e-Health Solutions for Aging in Place with Cognitive Impairment: Preliminary Results of a Systematic Review

Samantha Dequanter[1][a], Marie-Pierre Gagnon[2,3][b], Mame-Awa Ndiaye[2], Jessica Dion[2], Ellen Gorus[4], Anne Bourbonnais[5][c], Anik Giguère[2,6], Samira Abbasgholizadeh Rahimi[2], Maaike Fobelets[1][d] and Ronald Buyl[1][e]

[1]*Faculty of Medicine and Pharmacy, Department of Public Health Sciences, Vrije Universiteit Brussel, Belgium*
[2]*Institute of Health and Social Services in Primary Care, Research Center on Healthcare and Services in Primary Care of Laval University (CERSSPL-UL), Québec, Canada*
[3]*Faculty of Nursing Sciences, Université Laval, Québec, Canada*
[4]*Faculty of Medicine and Pharmacy, Department of Gerontology, Vrije Universiteit Brussel, Belgium*
[5]*Faculty of Nursing Sciences, Université de Montréal, Montréal, Canada*
[6]*Faculty of Medicine, Université Laval, Québec, Canada*

Keywords: e-Health, Information and Communication Technology, Gerontechnology, Aging, Cognitive Impairment, Dementia, Caregivers, Systematic Review.

Abstract: Worldwide, the proportion of older adults (60+) is growing very fast, increasing the prevalence of cognitive disorders such as Mild Cognitive Impairment and dementia. Recent literature shows a clear preference of older adults towards Aging in Place (AIP). In order to realize AIP in cognitively impaired older adults, appropriate measurements regarding safety and practical feasibility need to be taken. In answer to this issue, various e-Health solutions have been developed in the last decade, targeting support of memory, social contact, daily activities and personal safety. Much attention has also been given to solutions for caregivers of cognitively impaired older adults. Since the field of e-Health research is expanding at fast pace, implementing effective e-Health solutions based on research evidence constitutes a challenge. Therefore, this systematic review aims to review recent study findings in the field of e-Health research regarding community-dwelling cognitively impaired older adults and their informal caregivers. We also consider potential adverse effects of adoption of these solutions. An initial search led to 12999 potentially relevant citations. First-level title-screening of citations was completed in January 2019. Third-level full-text screening is targeted for April 2019. If possible, effect sizes for each type of e-Health intervention will be calculated.

1 INTRODUCTION

The worldwide proportion of individuals aged 60 and above is growing faster than ever (World Health Organization [WHO], 2018). Even the oldest-old (85+ years) are substantially growing in number in Europe and in the U.S. and this evolution is projected to continue for several more decades (Eurostat, 2018; Vincent and Velkoff, 2010). Advanced age is a well-known risk factor for cognitive disorders such as Mild Cognitive Impairment and dementia (Alzheimer's Association, 2016; Artero et al., 2008). In turn, these conditions, along with the functional decline and increased dependency they entail, result in a four- to six-fold risk of admission in a nursing home as compared to cognitively healthy older adults (Banaszak-Holl et al., 2004; Gnjidic et al., 2012; Löfqvist et al., 2013). However, older adults usually tend to have a reluctant and avoiding attitude towards

[a] https://orcid.org/0000-0001-7566-3093
[b] https://orcid.org/0000-0002-0782-5457
[c] https://orcid.org/0000-0002-6823-4044
[d] https://orcid.org/0000-0002-8316-6422
[e] https://orcid.org/0000-0002-6598-9505

Dequanter, S., Gagnon, M., Ndiaye, M., Dion, J., Gorus, E., Bourbonnais, A., Giguère, A., Rahimi, S., Fobelets, M. and Buyl, R.
e-Health Solutions for Aging in Place with Cognitive Impairment: Preliminary Results of a Systematic Review.
DOI: 10.5220/0007746402670273
In *Proceedings of the 5th International Conference on Information and Communication Technologies for Ageing Well and e-Health (ICT4AWE 2019)*, pages 267-273
ISBN: 978-989-758-368-1

relocation. Attachment to the home and the neighbourhood, as well as the fear of losing autonomy appear to be important explaining factors (Ahn et al., 2019; Löfqvist et al., 2013). This hesitation and aversion is not completely indefensible, since recent findings point out negative effects associated with relocation of older adults with dementia. High emotional distress and decline in overall well-being appear to be the most prominent (Ryman et al., 2018).

With these arguments in mind, the preference for aging at home seems justifiable. This phenomenon is referred to as Aging In Place (AIP) (Centers for Disease Control and Prevention, 2009). It is defined as the possibility "to continue living in one's own home and community in a safe, independent and comfortable way, regardless of age or ability level". Although it is clear that AIP is desirable for many reasons, its implementation in practice can be challenging. This is particularly the case for older adults living with cognitive impairments, as the functional limitations they face may gradually lead to loss of independence in major life domains (Lau et al., 2015). In addition to engagement in daytime activities, memory support and social company are also important need areas (van der Roest et al., 2009). Furthermore, the caregiver burden is also important, as symptoms of distress and depression in caregivers are common and interact negatively with the ability of the care-receiver to age in place (Afram et al., 2014).

To address these needs and support AIP, many innovative approaches have been developed. Amongst them are those emerging from the research field of e-Health. The latter is an overarching term covering the various uses of Information and Communication Technology (ICT) in the sphere of health care and health promotion (WHO, 2019). Development of e-Health solutions for cognitively impaired older adults has particularly been focused on the support of memory, social contact, daily activities and safety (Kim et al., 2017).

The solutions that compensate for impaired memory and planning abilities consist of electronic memory aids, voice prompting devices and cognitive training programs delivered through mobile applications or online websites. These solutions are reported to enhance quality of life through increasing task performance and overall independence (Blackman et al., 2016; Kim et al., 2017; Meiland et al., 2017; Tyack and Camic, 2017).

Various e-Health solutions also have the ability to support social engagement, mood and well-being of older adults with cognitive impairment (Lorenz et al., 2017; Meiland et al., 2017; Tyack and Camic, 2017). Firstly, simplified pre-programmed video or telephone solutions aim to keep these older adults connected to their social network (Lauriks et al., 2007). Secondly, social competence training is made possible through the use of simulated virtual social environments (Tyack and Camic, 2017). These environments are often integrated in virtual games, e.g. in which players are guided through the process of going shopping. With regard to facilitating communication and overall social interaction with caregivers, social robot therapy could potentially be of benefit, as well as using digital multimedia for art and music expression and for facilitating reminiscing (Lauriks et al., 2007; Lorenz et al., 2017; Meiland et al., 2017; Tyack and Camic, 2017).

With regard to support of activities of daily living (ADL) and safety of cognitively impaired older adults, smart home technology is increasingly gaining attention. This type of e-Health technology is part of the Ambient Assisted Living (AAL) technology and refers to the networked connection of the home with the world beyond, in which sensors play an important role and can be monitored remotely (Balta-Ozkan et al., 2013; Blackman et al., 2016). The benefits of this technology lie in the unobtrusive automatic registration of activity and behaviour of residents, which enables continuous monitoring as well as disease management (Marikyan et al., 2019). These systems have the ability to automatically generate alarm responses in predetermined conditions. This can be of importance for detection of potentially major safety incidents, e.g. flooding or a house fire, as well as detection of changes in ADL routines, indicating potential cognitive deterioration (Blackman et al., 2016). Regarding safety concerns, the passive detection of wandering of older adults with dementia is also possible through use of sensors in door posts or fences, or by means of geotracking through Global Positioning System (GPS)-enabled systems that are integrated in wearables or mobile telephones (Blackman et al., 2016; Kim et al., 2017; Meiland et al., 2017). Moreover, localization applications have the potential to support autonomous spatial orientation, and thus, to support the independence of these individuals (Kim et al., 2017).

Literature also identified positive effects of e-Health solutions for caregivers of cognitively impaired older adults. Mobile applications, online websites and video conferences delivering education and stress management training are only a few examples (Kim et al., 2017). Positive effects of these interventions on caregiver self-efficacy, anxiety and depression levels, and disease knowledge have been observed (Parra-Vidales et al., 2017). Moreover, solutions concerning art viewing or music playing that

target the caregiver and care-receiver dyad are reported to result in lower perceived burden, better communication and higher quality of the dyadic relationship (Tyack and Camic, 2017). Furthermore, e-Health interventions that directly target the psychological needs of caregivers also show promising results. In a recent study, technology-based equivalents of Cognitive Behavioural Therapy (CBT) showed positive effects on caregiver depression that were comparable to the face-to-face intervention (Scott et al., 2015).

In conclusion, many different e-Health technologies for cognitively impaired older adults and caregivers have been developed and studied. Most studies demonstrated substantial benefits for both parties in this dyad. However, these study findings should be interpreted with caution since many of the studies have poor methodological quality as reflected in small sample sizes, uncontrolled study designs and inadequate outcome measures (Meiland et al., 2017). Moreover, the tenability of the reported findings is debatable. Everyday new innovative technologies are developed, which render study findings outdated at a fast pace. Therefore we believe that there is a need to revisit the literature and to cover the current state of play in the field of e-Health solutions for AIP with cognitive impairment.

2 OBJECTIVES

This systematic review aims to identify empirically validated e-Health solutions for community-dwelling seniors living with cognitive impairment and their informal caregivers. Moreover, we will analyse and evaluate the effectiveness of these solutions in terms of relevant health and well-being outcomes. Potential adverse effects related to adoption of these solutions will also be considered.

3 METHODS

3.1 Search Strategy

We conducted a literature review of six electronic databases including PubMed, CINAHL, the Cochrane Library, PsycINFO, Web of Science, Embase and Sociological Abstracts. The search strategy incorporated search terms that were related to target populations or types of interventions. The strategy that was entered in PubMed is listed in Table 1. Adaptations to this search strategy were made in order to guarantee compatibility with the entry formats of the different other databases. A publication date filter was used to exclude articles published before 2013, thereby minimizing irrelevant or outdated references.

3.2 Study Selection

The study selection process started in October 2018 after importing the titles and abstracts of the citations using the Rayyan software (Ouzzani et al., 2016). The final selection of articles comprised publications from January 2013 until the date of search, which is October 2018. The selection process follows a multi-level method in which title, abstract and full-text of articles are consecutively screened (Mateen et al., 2013). First-level screening of title was independently conducted by four researchers working in pairs by January 2019. One pair of reviewers screened reference titles published from 2013 until 2015 (SD and MAN) and one pair of reviewers screened reference titles published from 2016 until 2018 (MPG and JD). Screening conflicts will be resolved through discussion, or if necessary with the help of a third reviewer (RB). After title-screening conflict resolution, second- and third-level screening will be executed in February 2019 and April 2019 respectively.

To be considered for inclusion, references have to adhere to a set of inclusion criteria. Firstly, studies should contain at least one e-Health solution situated in the field of telehealth, telemedicine and telecare, ambient/active assisted living (AAL) or (robotic) assistive technology. Additionally, these e-Health solutions need to be developed for or tested with informal caregivers of community-dwelling cognitively impaired older adults, or with the latter themselves. Articles that do not comply with this criterion but that contain an e-Health solution that is recognized as being memory supportive or of benefit for one of the described target groups, will be considered for inclusion. Older people are defined as having the chronological age of 65 years or more. Informal caregivers have to be 18 years or older. The community-dwelling characterization is operationalized by the condition of living at home or in an independent living facility. Studies that exclusively describe e-Health solutions for institutional settings such as nursing homes will be excluded. Furthermore, articles need to be written in English, French, Dutch or Spanish to be included. All study designs, interventional and non-interventional, are considered for inclusion, though editorials, comments, letters to the editor and technical notes

will be excluded. Articles reviewing e-Health solutions and measuring their effectiveness will be excluded from analysis, but will be reviewed for additional references (snowballing).

Articles meeting the inclusion criteria will be assessed by two independent reviewers (SD and MAN) for methodological quality using the Cochrane Risk of Bias tool (Higgins and Green, 2011) in case of an intervention study, or checklists F, G and H provided by the National Institute of Health and Care Excellence for other study designs (NICE). Any disagreements that arise between the reviewers will be resolved through discussion, or with the help of a third reviewer.

Table 1: Search strategy as used in PubMed.

No.	Concepts	Concept equations
1	Dementia or Cognitive Impairment (Controlled vocabulary)	"Dementia"[Mesh] OR "Alzheimer Disease"[Mesh] OR "Neurodegenerative Diseases"[Mesh] OR "Cognitive Dysfunction"[Mesh] OR "Frontotemporal Dementia"[Mesh] OR "Huntington Disease"[Mesh] OR "Parkinsonian Disorders"[Mesh] OR "Prion Diseases"[Mesh]
2	Dementia or Cognitive Impairment (Free text)	alzheimer*[Title/Abstract] OR dementi*[Title/Abstract] OR cognitive impairment*[Title/Abstract] OR neurocognitive disorder*[Title/Abstract] OR neurodegenerative[Title/Abstract] OR cognitive dysfunction*[Title/Abstract] OR cognitive decline*[Title/Abstract] OR frontotemporal degeneration*[Title/Abstract] OR huntington's disease*[Title/Abstract] OR huntington disease*[Title/Abstract] OR lewy body disease*[Title/Abstract] OR Parkinson*[Title/Abstract] OR prion disease*[Title/Abstract] OR senility[Title/Abstract]
3	Dementia or Cognitive Impairment	#1 OR #2
4	e-Health Technology (Controlled vocabulary)	"Telemedicine"[Mesh] OR "Remote Consultation"[Mesh] OR "Telepathology"[Mesh] OR "Telerehabilitation"[Mesh] OR "Telenursing"[Mesh]
5	e-Health Technology (Free text)	econsult*[tiab] OR e-consult*[tiab] OR ediagnos*[tiab] OR e diagnos*[tiab] OR mobile health*[tiab] OR mhealth*[tiab] OR m health*[tiab] OR telehealth*[tiab] OR tele health[tiab] OR remote consult*[tiab] OR "remote patient monitoring"[tiab] OR teleconsult*[tiab] OR tele consult*[tiab] OR telenursing[tiab] OR tele nursing[tiab] OR telediagnos*[tiab] OR tele diagnos*[tiab] OR telemedic*[tiab] OR tele medic*[tiab] OR telemonitor*[tiab] OR tele monitor*[tiab] OR ehealth*[tiab] OR e health*[tiab] OR telecare[tiab] OR tele care[tiab] OR digital health[tiab] OR telecounsel*[tiab] OR tele counsel*[tiab] OR remote counsel*[tiab] OR distance consult*[tiab] OR distance counsel*[tiab] OR distant consult*[tiab] OR telehomecare*[tiab] OR telepatholog*[tiab] OR health technolog*[tiab] OR medical technolog*[tiab]
6	e-Health Interventions	#4 OR #5
7	Technology (Controlled vocabulary)	"Electronic Mail"[Mesh] OR "Telefacsimile"[Mesh] OR "Modems"[Mesh] OR "Videoconferencing"[Mesh] OR "Computer Communication Networks"[Mesh] OR "Internet"[Mesh] OR "User-Computer Interface"[Mesh] OR "Multimedia"[Mesh] OR "Cell Phone"[Mesh] OR "Computers, Handheld"[Mesh] OR "Mobile Applications"[Mesh] OR "Minicomputers"[Mesh] OR "Microcomputers"[Mesh]
8	Technology (Free text)	telefacsimile*[Title/Abstract] OR cell phone*[Title/Abstract] OR video-conferen*[Title/Abstract] OR videoconference*[Title/Abstract] OR videophone*[Title/Abstract] OR video-phone*[Title/Abstract] OR computer*[Title/Abstract] OR Internet[Title/Abstract] OR iphone*[Title/Abstract] OR smartphone*[Title/Abstract] OR information technolog*[Title/Abstract] OR communication technolog*[Title/Abstract] OR mobile technolog*[Title/Abstract] OR mobile application*[Title/Abstract] OR phone application*[Title/Abstract] OR tablet*[Title/Abstract] OR mobile phone*[Title/Abstract] OR healthcare robotics[Title/Abstract] OR assistive technology[Title/Abstract] OR gerontechnology[Title/Abstract] OR gerontotechnology[Title/Abstract] OR intelligent system*[Title/Abstract] OR networked technolog*[Title/Abstract] OR virtual reality[Title/Abstract] OR (("app"[Title/Abstract]) NOT ("amyloid precursor protein"[Title/Abstract])) OR "apps"[Title/Abstract] OR world wide web*[Title/Abstract] OR webportal*[Title/Abstract] OR web portal*[Title/Abstract] OR ipad[Title/Abstract] OR ipads[Title/Abstract] OR text messag*[Title/Abstract] OR "ussd"[Title/Abstract] OR laptop*[Title/Abstract] OR palmtop*[Title/Abstract] OR palm top*[Title/Abstract] OR interactive voice response*[Title/Abstract] OR multimedia[Title/Abstract] OR android[Title/Abstract] OR digital[Title/Abstract] OR online[Title/Abstract] OR on-line[Title/Abstract] OR texting[Title/Abstract] OR minicomputer*[Title/Abstract] OR microcomputer*[Title/Abstract] OR mobile device*[Title/Abstract] OR ambient assisted living[Title/Abstract] OR active assisted living[Title/Abstract] OR e-learning[Title/Abstract] OR elearning[Title/Abstract] OR wayfinding[Title/Abstract] OR geotracking*[Title/Abstract] OR geo-tracking*[Title/Abstract] OR global positioning system*[Title/Abstract] OR GPS track*[Title/Abstract] OR GPS device*[Title/Abstract] OR GPS technolog*[Title/Abstract] OR GPS navigation*[Title/Abstract] OR GPS logging device*[Title/Abstract] OR electronic mail*[Title/Abstract] OR cellular phone*[Title/Abstract] OR geographic information system*[Title/Abstract] OR telecommunication*[Title/Abstract] OR e-mail[Title/Abstract] OR fax[Title/Abstract] OR "self-help device*"[Title/Abstract] OR "patient portal*"[Title/Abstract] OR modem*[Title/Abstract]

Table 1: Search strategy as used in PubMed(cont.).

9	Technology	#7 OR #8
10	e-Health Technology	#6 OR #9
11	Intervention (Controlled vocabulary)	"Remote Consultation"[Mesh] OR "Counseling"[Mesh] OR "Social Support"[Mesh] OR "Self Medication"[Mesh] OR "Self Care"[Mesh] OR "Self-Management"[Mesh] OR "Consumer Health Information"[Mesh] OR "therapy" [Subheading] OR "Education"[Mesh] OR "education" [Subheading] OR "Education, Distance"[Mesh] OR "Patient Education as Topic"[Mesh] OR "Pain Management"[Mesh] OR "Self-Help Groups"[Mesh] OR "Home Care Services"[Mesh]
12	Intervention (Free text)	consult*[Title/Abstract] OR couns*[Title/Abstract] OR "follow up"[Title/Abstract] OR "follow ups"[Title/Abstract] OR support*[Title/Abstract] OR healthcare*[Title/Abstract] OR "care"[Title/Abstract] OR "cares"[Title/Abstract] OR self-medicat* [Title/Abstract] OR selfcar*[Title/Abstract] OR selfmanagement [Title/Abstract] OR selfhelp [Title/Abstract] OR selfadminist*[Title/Abstract] OR selfmonitor*[Title/Abstract] OR selfmedicat*[Title/Abstract] OR caregiving[Title/Abstract] OR psychoeducation [Title/Abstract] OR information[Title/Abstract] OR advis*[Title/Abstract] OR advice[Title/Abstract] OR intervention*[Title/Abstract] OR therap*[Title/Abstract] OR program*[Title/Abstract] OR train*[Title/Abstract] OR educat*[Title/Abstract] OR manag*[Title/Abstract] OR help[Title/Abstract] OR assist*[Title/Abstract] OR monitor*[Title/Abstract] OR administ*[Title/Abstract] OR strategy[Title/Abstract] OR strategies[Title/Abstract]OR project[Title/Abstract] OR projects[Title/Abstract] OR procedure*[Title/Abstract]
13	Intervention	#11 OR #12
14	Total Result	#3 AND #10 AND #13
	Publication Date Filter	2013-2018

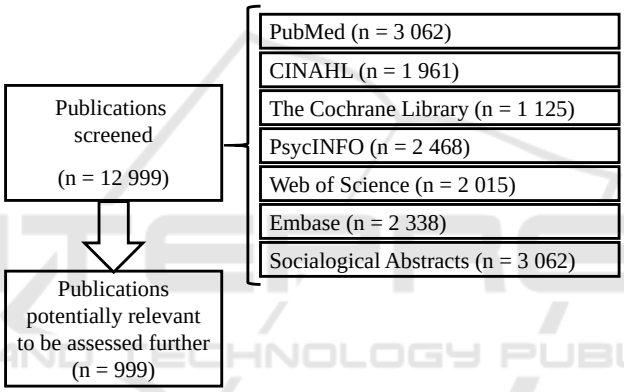

Figure 1: PRISMA flow diagram for the selection of studies.

3.3 Data Extraction and Synthesis

Articles that meet the selection criteria are compiled into a predesigned Excel data spreadsheet detailing primary study characteristics (authors, year, country of origin, study design, study population, sample size), the identified e-Health solution(s), the used data collection methods and the outcomes of significance for the review question. The extraction of these data will be conducted independently by two reviewers (SD and MAN).

Studies will be labelled in the data extraction process in order to make a taxonomy of e-Health solution types. After discussion, the authors agreed upon using a deductive method consisting of the following prefixed categories: AAL-Activities of daily living, AAL-Wayfinding and tracking, AAL-security and safety, (robotic) assistive technology, telehealth and telemedicine, virtual reality, technologies for personal organization and technologies for psychosocial support.

Where possible, data will be pooled in statistical meta-analysis and effect sizes with 95% confidence intervals will be calculated. In order to decide whether comparison of individual studies is justified, heterogeneity will be assessed statistically using the standard Chi-square test and explored using subgroup analysis based on the different included study designs. If statistical pooling is impossible the review findings will be presented in narrative form

4 RESULTS

Figure 1 depicts a flow diagram illustrating the selection process of the review. After elimination of duplicates the systematic literature review resulted in a total of 12999 hits. First-level screening of reference titles was completed in January 2019 and resulted in

12000 exclusions and 999 references that are potentially relevant. Second-level screening by abstract is in progress. Final assessment of the remaining publications by reading the full texts will be completed by April 2019. Data extraction and synthesis of the included studies is planned to be completed by July 2019.

5 CONCLUSIONS

Aging in place is a worldwide concern urging policy makers to expand their strategies with promising innovative approaches. E-Health technologies seem to offer such possibilities, even for older adults living with cognitive impairment. Moreover, the social burden on informal care could also potentially be alleviated by e-Health solutions. Since development of these solutions is accelerating in fast pace, it is important to inform the implementation of effective e-Health solutions based on the most recent research evidence. This review will revisit the literature and identify promising e-Health solutions for AIP with cognitive impairment. Therefore, this review will gain insight into the potential role of e-Health in the strengthening of community care for older adults with cognitive impairments and in the associated informal care.

ACKNOWLEDGEMENTS

This work was made possible through funding from the Fonds Wetenschappelijk Onderzoek (FWO, Belgium) and Fonds de Recherche de Québec (FRQ, Canada). The authors declare no conflicts of interest.

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