three aims: (a) to document AF using real-time ECG capture; (b) to evaluate the impact on AF treatment and Quality-Adjusted Life Years (QALYs—A generic measure of disease burden); and (c) to evaluate the effectiveness of text messaging on AF knowledge and proactive self-management of multiple chronic conditions.

The environment theme highlighted the different types of environment where studies were undertaken. Four secondary themes were identified: multiple screening centres, university/laboratory, rural community/hospital and a Veteran Affairs centre. The Aronsson et al. [37] study was located in multiple screening centres (n = 6) as reported in their earlier publication by Friberg et al. [45]. Five studies took place in university/laboratory settings Boudreaux et al. [39], Halcox et al. [42], Haberman et al. [26], McManus et al. [43], and Hickey et al. [41]. One study by Doliwa, Rosenqvist and Frykman was conducted in a hospital setting [38]. The study by Evans et al. [40] took place in a rural community/hospital where cardiology resources were limited. Moreover, there was only one 12-lead ECG tape available. The Turakhia et al. [44] study was conducted at the Veteran Affairs (VA) Palo Alto Health Care System.

The population theme encompasses three secondary themes: recruitment, sample, and sample size. Across all the studies, the nature of recruitment varied and included hospital clinics by Halcox et al. [42], the recruitment of veterans by Turakhia et al. [44], specific cardiology clinics/departments by Evans et al. [40], Haberman et al. [26], and McManus et al. [42], and university students by Haberman et al. [26]. The sample also varied and included older adults [44], athletes [26], healthy adults [26] and those with existing comorbidities (i.e., coronary disease, heart failure) [26]. The size of samples ranged from Aronsson et al. [37]'s 25,415 participants [37] to Doliwa, Rosenqvist, and Frykman's 22 participants [38]. Boudreaux et al. [39] recruited participants aged between 18 and 35 years, while Aronsson et al. [37] primarily recruited adults aged between 75 and 76 years. The majority of studies recruited participants of both genders with the exception of Turakhia et al. [44] who recruited only male participants.

The wearable devices theme encompassed three secondary themes: commercial, wearable patch and purpose-built devices. Eight studies utilised commercial devices. Two studies used the Zenicor ECG device: Aronsson et al. [37], and Doliwa, Rosenqvist, and Frykman [38]. One study by Boudreaux et al. [39] used multiple heart rate measuring mobile devices (i.e., Apple Watch Series 2, Fitbit Blaze, Fitbit Charge 2, Polar H7, Polar A360, Garmin Vivosmart HR, TomTom Touch, and Bose SoundSport Pulse headphones). Five studies—Evans et al. [40] Halcox et al. [42] Haberman et al. [26], Hickey and Freedson, [41] and McManus et al. [43]—Used the AliveCor Kardia mobile device, which is attached to an Apple iPhone. One study, Turakhia et al. [44], deployed the Zio wearable patch that sits against chest skin. Finally, McManus et al. [43] used a purpose-built mobile app (mApp) called PULSE-SMART to undertake participants ECG readings and that was connected to an Apple iPhone 4S.

The assessment theme encapsulates 11 secondary themes: the completion of assessment (i.e., health practitioner); self-assessment surveys—non-validated (health—anxiety, perceived benefits from health care practitioners), qualitative data (i.e., patient diary of symptoms); AF scales for the Assessment, Medication Assessment, Other Assessment, Quality of Life, Anxiety Scale; Technology-based Assessment and ECG monitoring (Holter or Mobile device) and patient health medical records (demographics, medical history, health behaviours). Due to the number of themes, this section only states theme type and one respective study. The completion of assessment by a health practitioner: Evans et al. [40]. Self-assessment surveys—non validated (health—anxiety, perceived benefits from health care practitioners): Doliwa et al. [38]. Qualitative data (i.e., patient diary of symptoms): Turakhia et al. [44]. AF scales for Assessment: Hickey et al. [41]. Medication Assessment, Other Assessment: Hickey et al. [41]. Quality of Life: McManus et al. [43]. Anxiety Scale: Hickey et al. [41].

Technology-based Assessment and ECG monitoring (Holter or Mobile device): Halcox et al. [42]. Finally, patient health medical records (demographics, medical history, health behaviours): Turakhia et al. [44].

The study that utilised the majority of assessments was that undertaken by Hickey and Freedson [41]. Hickey and Freedson [41] used 10 instruments (n = 10) in conjunction with baseline and monthly data recording (via electronic medical records system review) throughout the six-month duration of the study. The 10 assessments deployed were: the Atrial Fibrillation Knowledge Scale (AFKS) [46]; the Canadian Cardiovascular Society Severity in Atrial Fibrillation scale (CCS-SAF) [47]; the Atrial Fibrillation Effect on Quality of Life (AFEQT) [48]; the Control Attitudes Scale-Revised (CAS-R) [49]; the Morisky 4-item Self-Report Measure of Medication-Taking Behaviour (MMAS-4) [50,51]; the Self-Efficacy for Appropriate Medication Use Scale (SEAMS) [52]; the Short Form Health Survey (SF-36 Quality of Life) [53,54]; European Questionnaire 5 Dimensions (EQ-5D) [55,56]; the Patient Health Questionnaire (PHQ-9) [57]; and the State Trait Anxiety Inventory (STAI) [58].

The study design theme encompasses three secondary themes: duration, study criteria, and study type. Across the studies (depending upon the study design), some studies required their patients/participants to provided additional information in conjunction to their respective mobile ECG reading. Readings were taken over various times in the respective studies. Halcox et al. [42] measured twice per week for 12 months, while Hickey and Freedson [41] recorded three times per week over a six-month period. Aronsson et al. [37], Evans et al. [40], Turakhia et al. [44], used a two-week period. Doliwa, Rosenqvist, and Frykman [38] patients used the Zenicor ECG device over a 30-day period while McManus et al. [43] used a 2-min waveform reading. Five studies stated that their study design included study criteria (i.e., inclusion/exclusion). For example, Doliwa, Rosenqvist, and Frykman [38] recruited 22-participants with a diagnosis of symptomatic paroxysmal AF. While Haberman et al. [26] recruited 335 participants from Division I athletes, healthy young adults, and cardiology clinics. Hickey and Freedson [41] recruited adults >18 years, who had a 30-day history of AF, were either male or female, able to use a smartphone, and participants who were able to read and receive text messages on the day of enrolment onto the study. Furthermore, Turakhia et al. [44] recruited participants from cardiology, echocardiography and stress-testing clinics with additional inclusion criteria of specific age and having a minimum of two risk factors. The exclusion criteria included prior AF diagnoses, stroke, transient ischemic attacks, implantable pacemaker or defibrillator or someone who experienced palpitations or syncope in the previous year [44]. The McManus et al. [43] study was the one investigation aimed at testing a hypothesis using a prototype which measured waveforms via the iPhone 4S. Across all selected studies, each one reported a different study type (i.e., RCT or comparative). None of the nine studies reported the same study design.

4. Discussion

Principle Findings

This review paper provides a contemporary insight into the growing field of mobile ECG monitoring and detecting AF that coincides with palpitations. Out of 981 abstracts, a total of nine papers were selected for a comprehensive examination. A total of six primary themes were identified and, within each primary theme, a series of secondary themes were ascertained. Given the increasing use of wearable devices coupled with the increase in ageing populations and the drive to provide cost-effective primary care, the evidence lends itself to the adoption of mobile ECG monitoring into care practice and policy. As stated earlier in this paper, NICE [10] in the UK are primarily using the AliveCor Kardia ECG device.

The primary themes, environment and population, highlight the range of research centres, laboratories, and geographic locations that have investigated ECG mobile devices. Nonetheless, there is an argument that these selected studies are community based. However, the participants are not reported to have been recruited through a physician, surgery, or from a hospital via a cardiologist. The theme of population highlighted the varying sample sizes and how, in some instances, participants were recruited through cardiology clinics or departments; nevertheless, this was limited to three studies. Overall, the age range of participants illustrated a spread across populations; ensuring patients of all ages who presented with palpitations were involved in the studies. The primary theme wearable devices encompassed commercial, wearable, and purpose-built technology as a means of detecting and measuring AR and AF during periods when palpitations are prevalent. Overall, four studies used the AliveCor Kardia device, accessible via the Apple iPhone, while two studies deployed the commercial ECG device Zenicor. To date, there have only been a handful of studies published in academic journals [13–15], or via the Zenicor website [59] that examine purpose-built or commercial ECG devices.

With the exception of Evans et al. [40], no other selected study provided an insight into the use of mobile ECG devices and monitoring from the perspective of health practitioners. The final nine selected papers provide insights into the varying rationales for monitoring palpitations and AR across populations. We suggest that undertaking a community-based approach that included a physician (s) or consultant cardiologist would offer greater insights into the benefits of mobile ECG monitoring from the viewpoint of both health practitioner and providers.

All nine studies used an assortment of assessments and measures, which formed 11 secondary themes. The assessment theme indicates the complexity of deploying mobile ECG devices in conjunction with additional health outcomes to ascertain patient's levels of anxiety, quality of life, and the detection of AF through self-reporting and/or clinical practitioners. Varying study designs were executed. Nonetheless, given the limited duration of assessment, the results showed a positive trend in detecting AF. While AF and AR may vary across populations, the studies did report that patient response via the technology occurred at the time of the patient experiencing palpitations. Furthermore, the objectives of the studies also varied and ranged from validation to feasibility, cost effectiveness and clinical trials. This is further evidenced by the increase in clinical trials, as noted in this review's introduction. Consequently, the many clinical trials at various stages across the world highlight the widespread interest in this application of mobile health technology. However, drawing comparisons across the selected studies is problematic based upon the varying environments, assessments, populations, and wearable devices. While the cost effectiveness is a principal concern for primary care and health care strategists, preliminary evidence from this review (Table 2), coupled with findings from recent international studies such as Hendrikx et al. [13], Usadel et al. [14] and Dahlqvist et al. [15], demonstrates the great potential of deploying wearable ECG devices.

Table 2. Databases searched, search terms used, and adaptations employed.

Database	Search Term Used	Adaptions
Association for Computing Machinery (ACM)	(Arrhythmia Atrial Fibrillation ECG EKG Palpitations wearables) AND (-Algorithms -map -sensor -consumer -mathematical -statistical) AND keywords. author. keyword:(Arrhythmia Atrial Fibrillation ECG EKG Palpitations wearables -wavelet -brain -skin -posture -music -grasp -grip -sonic -speculative) AND record Abstract: (Arrhythmia Atrial Fibrillation ECG EKG Palpitations wearables)	Manufacturers'/generic names not recognised. NOT any: Algorithms map sensor consumer mathematical statistical. Keyword NOT: wavelet brain skin posture music grasp grip sonic
CINHAL	(TX ("Palpitations" OR "Arrhythmia" OR "Atrial Fibrillation")) AND (TX "Wearable ECG") AND (TX "Wearable EKG") OR (TX ("Wearable technologies" OR Wearable devices)) NOT (TX ("Catheter" OR "Surgery" OR "Ablation" OR "Catheter ablation" OR "Nursing Practice" OR "Gait")) NOT (TX "Students")	Manufacturers'/generic names not recognised. NOT "Catheter" OR "Surgery" OR "Ablation" OR "Catheter ablation" OR "Nursing Practice" NOT "Students"
Google scholar (wearable device)	ECG EKG Alive OR Cor OR Zoe OR Patch OR Scanadu OR Scout OR Perminova OR CoVa OR necklace OR Kardia OR ECG OR Necklace OR Cardio OR Analytics OR Heal OR Force OR Smart OR Cardio OR Beurer OR ME80 OR Beurer OR PM2 "wearable device"	Excluded patents

Table 2. *Cont.*

Database	Search Term Used	Adaptions
Google scholar (wearable technology)	ECG EKG Alive OR Cor OR Zoe OR Patch OR Scanadu OR Scout OR Perminova OR CoVa OR necklace OR Kardia OR ECG OR Necklace OR Cardio OR Analytics OR Heal OR Force OR Smart OR Cardio OR Beurer OR ME80 OR Beurer OR PM2 "wearable technology"	Excluded patents
PubMed	Palpitations OR Arrhythmia OR Atrial Fibrillation And (ECG) AND (EKG) OR Wearable technologies OR Wearable devices)) AND (Alive Cor OR Zoe Patch OR Scanadu Scout OR Perminova CoVa necklace OR Kardia OR ECG Necklace OR Cardio Analytics OR Heal Force OR Smart Cardio OR Beurer ME80 OR Beurer PM25 OR Prince 180B OR Cardea SOLO OR Spyder Pro OR Spyder Personal OR MiCor A100)) NOT (sport AND algorithms))	AND NOT sport AND algorithms
PubMed MESH	Wearable devices OR Wearable technologies AND (ECG OR EKG) AND (Palpitations OR Arrhythmia OR Atrial Fibrillation)	Manufacturers'/generic names not recognised. AND NOT sport AND algorithms
Scopus	Palpitations OR Arrhythmia OR Atrial Fibrillation And {ECG} AND {EKG} OR Wearable* AND techonolo* OR device AND NOT algorithms	Manufacturers'/generic names not used Use wildcard* AND NOT algorithms
Scopus	Alive Cor" OR "Zoe Patch" OR "Scanadu Scout" OR "Perminova CoVa Necklace" OR "QardioCore" OR "Kardia" OR "ECG Necklace" OR "Cardio Analytics" OR "Heal Force" OR "Smart Cardio" Or "ChoiceMMed" OR "Beurer ME80" OR "Beurer PM25" OR "Zodore" OR "Prince 180B" OR "Cardea SOLO" OR "Spyder Pro" OR "Spyder Personal" OR "MiCor A100")	Dropped: "Palpitations" OR "Arrhythmia" OR "Atrial Fibrillation" AND "ECG" OR "EKG"

5. Limitations

One of the limitations of this scoping review is that each database requires its own set of limiters. Consequently, each database search is slightly different as demonstrated in Table 3. The database searches did not identify the papers of Hendrikx et al. [13], Usadel et al. [14] and Dahlqvist et al. [15] that are available via the Zenicor website [59]. These papers were published in April and May 2018 and therefore outside of the time period of this scoping literature review. Furthermore, these papers did not fit the inclusion criteria because their primary area of investigation centred on the diagnosis and treatment of stroke patients. Although the Dahlqvist et al. [15] paper fits the inclusion criteria, the authors decided not to include it in Table 2 given that it did not appear in the search period. Moreover, the Dahlqvist et al. [13] study did not fit the >18 age inclusion criteria of this scoping review as participants in the respective study were children aged between 5 and 17 years old. Another paper was excluded because it was published in Swedish [60] and consequently failed the English language inclusion criterion.

Table 3. Summary of articles (N = 9) included for this scoping review.

1st Author Year Country	Objectives	Participants	Study Design	Assessment(s)	Technology	Main Findings
Aronsson et al. [40] 2015 Sweden	To estimate the cost effectiveness of 2 weeks of intermittent screening for asymptomatic atrial fibrillation (AF) in 75/76-year-old individuals.	n = 25,415 Aged 75–76 years Female 55.9%	Observational Cohort study	In total, 30-s recordings taken twice daily, or when symptoms of palpitations for 2 weeks.	Zenicor EKG device	With the use of a decision analytic simulation model, it has been shown that screening for asymptomatic AF in 75/76-year-old individuals is cost effective.
Doliwa, Rosenqvist, and Frykman [41] 2012 Sweden	To compare short intermittent heart rhythm recording with or without symptoms with continuous ECG recordings for 30 days, with two registrations of 10 s per day.	n = 22 Aged 46–77 years Females 27% Median age 63 years	Experimental study, randomised controlled blinded trial	Recordings were taken twice daily; once in the morning and once in the evening for a 30-day period. Participants were asked to record when experiencing arrhythmia symptoms (recorded as symptomatic).	Zenicor EKG device	AF episodes were diagnosed in 18 (82%) patients compared with seven (32%) patients using continuous ECG, (p = 0.001. Short-term ECG registrations over extended periods of time seem to be a more sensitive tool, compared with short continuous ECG recordings, for the detection of AF episodes.
Boudreau et al. [42] 2017 USA	To determine the validity of eight monitors for Heart Rate (HR) compared with an ECG and seven monitors for Energy Expenditure (EE) compared with a metabolic analyser during graded cycling and resistance exercise.	n = 50 Aged 18–35 years Female n = 28 (56%) Mean age 22.71 ± 2.99	Experimental comparative study	Session 1: Performed a graded exercise test on a cycle ergometer. Session 2: Performed a graded exercise test of four different strength training exercises on a resistance exercise machine. Repeated 3 days later in the laboratory. Exclusion: Cardiovascular disease or musculoskeletal injury in the last 6 months.	Apple Watch Series 2, Fitbit Blaze, Fitbit Charge 2, Polar H7, Polar A360, Garmin Vivosmart HR, TomTom Touch, and Bose SoundSport Pulse (BSP) headphones	This study revealed that both HR and EE differed among the eight wearable devices during both cycling and resistance exercise and had varying levels of validity when compared with a six-lead ECG and metabolic analyser. It was also observed that HR measures from wearable devices were more accurate at rest and lower exercise intensities than at higher intensities. Among tested devices, HR accuracy, as reflected by intraclass correlation and MAPE values, was highest in the PH7, BSP, and AWS2. The PH7 and AWS2 also proved to provide more accurate caloric estimations than other devices. HR from wearable devices differed at different exercise intensities; EE estimates from wearable devices were inaccurate.

Table 3. *Cont.*

1st Author Year Country	Objectives	Participants	Study Design	Assessment(s)	Technology	Main Findings
Evans et al. [43] 2017 Kenya	To examine the feasibility of using mobile ECG recording technology to detect AF.	n = 50 Mean age 54.3 ± 20.5. Females 66%	Prospective observational study	Of 2-week duration. In a rural community. Health practitioners (physicians, clinical officers, nurse) completed a self-assessment of a 4-item scale relating to ICT access, knowledge/interpretation of results and perception of AF in the community.	AliveCor Kardia Mobile ECG device	ECG tracings of four of the 50 patients who completed the study showed AF (8% AF yield), and none had been previously diagnosed with AF. Using mobile ECG technology in screening for AF in low-resource settings is feasible and can detect a significant proportion of AF cases that will otherwise go undiagnosed. Further study is needed to examine the cost effectiveness of this approach for the detection of AF and its effect on reducing the risk of stroke in developing countries.
Haberman et al. [26] 2015 USA	Compare the standard 12-lead ECG to the smartphone ECG in healthy young adults, elite athletes, and cardiology clinic patients. Accuracy for determining baseline ECG intervals and rate and rhythm was assessed.	n = 335 Mean age 35 ± 20 Female 51%	Experimental comparative study	Using an iPhone case or iPad, 30-s lead iECG waveforms were obtained. Standard 12-lead ECGs were acquired immediately after the smartphone tracing was obtained. De-identified ECGs were interpreted by automated algorithms and adjudicated by two board-certified electrophysiologists	AliveCor device (30-s ECG wireless reading). Patients trained over 1–2 min to take their own readings	This study provides evidence that wireless ECG devices can be used on a large scale to detect rate, conduction intervals and AF. Incorporation of automated discrimination, with enhanced smartphone features with notification capability and decision support. Both smartphone and standard ECGs detected atrial rate and rhythm, AV block, and QRS delay with equal accuracy. Sensitivities ranged from 72% (QRS delay) to 94% (atrial fibrillation). Specificities were all above 94% for both modalities.

Table 3. *Cont.*

1st Author Year Country	Objectives	Participants	Study Design	Assessment(s)	Technology	Main Findings
Hickey et al. [44] 2016 USA	The primary aims of the iHEART study are to: (1) document AF using real-time ECG capture; (2) evaluate the impact on AF treatment and Quality-Adjusted Life Years (QALYs); and (3) evaluate the effectiveness of text messaging on AF knowledge and promoting proactive self-management of multiple chronic conditions	n = 300 Aged > 18 years	Study protocol, observational study. Single-centre prospective	ECG reading taken at baseline. Complete all questionnaires at baseline and at 6 months. Questionnaires included the Atrial Fibrillation Knowledge Scale, the Canadian Cardiovascular Society Severity in Atrial Fibrillation scale, the Atrial Fibrillation Effect on Quality of Life, the Control Attitudes Scale-Revised, the Morisky 4-item Self-Report Measure of Medication-Taking Behaviour, the Self-Efficacy for Appropriate Medication Use Scale, the Short Form Health Survey, European Questionnaire 5 Dimensions, the Patient Health Questionnaire, and the State Trait Anxiety Inventory.	iPhone, AliveCor Mobile ECG Kardia app	This will be the first study to investigate the utility of a mobile health intervention in a "real world" setting. We will evaluate the ability of the iHEART intervention to improve the detection and treatment of recurrent atrial fibrillation and assess the intervention's impact on improving clinical outcomes, quality of life, quality-adjusted life-years and disease-specific knowledge.

Table 3. *Cont.*

1st Author Year Country	Objectives	Participants	Study Design	Assessment(s)	Technology	Main Findings
Halcox et al. [45] 2017 UK		n = 1001, Mean age 72.6 ± 5.4 Females 53.34%	Experimental study	Baseline characteristics. Participant experience survey (completed at the end of the study). Questions included anxiety about their heart rhythm problems, more likely to visit their doctor, or prefer to switch to a study group (responses reported via a 10-point visual analogue scale). iECG patients were asked about ease of use, restriction of activities, anxiety, concern about data security and a general satisfaction with the device (via 5-point Likert scale). Health economics were estimated from the UK National Health Service (NHS) and personal social services, using data from the study activity and relevant costs.	AliveCor Kardia device	Screening with twice-weekly single-lead iECG with remote interpretation in ambulatory patients ≥65 years of age at increased risk of stroke is significantly more likely to identify incident AF than RC over a 12-month period. This approach is also highly acceptable to this group of patients, supporting further evaluation in an appropriately powered, event-driven clinical trial.

Table 3. *Cont.*

1st Author Year Country	Objectives	Participants	Study Design	Assessment(s)	Technology	Main Findings
McManus et al. [46] 2016 USA	To test whether an enhanced smartphone app for AF detection can discriminate between sinus rhythm (SR), AF, premature atrial contractions (PACs), and premature ventricular contractions (PVCs).	**AF—**n = 98 65.9 ± 12.2 Male—n = 70 (71.4%) White n = 91(92.9) **PAC—**n = 15 73.1 ± 5.9 Male—n = 11 (73.3%) White n = 14(93.3) **PVC—**n = 15 62.8 ± 13.8 Male—n = 9 (60%) White n = 13(86.7) **Sinus Rhythm—**n = 91 66 ± 11.9 Male—n = 63 (69.2%) White n = 86(94.5)	Experimental study	Analysis of 219 2-min pulse recordings. Usability questionnaire to sub-group of ns = 65 app users. Examined the sensitivity, specificity, and predictive accuracy of the app for AF, PAC, and PVC discrimination from sinus rhythm using the 12-lead EKG or 3-lead telemetry as the gold standard.	PULSE-SMART prototype App used via the iPhone 4S	The smartphone-based app demonstrated excellent sensitivity (0.970), specificity (0.935), and accuracy (0.951) for real-time identification of an irregular pulse during AF. The app also showed good accuracy for PAC (0.955) and PVC discrimination (0.960). The vast majority of surveyed app users (83%) reported that it was "useful" and "not complex" to use.
Turakhia et al. 2015a [47] USA	To detect silent AF in asymptomatic patients with known risk factors through screening for AF using continuous ambulatory ECG.	n = 75, Mean age 69 ± 8.0 years. Male only	Observational study, single centre	Records up to 14 days of monitoring on a single vector. Participants press the symptomatic trigger on the device if symptoms presented. Patient diary, detailing symptoms. Baseline characteristics: demographics, medical history, ECG parameters, health behaviours were abstract from patient medical record by two trained investigators.	Zio wearable patch-based device	AF was detected in four subjects (5.3%; AF burden 28–48%). Atrial tachycardia (AT) was present in 67% (≥4 beats), 44% (≥8 beats), and 6.7% (≥60 s) of subjects. The combined diagnostic yield of sustained AT/AF was 11%. In subjects without sustained AT/AF, 11 (16%) had ≥30 supraventricular ectopic complexes per hour Outpatient extended ECG screening for asymptomatic AF is feasible, with AF identified in one in 20 subjects and sustained AT/AF identified in one in nine subjects, respectively. We also found a high prevalence of asymptomatic AT and frequent supraventricular ectopic complexes, which may be relevant to development of AF or stroke.

6. Future Research

Based on the findings of this review, the authors propose several areas for furthering and expanding this research:

1. Future work may wish to consider undertaking a systematic review in order to synthesise existing and recently published work. This systematic review could include development features, accuracy, algorithms, utility and reproducibility, in addition to diagnostics and user/patient experience(s).
2. Following the work of Evans et al. [40], clinicians and researchers alike should consider exploring the use of mobile ECG devices from the standpoint of health practitioners working in the delivery of primary and community care.
3. Implementing and conducting qualitative data collection in future studies would provide a greater insight and understanding of the needs, apprehensions, and expectations of patients and primary care practitioners. Simultaneously, this would provide the opportunity to examine the role of patient's and support networks. Evans et al. [40] illustrated the potential opportunities for mobile ECG monitoring in low, middle income countries (LMICs), and by their approach has the potential to offer substantial changes in developed and developing regions.
4. Future investigations should explore the adherence and adoption of mobile ECG devices, learning from previous health, gerontological and ICT studies [61–68]. Existing research in different fields has demonstrated how technology has been used and evaluated by community dwelling adults living in different geographic locations. Understanding people's motivations and behaviour in relation to technology would significantly support future work in this field. In addition, the impact of technology efficacy by health practitioners on service delivery could be assessed.

    a. Privacy and security issues and concerns surrounding data need to be addressed from a multi-disciplinary standpoint. Further work is needed to explore the use of wearable devices from a clinical environment and conducting qualitative data to gain an in-depth insight into the concerns of patients, support networks and practitioners.

5. Future studies should determine the exact cost effectiveness of deploying mobile ECG devices with the aim of providing evidence to health care strategists, governments and managers of the benefits of this form of technology in the community. Such studies could have a significant impact in the care pathways following the detection of AR and AF.
6. To ascertain how mobile ECG devices could affect the delivery of primary care, we suggest that a large-scale feasibility study, encompassing variable populations (i.e., age range, ethnicity and socio economic), should be conducted to provide results to different actors (i.e., government, health care practitioners, health care strategists, researchers, patients and support networks). It is important that such studies include as full a range of actors as possible from primary care physicians, cardiologists, patients, lay people, patients' support networks, health organizations (i.e., NICE), and government funding agencies.
7. Future scoping reviews should follow the recent extension to the existing PRISMA protocol—the PRISMA Extension for Scoping Reviews (PRISMA-ScR) [68].

The findings of this scoping review contribute to the fields of primary care, medicine and wearable devices. Nonetheless, ECG wearable devices are directly available to consumers via retail outlets and online websites. With this in mind, there is a risk to users who choose to purchase devices from online stores or directly from suppliers or manufacturer's website. Users may not fully understand the recordings or misunderstand the information presented to them. For example, the accurate interpretation of output statistics and the recognition of any false positives and false negatives. Thus, this leads to a myriad of issues for clinicians, users, and carers and may have health consequences for individuals and cost implications for service providers. These devices while readily available on the market have not necessarily gone through the process of being categorised as medical devices. This issue was raised by Marston and Smith [65,66] concerning the delivery of physiotherapy via videogame consoles. Consequently, Marston and Smith [65,66] argued for the need and requirement of videogame consoles to undergo some form of official categorization and approval rating. While there are worldwide videogame classifications [66], this is not the case for wearable devices and in particular mobile ECG devices. We argue for a requirement for the manufacturers of mobile ECG devices to gain FDA and European Medicines Agency (EMA) approval. However, as noted by Mantovani and Bocos [67] and Wiersinga [69], gaining FDA and EMA approval is not a straightforward process and, given the phenomenal developments within this domain, applying for medical device classification could be very time consuming. However, Wiersinga [69] discusses in depth the regulation processes for medical devices from the standpoint of industry and proposed recommendations for best practice.

7. Conclusions

This review is distinctive because it demonstrates positive trends to using and deploying mobile ECG devices across different environmental settings and populations. With global populations set to increase over the coming decades, the need to identify alternative solutions to facilitate and ensure primary care providers are able to deliver cost-effective health care is crucial, for both the service provider and the patient [9]. Detecting and diagnosing AR/AF using mobile ECG devices would reduce the risk of morbidity and associated health implications such as stroke or mortality [5–7,70].

Based on the evidence displayed in this review, the authors believe substantial work is warranted at both a national and international scale with a view to supporting primary care providers to deliver high levels of care at a low cost to the service provider. This, in turn will alleviate patient anxiety, risk of morbidity and mortality. In addition, it would positively impact on national and international guidelines concerning pathways to care.

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Abbreviations

ACM	Association of Computing Machinery
AF	Atrial Fibrillation
AFEQT	Atrial Fibrillation Effect on Quality of Life
AFKS	Atrial Fibrillation Knowledge Scale
AR	Arrhythmia
CAS-R	Control Attitudes Scale-Revised
CCS-SAF	Canadian Cardiovascular Society Severity in Atrial Fibrillation scale
CE	Cost Effectiveness
ECG/EKG	Electrocardiogram
EE	Energy Expenditure
EQ-5D	European Questionnaire 5 Dimensions
HR	Heart rate
mApp	Mobile Apps

NHS	National Health Service
NICE	National Institute for Health Care Excellence
PHQ-9	Patient Health Questionnaire
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
QALY	Quality-Adjusted Life Years
QOL	Quality of Life
RCT	Randomised controlled trial
SEAMS	Self-Efficacy for Appropriate Medication Use Scale
STAI	State Trait Anxiety Inventory
UK	United Kingdom
USA	United States of America
VA	Veteran Affairs

References

1. Public Health England (PHE). *Atrial Fibrillation Prevalence Estimates in England: Application of Recent Population Estimates of AF in Sweden*; Public Health England: London, UK, 2017. Available online: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/644869/atrial_fibrillation_AF_briefing.pdf and http://www.webcitation.org/77eZ6R3Y7 (accessed on 14 February 2019).
2. United Nations. *World Population Prospects: The 2017 Revision, Key Findings and Advance Tables*; Report No.: ESA/P/WP/248; United Nations: New York, NY, USA, 2017. Available online: https://esa.un.org/unpd/wpp/Publications/Files/WPP2017_KeyFindings.pdf and http://www.webcitation.org/754kCtnkX (accessed on 14 February 2019).
3. Alliance, A. Atrial Fibrillation. Available online: http://www.heartrhythmalliance.org/aa/uk/atrial-fibrillation. (accessed on 14 February 2019).
4. Alliance, A. What Is an Arrhythmia? Available online: http://www.heartrhythmalliance.org/aa/uk/what-is-an-arrhythmia?gclid=Cj0KCQiA6JjgBRDbARIsANfu58E53eiuxOFo9nYKJcxOQNi0iIn_T6ZnEU28WcZQcprn6AqNtvyOM7MaAg2bEALw_wcB (accessed on 14 February 2019).
5. Odutayo, A.; Wong, C.X.; Hsiao, A.J.; Hopewell, S.; Altman, D.G.; Emdin, C.A. Atrial fibrillation and risks of cardiovascular disease, renal disease, and death: systematic review and meta-analysis. *BMJ* **2016**, *354*, i4482. [CrossRef] [PubMed]
6. Wang, T.J.; Larson, M.G.; Levy, D.; Vasan, R.S.; Leip, E.P.; Wolf, P.A.; D'Agostino, R.B.; Murabito, J.M.; Kannel, W.B.; Benjamin, E.J. Temporal relations of atrial fibrillation and congestive heart failure and their joint influence on mortality: The Framingham heart study. *Circulation* **2003**, *107*, 2920–2925. [CrossRef] [PubMed]
7. Thrall, G.; Lane, D.; Carroll, D.; Lip, G.Y.H. Quality of life in patients with atrial fibrillation: A systematic review. *Am. J. Med.* **2006**, *119*, 448.e1–448.e19. [CrossRef] [PubMed]
8. Kannel, W.; Wolf, P.; Benjamin, E.; Levy, D. Prevalence, incidence, prognosis, and predisposing conditions for atrial fibrillation: population-based estimates. *Am. J. Cardiol.* **1998**, *82*, 2N–9N. [CrossRef]
9. Cheung, C.C.; Krahn, A.D.; Andrade, J.G. The emerging role of wearable technologies in detection of arrhythmia. *Can. J. Cardiol.* **2018**, *34*, 1083–1087. [CrossRef] [PubMed]
10. National Institute for Clinical Excellence (NICE). AliveCor Heart Monitor and AliveECG app (Kardia Mobile) for Detecting Atrial Fibrillation. 2015. Available online: https://www.nice.org.uk/advice/mib35 (accessed on 14 February 2019).
11. Campbell, B.; Richley, D.; Ross, C.; Eggett, C.J. Clinical Guidelines by Consensus: Recording a Standard 12-Lead Electrocardiogram. An Approved Method by the Society for Cardiological Science and Technology (SCST). 2017. Available online: http://www.scst.org.uk/resources/SCST_ECG_Recording_Guidelines_20171.pdf (accessed on 30 July 2019).
12. Marston, H.R.; Hall, A.K. Gamification: Application for Health and Health Information Technology Engagement. In *Handbook of Research on Holistic Perspectives in Gamification for Clinical Practice*; Novak, D., Tulu, B., Brendryen, H., Eds.; Medical Information Science Reference: Hershey, PA, USA, 2015; pp. 78–104.

13. Hendrikx, T.; Rosenqvist, M.; Wester, P.; Sandström, H.; Hörnsten, R. Intermittent short ECG recording is more effective than 24-hour Holter ECG in detection of arrhythmias. *BMC Cardiovasc. Disord.* **2014**, *14*, 1–8. [CrossRef] [PubMed]
14. Usadel, L.; Haverkämper, G.; Herrmann, S.; Löber, R.; Weiss, K.; Opgen-Rhein, B.; Berger, F.; Will, J.C. Arrhythmia detection in pediatric patients: ECG quality and diagnostic yield of a patient-triggered Einthoven lead-I event recorder (Zenicor EKG-2TM). *Pediatr. Cardiol.* **2016**, *37*, 491–496. [CrossRef] [PubMed]
15. Dahlqvist, J.A.; Karlsson, M.; Wiklund, U.; Hörnsten, R.; Rydberg, A. Handheld ECG in analysis of arrhythmia and heart rate variability in children with Fontan circulation. *J. Electrocardiol.* **2014**, *47*, 374–382. [CrossRef]
16. HeartCheck™ device. Available online: https://www.theheartcheck.com/consumer.html (accessed on 14 February 2019).
17. Quinn, F.R.; Gladstone, D.J.; Ivers, N.M.; Sandhu, R.K.; Dolovich, L.; Ling, A.; Nakamya, J.; Ramasundarahettige, C.; Frydrych, P.A.; Henein, S.; et al. Diagnostic accuracy and yield of screening tests for atrial fibrillation in the family practice setting: A multicenter cohort study. *CMAJ Open* **2018**, *6*, 308–315. [CrossRef]
18. EMAY Handheld ECG/EKG. Available online: http://www.emayltd.com/index.php/Home/Index/detail/id/17 (accessed on 14 February 2019).
19. ClinicalTrials Search Term—EMAY device. Results (n = 0). Available online: :http://www.webcitation.org/77hmzZ5BS (accessed on 14 February 2019).
20. Beurer Mobile ECG Device. Available online: https://www.beurer.com/web/gb/products/medical/ecg-and-pulse-oximeter/mobile-ecg-device (accessed on 14 February 2019).
21. AliveCor. KardiaMobile. 2019. Available online: https://shop.gb.alivecor.com/products/kardiamobile (accessed on 14 February 2019).
22. AliveCor. Clinical Research. 2019. Available online: https://alivecor.com/research (accessed on 14 February 2019).
23. Pevnick, J.M.; Birkeland, K.; Zimmer, R.; Elad, Y.; Kedan, I. Wearable technology for cardiology: An update and framework for the future. *Trends Cardiovasc. Med.* **2018**, *28*, 144–150. [CrossRef]
24. Lau, J.; Lowres, N.; Neubeck, L.; Neubeck, L.; Brieger, D.B.; Sy, R.W.; Galloway, C.D.; Albert, D.E.; Freedman, S.B. iPhone ECG application for community screening to detect silent atrial fibrillation: A novel technology to prevent stroke. *Int. J. Cardiol.* **2013**, *165*, 193–194. [CrossRef] [PubMed]
25. Lowres, N.; Neubeck, L.; Salkeld, G.; Krass, I.; McLachlan, A.J.; Redfern, J.; Bennett, A.A.; Briffa, T.; Bauman, A.; Martinez, C.; et al. Feasibility and cost-effectiveness of stroke prevention through community screening for atrial fibrillation using iPhone ECG in pharmacies. The Searchaf study. *Thromb. Haemost.* **2014**, *111*, 1167–1176. [CrossRef] [PubMed]
26. Haberman, Z.C.; Jahn, R.T.; Bose, R.; Tun, H.; Shinbane, J.S.; Doshi, R.N.; Chang, P.M.; Saxon, L.A. Wireless smartphone ECG enables large-scale screening in diverse populations. *J. Cardiovasc. Electrophysiol.* **2015**, *26*, 520–526. [CrossRef] [PubMed]
27. Tarakji, K.G.; Wazni, O.M.; Callahan, T.; Kanj, M.; Hakim, A.H.; Wolski, K.; Wilkoff, B.L.; Saliba, W.; Lindsay, B.D. Using a novel wireless system for monitoring patients after the atrial fibrillation ablation procedure: The iTransmit study. *Heart Rhythm* **2015**, *12*, 554–559. [CrossRef] [PubMed]
28. Zenicor Medical Systems. 2019. Available online: https://zenicor.com/our-contact-information (accessed on 14 February 2019).
29. Zenicor Medical Systems. Zenicor-ECG. 2019. Available online: https://zenicor.com/zenicor-ekg (accessed on 14 February 2019).
30. Reed, M.J.; Grubb, N.R.; Lang, C.C.; O'Brien, R.; Simpson, K.; Padarenga, M.; Grant, A.; Tuck, S. Multi-centre randomised controlled trial of a smartphone-based event recorder alongside standard care versus standard care for patients presenting to the emergency department with palpitations and pre-syncope: The IPED (Investigation of Palpitations in the ED) study. *Trials* **2018**, *19*, 7–11.
31. ClinicalTrials. Available online: http://www.webcitation.org/77hmrlWkq (accessed on 14 February 2019).
32. ClinicalTrials. Search Term—AliveCor: Results (n = 25). 2019. Available online: https://clinicaltrials.gov/ct2/results?cond=&term=aliveCor&cntry=&state=&city=&dist= (accessed on 14 February 2019).
33. ClinicalTrials. Search Term—Zenicor: Results (n = 5). 2019. Available online: https://clinicaltrials.gov/ct2/results?cond=&term=zenicor&cntry=&state=&city=&dist= (accessed on 14 February 2019).

34. ClinicalTrials. Search Term—Atrial Fibrillation, Wearable Devices: Results (n = 17). 2019. Available online: https://clinicaltrials.gov/ct2/results?cond=&term=atrial+fibrillation%2C+wearable+devices&cntry=&state=&city=&dist= (accessed on 14 February 2019).
35. ClinicalTrials. Search Term—HeartCheck Hand-Held ECG Device: Results (n = 1). 2019. Available online: https://clinicaltrials.gov/ct2/results?cond=&term=HeartCheck+Hand-held+ECG+device&cntry=&state=&city=&dist= (accessed on 14 February 2019).
36. Arksey, H.; O'Malley, L. Scoping studies: Towards a methodological framework. *Int. J. Soc. Res. Methodol. Theory Pract.* **2005**, *8*, 19–32. [CrossRef]
37. Aronsson, M.; Svennberg, E.; Rosenqvist, M.; Engdahl, J.; Al-Khalili, F.; Friberg, L.; Frykman-Kull, V.; Levin, L.A. Cost-effectiveness of mass screening for untreated atrial fibrillation using intermittent ECG recording. *Europace* **2015**, *17*, 1023–1029. [CrossRef]
38. Doliwa, P.S.; Rosenqvist, M.; Frykman, V. Paroxysmal atrial fibrillation with silent episodes: Intermittent versus continuous monitoring. *Scand. Cardiovasc. J.* **2012**, *46*, 144–148. [CrossRef]
39. Boudreaux, B.D.; Hebert, E.P.; Hollander, D.B.; Williams, B.M.; Cormier, C.L.; Naquin, M.R.; Gillan, W.W.; Gusew, E.E.; Kraemer, R.R. Validity of wearable activity monitors during cycling and resistance exercise. *Med. Sci. Sports Exerc.* **2017**, *50*, 624–633. [CrossRef]
40. Evans, G.F.; Shirk, A.; Muturi, P.; Soliman, E.Z. Feasibility of using mobile ECG recording technology to detect atrial fibrillation in low-resource settings. *Glob. Heart* **2017**, *12*, 285–289. [CrossRef]
41. Hickey, A.M.; Hauser, N.R.; Valente, L.E.; Riga, T.C.; Frulla, A.P.; Masterson Creber, R.; Whang, W.; Garan, H.; Jia, H.; Csiacca, R.R.; et al. A single-center randomized, controlled trial investigating the efficacy of a mHealth ECG technology intervention to improve the detection of atrial fibrillation: The iHEART study protocol. *BMC Cardiovasc. Disord.* **2016**, *16*, 152. [CrossRef] [PubMed]
42. Halcox, J.P.J.; Wareham, K.; Cardew, A.; Gilmore, M.; Barry, J.P.; Phillips, C.; Gravenor, M.B. Assessment of remote heart rhythm sampling using the AliveCor heart monitor to screen for atrial fibrillation the REHEARSE-AF study. *Circulation* **2017**, *136*, 1784–1794. [CrossRef] [PubMed]
43. McManus, D.D.; Chong, J.W.; Soni, A.; Saczynski, J.S.; Esa, N.; Napolitano, C.; Darling, C.E.; Boyer, E.; Roselle, R.K.; Floyd, K.C.; et al. Pulse-Smart: Pulse-based arrhythmia discrimination using a novel smartphone application. *J. Cardiovasc. Electrophysiol.* **2016**, *27*, 51–57. [CrossRef] [PubMed]
44. Turakhia, M.P.; Ullal, A.J.; Hoang, D.D.; Than, C.T.; Miller, J.D.; Friday, K.J.; Perez, M.V.; Freeman, J.V.; Wang, P.J.; Heidenreich, P.A.; et al. Feasibility of extended ambulatory electrocardiogram monitoring to identify silent atrial fibrillation in high-risk patients: The screening study for undiagnosed atrial fibrillation (STUDY-AF). *Clin. Cardiol.* **2015**, *38*, 285–292. [CrossRef] [PubMed]
45. Friberg, L.; Bergfeldt, L. Atrial fibrillation prevalence revisited. *J. Intern. Med.* **2013**, *274*, 461–468. [CrossRef] [PubMed]
46. Hendriks, J.M.L.; Crijns, H.J.G.M.; Tieleman, R.G.; Vrijhoef, H.J.M. The atrial fibrillation knowledge scale: Development, validation and results. *Int. J. Cardiol.* **2013**, *168*, 1422–1428. [CrossRef] [PubMed]
47. Dorian, P.; Cvitkovic, S.S.; Kerr, C.R.; Crystal, E.; Gillis, A.M.; Guerra, P.G.; Mitchell, L.B.; Roy, D.; Skanes, A.C.; Wyse, D.G. A novel, simple scale for assessing the symptom severity of atrial fibrillation at the bedside: The CCS-SAFE Scale. *Can. J. Cardiol.* **2006**, *22*, 383–386. [CrossRef]
48. Aliot, E.; Botto, G.L.; Crijns, H.J.; Kirchhof, P. Quality of life in patients with atrial fibrillation: How to assess it and how to improve it. *Europace* **2014**, *16*, 787–796. [CrossRef]
49. Moser, D.K.; Riegel, B.; McKinley, S.; Doering, L.V.; Meischke, H.; Heo, S.; Lennie, T.A.; Dracup, K. The control attitudes scale-revised: Psychometric evaluation in three groups of patients with cardiac illness. *Nurs. Res.* **2009**, *58*, 42–51. [CrossRef]
50. Moon, S.J.; Lee, W.Y.; Hwang, J.S.; Hong, Y.P.; Morisky, D.E. Accuracy of a screening tool for medication adherence: A systematic review and meta-analysis of the Morisky medication adherence scale-8. *PLoS ONE* **2017**, *12*, 1–18. [CrossRef]
51. Morisky, D.; Green, L.; Levine, D. Concurrent and predictive validity of a self-reported measure of medication adherence. *Med. Care* **1986**, *24*, 67–74. [CrossRef]
52. Risser, J.; Jacobson, T.A.; Kripalani, S. Development and psychometric evaluation of the self-efficacy for appropriate medication use scale (SEAMS) in low-literacy patients with chronic disease. *J. Nurs. Meas.* **2007**, *15*, 203–219. [CrossRef]

53. Jenkinson, C.; Wright, L.; Coulter, A. Criterion validity and reliability of the SF-36 in a population sample. *Qual. Life Res.* **1994**, *3*, 7–12. [CrossRef] [PubMed]
54. Jenkinson, C.; Layte, R.; Coulter, A.; Wright, L. Evidence for the sensitivity of the SF-36 health status measure to inequalities in health: Results from the Oxford healthy lifestyles survey. *J. Epidemiol. Community Health* **1996**, *50*, 377–380. [CrossRef]
55. Brooks, R. EuroQol: The current state of play. *Health Policy* **1996**, *37*, 53–72. [CrossRef]
56. Group, T.E. EuroQol—A new facility for the measurement of health-related quality of life. *Health Policy* **1990**, *16*, 199–208.
57. Kroenke, K.; Spitzer, R.L.; Williams, J.B.W. The PHQ-9: Validity of a brief depression severity measure. *J. Gen. Intern. Med.* **2001**, *16*, 606–613. [CrossRef]
58. Tluczek, A.; Henriques, J.B.; Brown, R.L. Support for the reliability and validity of a six-item state anxiety scale derived from the state-trait anxiety inventory. *J. Nurs. Meas.* **2009**, *17*, 19–28. [CrossRef]
59. Zenicor Medical Systems AB. Research-Arrhythmia Investigations. Available online: https://zenicor.com/arrhythmia-investigations (accessed on 14 February 2019).
60. Hendrikx, T.; Rosenqvist, M.; Sandström, H.; Persson, M.; Hörnsten, R. Identification of paroxysmal, transient arrhythmias: Intermittent registration more efficient than the 24-hour Holter monitoring. *Lakartidningen* **2015**, *112*, C6SE.
61. Marston, H.R.; Freeman, S.; Genoe, R.; Kulcyzki, C.; Musselwhite, C. *The Cohesiveness of Technology in Later Life: Findings From the Technology in Later Life (TILL) Project Knowledge Exchange Seminar Series 2017–2018*; Stormont: Belfast, UK, 2018.
62. Waights, V.; Bamidis, P.; Almeida, R. Technologies for care—The imperative for upskilling carers. In *Knowledge Exchange Seminar Series 2017–18*; Stormont: Belfast, UK, 2018.
63. Genoe, R.; Kulczycki, C.; Marston, H.; Freeman, S.; Musselwhite, C.; Rutherford, H. E-leisure and older adults: Findings from an international exploratory study. *Ther. Recreat. J.* **2018**, *52*, 1–18. [CrossRef]
64. Marston, H.R.; Kroll, M.; Fink, D.; de Rosario, H.; Gschwind, Y.J. Technology use, adoption and behavior in older adults: Results from the iStoppFalls project. *Educ. Gerontol.* **2016**, *42*, 371–387. [CrossRef]
65. Marston, H.R.; Smith, S.T. Interactive videogame technologies to support independence in the elderly: A narrative review. *Games Health J.* **2012**, *1*, 139–152. [CrossRef] [PubMed]
66. Marston, H.R.; Smith, S.T. Understanding the digital game classification system: A review of the current classification system & its implications for use within games for health. *Hum. Fact. Comput. Inform. LNCS* **2013**, *7946*, 314–331.
67. Mantovani, E.; Bocos, P.C. Are mHealth apps safe? The intended purpose rule, its shortcomings and the regulatory options under the EU medical device framework. In *Mobile e-Health. Human–Computer Interaction Series*; Marston, H., Freeman, S., Musselwhite, C., Eds.; Springer: Cham, Switzerland, 2017; ISBN 978-3-319-60672-9.
68. Tricco, A.C.; Lillie, E.; Zarin, W.; O'Brien, K.K.; Colquhoun, H.; Levac, D.; Moher, D.; Peters, M.D.J.; Horsley, T.; Weeks, L.; et al. PRISMA extension for scoping reviews (PRISMA-ScR): Checklist and explanation the PRISMA-ScR statement. *Ann. Intern. Med.* **2018**, *169*, 467–473. [CrossRef] [PubMed]
69. Wiersinga, J. Regulation of medical digital technologies. In *Mobile e-Health. Human–Computer Interaction Series*; Marston, H., Freeman, S., Musselwhite, C., Eds.; Springer: Cham, Switzerland, 2017; ISBN 978-3-319-60672-9.
70. Chugh, S.S.; Havmoeller, R.; Narayanan, K.; Singh, D.; Rienstra, M.; Benjamin, E.J.; Gillum, R.F.; Kim, Y.-H.; McAnulty, J.H., Jr.; Zheng, Z.J.; et al. Worldwide epidemiology of atrial fibrillation: A global burden of disease 2010 study. *Circulation* **2014**, *129*, 837–847. [CrossRef] [PubMed]

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