Computers in Human Behavior 63 (2016) 594–603

Contents lists available at ScienceDirect

Computers in Human Behavior

journal homepage: www.elsevier.com/locate/comphumbeh

Review

The impact of technology on older adults' social isolation

Pouria Khosravi*, [1], Azadeh Rezvani [1], Anna Wiewiora

Faculty of Business, Queensland University of Technology, Australia

ARTICLE INFO

Article history:
Received 22 March 2016
Received in revised form
30 May 2016
Accepted 31 May 2016

Keywords:
Assistive technology
ICT
Loneliness
Social isolation
Older adults

ABSTRACT

Research indicates that social isolation and loneliness have a negative effect on health and wellbeing among older people. Various technology-based interventions have been offered to reduce social isolation; however, research demonstrating the role of various types of technologies and their effectiveness in dealing with social isolation among seniors is scarce. This study undertakes a systematic literature review of empirical studies on various types of technologies and their effectiveness in alleviating social isolation among seniors. Relevant electronic databases were searched and through 6886 initial set of studies published from 2000 to 2015 we have found eight different technologies that have been applied to alleviate social isolation, namely, general ICT, video game, robotics, personal reminder information and social management system, asynchronous peer support chat room, social network sites, Telecare and 3D virtual environment. We further evaluated the effectiveness of the technologies with social isolation among seniors. Findings show that technologies can be used to reduce social isolation among seniors. However, more studies are needed to evaluate the effectiveness of new technologies.

Contents

1. Introduction 595
2. Methodology 595
 2.1. Search terms 595
 2.2. Inclusion/exclusion criteria 595
 2.3. Data extraction and synthesis 595
 2.4. Evaluation of the effectiveness of the technologies in the studies 596
3. Findings 596
 3.1. Trends 596
 3.2. Technologies used to assist seniors 597
 3.3. General ICT interventions 597
 3.4. Social network sites interventions 597
 3.5. Robotics interventions 598
 3.6. Video game interventions 598
 3.7. PRISMS interventions 599
 3.8. Koffee Klatch (chat room) intervention 599
 3.9. Tele-Care interventions 599
 3.10. 3D virtual environments 600
4. Discussion 600
5. Implications for practice 601
6. Conclusion 602
References 602

* Corresponding author. 2 George St, Queensland University of Technology, Brisbane, QLD 4000, Australia.
E-mail addresses: pouria.khosravi@hdr.qut.edu.au (P. Khosravi), a.rezvani@qut.edu.au (A. Rezvani), a.wiewiora@qut.edu.au (A. Wiewiora).
[1] The first two authors contributed equally to this work.

http://dx.doi.org/10.1016/j.chb.2016.05.092
0747-5632/

1. Introduction

The percentage of older people—those over the age of 65—will rise dramatically to 24% by 2030, in comparison to 10% in 2000.[2] This increase in ageing population has an influence on health care systems, including the cost of caring and increased use of health care systems (Langa, Valenstein, Fendrick, Kabeto, & Vijan, 2004; Lehnert et al., 2011). Health outcomes of seniors are affected not just by biomedical issues but also by psychosocial factors. Social isolation and loneliness are among risk factors that have negative effects on seniors' health (Holwerda et al., 2012). Seniors who have lost their partner, have fewer family or friends, and those who have limited contact with others are at risk of social isolation.

Studies show that social isolation and loneliness have been linked to poor cognitive functioning (Cacioppo & Hawkley, 2009; Shankar, McMunn, Banks, & Steptoe, 2011), mortality (Holt-Lunstad, Smith, & Layton, 2010; Shiovitz & Ayalon, 2010), impaired sleep and daytime dysfunction (Hawkley, Preacher, & Cacioppo, 2010), reductions in physical activity (Hawkley, Thisted, Masi, & Cacioppo, 2010), impaired mental health and even Alzheimer's disease (Wilson et al., 2007). Social isolation and loneliness are common among seniors; it is therefore vital to increase awareness of this issue within society and propose alternative solutions to minimize the impact of social isolation among the elderly.

Various technologies are being used to provide health care to seniors (Archer, Keshavjee, Demers, & Lee, 2014; Fischer, David, Crotty, Dierks, & Safran, 2014; Obi, Ishmatova, & Iwasaki, 2013; Slack et al., 2012). Information and communication technologies (ICTs) intended to alleviate loneliness and social isolation among seniors are considered as being significant in expanding and sustaining social contact, and improving emotional wellbeing (Cotten, Ford, Ford, & Hale, 2012; Wilson et al. 2007; Winstead et al., 2013). However, studies demonstrating the effectiveness of technological interventions remain scant, and those that do provide inconclusive results. This gap warrants a synthesis of the existing empirical data regarding the usefulness of technological interventions in assisting seniors to reduce social isolation and loneliness. Using a systematic literature review our research investigated the following questions:

RQ1. What technological interventions have been proposed to reduce social isolation?
RQ2. How effective have such technological interventions been in alleviating the social isolation of seniors?

This systematic review aims to identify ICTs that are designed to help seniors reduce their social isolation and loneliness, and assess the effectiveness of this technology in supporting seniors' wellbeing.

Social isolation refers to an objective and quantitative degree of network size and frequency of contact (Stokes, 1985), while loneliness is the subjective feeling of isolation and satisfaction with frequency of contact (de Jong Gierveld & Havens, 2004; Stokes, 1985). These two concepts of social isolation and loneliness are regarded as multidimensional concepts related to the lack of social incorporation (Stokes, 1983; Victor, Scambler, Bond, & Bowling, 2000) and are often used interchangeably in the literature and practice. Following this trend, our research includes studies that examine either or both of these concepts.

This study contributes to the literature on technological interventions in several ways. First, it advances our understanding regarding various technological interventions to alleviate social isolation and loneliness among seniors. Second, it provides insights into the effectiveness of these technologies on seniors' wellbeing. Finally, by better understanding various technological interventions and their effectiveness practitioners can advise seniors as to how they might take advantage of these technologies.

This paper is structured as follows: the next section defines the methodology chosen for this study, the subsequent section describes an overview of the findings and is followed by a discussion, contribution and recommendations for future research directions and practice.

2. Methodology

This study used a systematic literature review approach to evaluate and interpret the current literature and answer our research questions. We conducted the literature search following the four-staged guidelines (outlined in Fig. 1) suggested by the PRISMA guidelines (Moher, Liberati, Tetlaff, & Altman, 2009), as used by many studies (Nguyen, McElroy, Abecassis, Holl, & Ladner, 2015).

2.1. Search terms

We undertook systematic searches of published studies between 2000 and 2015 using six databases: Science Direct, ProQuest, PubMed, IEEE Xplore, PsychINFO and Scopus. Keywords were grouped into three categories: ("elderly" or "older" or "aged" or "seniors" or "elders") AND ("social isolation" or "loneliness" or "lonely" or "socially isolated") AND ("Technology" or "Information and communication technology" or "ICT" or "information technology" or "Information & communication technology" or "social media" or "Internet" or "computer"). We searched the above keywords in the publications' titles, keywords, abstracts or full texts.

2.2. Inclusion/exclusion criteria

We included studies that provided empirical evidence of the outcome of the technological interventions, as well as studies that: (1) involved seniors aged 50 or older with diverse types of study designs, (2) were published between 2000 and 2015, and (3) provided empirical evidence on the effectiveness of specific technologies to enhance social isolation or loneliness. Studies in languages other than English, conceptual papers, opinions and unpublished full-text documents were excluded.

2.3. Data extraction and synthesis

Using the above search criteria we identified 6886 papers to include in the qualified papers for this study. We then removed duplicates, which brought down the number of publications to 5832. In the screening stage 4962 papers were excluded based on the title. Two authors independently reviewed abstracts of the remaining 870 papers to ensure that selected papers fitted the focus and scope of our study (Fig. 1). This process reduced the number of papers to 90. Authors then read the full text of the 90 studies and selected 34 papers based on the inclusion criteria. An independent reviewer assessed the included studies against the inclusion criteria.

In the next stage, data from the 34 studies were extracted and synthesized for the purpose of systematic review. The extracted data included: (1) demographics, (2) methodology and study

[2] United Nations: Profiles of ageing by country or area. World Population Ageing 2013. Available at http://www.un.org/esa/population/publications/worldageing19502050/.

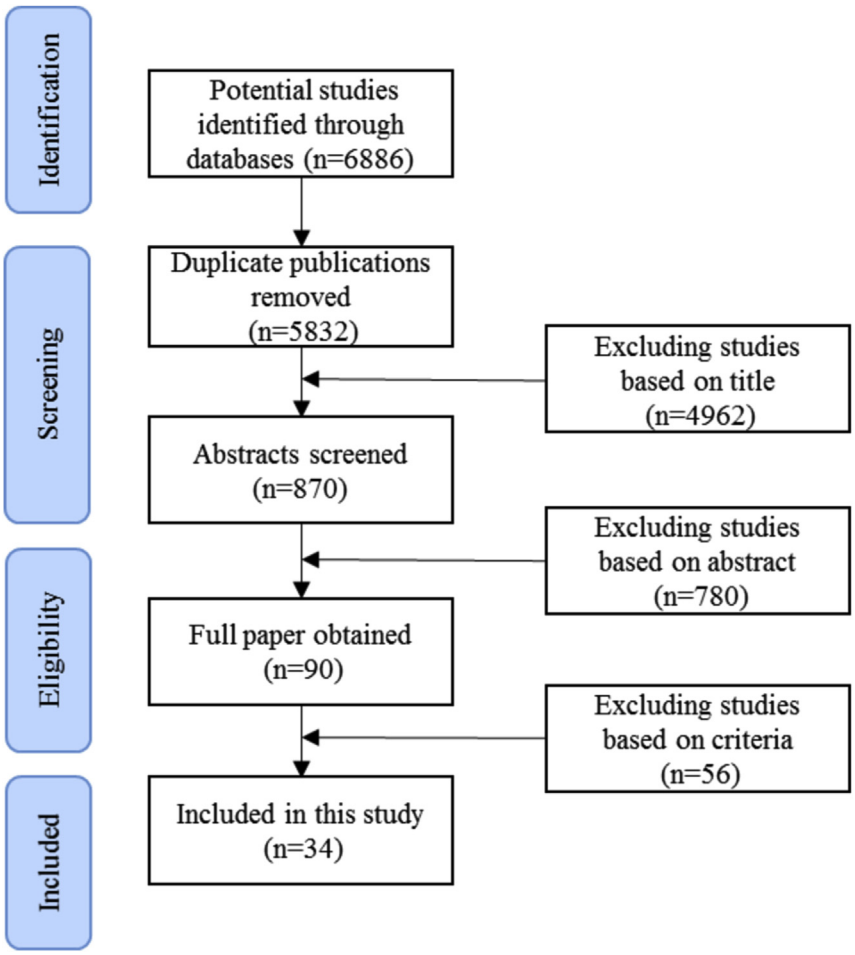

Fig. 1. Study selection procedures based on PRISMA guidelines.

design, (3) technological intervention, and (4) result or effectiveness of the technology.

2.4. Evaluation of the effectiveness of the technologies in the studies

To assess the effectiveness of the technologies in the selected studies we adopted a method proposed by Morrison, Yardley, Powell, and Michie (2012) and refined by Khosravi and Ghapanchi (2015) (Table 1). Following this method, two authors independently evaluated each study and gave it a score from 1 to 3 based on the study design, empirical analysis and results, and each author's own judgment. Three levels of technology effectiveness were considered: 1 = not effective, 2 = effective and 3 = very effective. Finally, a panel of three independent researchers reviewed and assessed the scores.

3. Findings

3.1. Trends

As shown in Fig. 2, most of the included studies were conducted in North America and Canada (N = 15, 60%). The remaining studies were conducted in Europe (N = 8, 20%), Australia (N = 2, 8%) and other countries (N = 3, 12%).

Fig. 3 demonstrates the number of studies investigating the role of technology in mitigating loneliness or isolation among the elderly published each year. It is evident that the number of studies have increased in the past few years, with seven papers published on that topic in 2012 alone. This increase suggests that this area is attracting growing attention among academics and practitioners, most likely because of the exponential growth of the older population.

Table 1
Criteria to evaluate the effectiveness of the technologies in the studies.

Subjective effectiveness score	Criteria
1 Not effective	Technology intervention showed no improvement in the outcome measures or no improvement in the intervention group compared to the control group
2 Effective	The findings were supported by a non-randomized controlled trial study with a fair quality Technology intervention demonstrated improvement in the outcome measures
3 Very effective	Findings were supported by the results of a randomized controlled trial study or equivalent fair quality study with a control group Technology intervention demonstrated significant improvement in the outcome measures or significant improvement in the intervention group compared to the control group

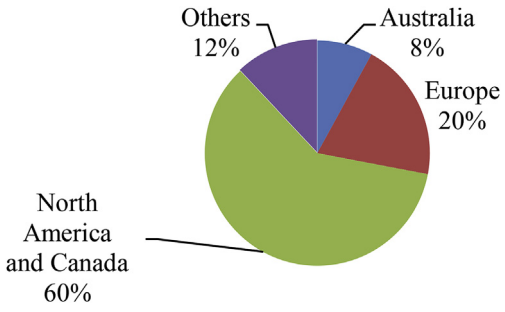

Fig. 2. Number of publications per continent.

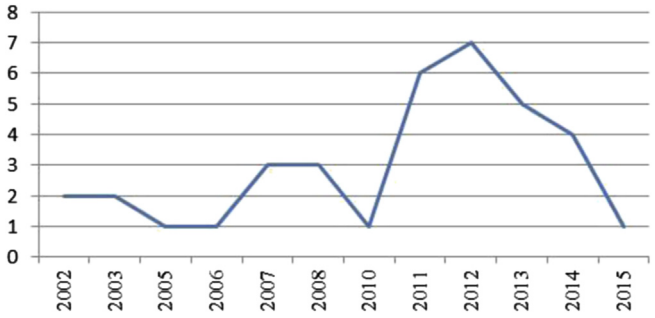

Fig. 3. Frequency of publications per year.

3.2. Technologies used to assist seniors

Based on a comprehensive literature review, the selected 34 studies were labelled with an appropriate technology name, study focus and context. Two authors in three rounds performed this process separately. During this process we merged some of the categories or revised some labels in order to achieve our final classification. Finally, the complete set of classifications was discussed in a meeting (Rust & Cooil, 1994), in the presence of a panel of three researchers, and a complete set of final categories was finalised.

Different types of technological interventions found across selected papers are shown in Fig. 4. We categorised these technological interventions into eight main categories: general ICTs, video games, robotics, personal reminder information and social management system (PRISMS), asynchronous peer support chat rooms, social network sites (SNSs), Tele-Care, and 3D virtual environments.

Most of the studies (with 15 publications in the final set) evaluated the impact of general ICTs on social isolation and loneliness.

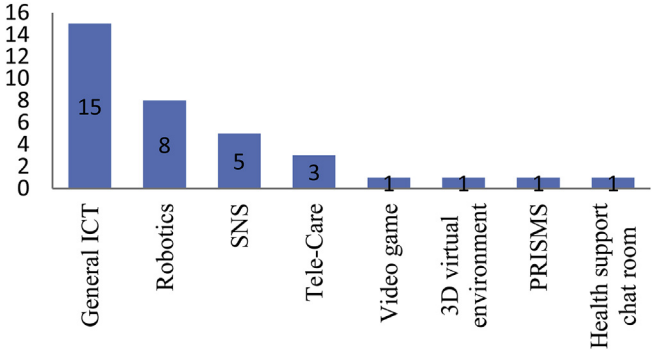

Fig. 4. Various technologies applied to alleviate social isolation/loneliness.

Robotics, SNSs and Tele-Care are the next three highest categories (with 7, 5 and 3 publications respectively). The remaining technologies were investigated only in single studies.

Most of the studies used validated measurement tools, with the University of California Los Angeles (UCLA) loneliness scale (Russell, Peplau, & Ferguson, 1978) being used in the greatest number of studies. de Jong Gierveld and Havens' (2004) loneliness scale, developed to measure loneliness in older people, was also used in a few studies.

3.3. General ICT interventions

According to our study findings, general ICTs, or computer and Internet use, provide new ways of communication that are accessible to all individuals and which assist in overcoming obstacles to social interaction among seniors (Young & Lo, 2012). Despite the various barriers that prevent seniors from using computer technology, including computer anxiety, research reports that increasing numbers of seniors are now exposed to and use technology in their daily lives (Wagner, Hassanein, & Head, 2010). General ICTs, in particular the Internet and email, provide a variety of ways for seniors to communicate with family and friends. These technologies provide a new way to interact with others, and provide access to a wide variety of information and community resources.

Two of the four randomized controlled trial (RCT) studies investigating ICTs demonstrated a significant reduction in loneliness (Cotten, Anderson, & McCullough, 2012, 2013). Both studies used UCLA measures and recruited seniors who were at the risk of isolation. The other two studies did not find any statistically significant improvements in their intervention groups. In the study conducted by White et al. (2002) training took place for only two weeks. This short time for training might explain the nonsignificant changes in the degree of seniors' loneliness. Woodward, Feddolino and Blaschke-Thompson (2011) also found that there were no statistically significant improvements in seniors' loneliness after the intervention (see Table 2). All of the quasi-experimental studies reported a significant reduction in social isolation or loneliness among seniors. Other studies that used surveys as their method of gathering data and one study that used in-depth interviews demonstrated mixed results (see Table 2).

3.4. Social network sites interventions

SNSs, such as Facebook or Twitter, assist in building and continuing social relationships and have been found to be essential in contributing to the wellbeing of seniors. Impaired mobility or geographical distance from family members may cause loneliness among seniors. SNSs have the capacity to overcome these obstacles by allowing seniors to maintain involvement with their family or friend networks, despite their immobility or distance from them.

Although SNSs are considered to be a cause of loneliness in younger generations (Kross et al., 2013), it has been argued that SNSs have the potential to reduce loneliness in seniors (Leist, 2013). Most of the studies (with the exception of one) in this category used survey methods, with two studies showing no relationship between loneliness and SNS use, and one study demonstrating increased loneliness among SNS users, compared to non-users. Two remaining studies, one using a survey method and one using in-depth interviews, show that SNSs reduced loneliness and increased seniors' social satisfaction (Table 3). These inconclusive results call for future research in this area, adapting various research methods and taking into account users' specific contextual and individual characteristics, which can play an important role in the perceived value of SNSs in mitigating loneliness and isolation.

Table 2
General ICTs.

Source	Participants	Method	Intervention/technology	Findings	Subjective effectiveness score
Cotton et al., (2013)	33 in intervention group and 33 in control group	Randomized controlled trial	Computer/Internet training and use; 8-weeks of training	Using Internet associated with lower levels of loneliness and social isolation	3
Woodward et al. (2011)	Experimental group (n = 45) control group (n = 38)	Randomized controlled trial	Computer/Internet training and use; 12 sessions of training during 6 months	There were no statistically significant improvements in other social support measures or in loneliness or depression	1
White et al. (2002)	39 participants in the intervention group- 45 in control group – mean age 72	Randomized controlled trial	Internet training and use; 2 weeks of training	There were no statistically significant differences in the change scores on the loneliness scale comparing the intervention and control groups. But there was a slightly greater tendency towards less loneliness in the intervention group	1
Cotton et al., (2013)	205 participants – mean age 82.8 –79 intervention group 126 control groups	Randomized controlled trial	Internet training and use; 8 weeks of training	Significant increase in agreement that using the Internet had made respondents feel less isolated	3
Slegers, Van Boxtel, and Jolles (2008)	123 participants assigned to intervention group and 68 to control group	Randomized controlled trial	Computer training and Internet use; 4-h training sessions over a period of 2 weeks	There was no significant difference in loneliness between two groups	1
Shapira, Barak, and Gal, (2007)	22 older adults in the intervention group (mean age of 80/26) participants in control group (aged 70–93)	Quasi-experimental study	Computer/Internet training and use; the training lasted 15 weeks and included one or two lessons per week	Internet use decreased feelings of loneliness	3
Blažun, Saranto, & Rissanen, (2012)	58 participants at the baseline (M = 72.4 years) and 45 older participants at the follow-up research study (M = 72.9 years	Quasi-experimental study	Computer/Internet training and use; training once a week for 3 –4 h lasting three weeks	Loneliness reduced significantly after intervention/increased level of social inclusion	2
Fokkema and Knipscheer, (2007)	12 participants with average age 66 with a chronic disease or handicap	Quasi-experimental study	Using the Internet at home; training conducted in five, 2-h lessons at home	Loneliness decreased	2
Şar, Göktörkb, Turac, and Kazazd, (2012)	563	Survey – Cross-sectional	Internet use	Seniors using the Internet have lower loneliness levels than those who do not	3
Bradley and Poppen, (2003)	20 participants with disabilities at risk of being isolated	Survey – Longitudinal	Computers for Homebound and Isolated Persons	Satisfaction in the amount of contact with others increased significantly	2
Toepoel (2013)	1171 in the age group 55–64, 637 in the age group 65–74 and 210 in the age group 75	Survey – Cross-sectional	Using computer	Spending time behind the computer (passive activities) were not associated with social connectedness	2
Cotten, Ford, Ford, and Hale (2014)	3,075, age over 50	Survey – Longitudinal over 4 waves of data	Internet use	Internet use reduced isolation and loneliness	3
Sum, Mathews, Hughes, and Campbell, (2008)	222 Australians over 55 years of age	Survey – Cross-sectional	Internet use	Internet use as a communication tool reduces social loneliness	3
James, Boyle, Yu, and Bennett, (2013)	661 community-dwelling older persons	Survey – Cross-sectional	Internet use	Higher frequency of Internet use correlates with less loneliness	2
Erickson and Johnson, (2011)	122 adults over 60 years old	Survey – Cross-sectional	Internet use	Internet use decreases loneliness	2

3.5. Robotics interventions

In recent years various types of robots have entered the market to provide social support for seniors, offering the potential to improve emotional wellbeing and help seniors to live independently (Bickmore, Caruso, Clogh-Gorr, & Heeren, 2005). This type of technology assists in providing a sense of social presence and communication (Beer & Takayama, 2011). Two different systems identified from four studies are included in this category. First is the pet robot, which provides the same advantages that have been found in animal-assisted therapy, such as reduced loneliness and social isolation without the risk of infection. Second is the conversational agent, which provides different approaches to reduce loneliness or social isolation, including companionship through social interaction, enabling seniors to connect with family members and friends (social presence) and offering "talk therapy" (see Table 4). Six out of seven studies in this category reported a decrease in social isolation and loneliness among seniors.

3.6. Video game interventions

Research demonstrates that playing video games has a positive effect on cognitive and physical stimulation. Video games capturing natural physical activities, such as Wii, were found to provide positive stimulation when compared to typical video games. A study conducted by Kahlbaugh, Sperandio, Carlson, and Hauselt (2011) showed that playing Wii leads to better social interaction and less loneliness among seniors (Table 5).

Table 3
Social network sites.

Source	Participants	Method	Intervention/ technology	Findings	Subjective effectiveness score
Hutto and Bell, (2014)	268 participants - age over 55	Survey – Cross-sectional	Using social network sites	Using SNSs increased social satisfaction and reduced loneliness	2
Bell et al. (2013)	142 older adults age = 52–92 years old in the USA	Survey – Cross-sectional	Using social network sites	There was no significant difference in loneliness between SNS users and non-users	1
Aarts, Peek, and Wouters, (2014)	626 participants aged 60 and over in the Netherlands	Survey – Cross-sectional	Using social network sites	There was no relationship between using SNSs and loneliness	1
Ballantyne, Trenwith, Zubrinich, and Corlis, (2010)	Six older people aged 69–85 years old in South Australia	Depth interviews	Using social network sites	Using SNSs reduced loneliness	2
Brandtz (2012)	440 participants aged 61–75 years old	Survey – Longitudinal	Using social network sites	SNS users reported more loneliness than non-users	1

3.7. PRISMS interventions

Weinert, Cudney, and Hill (2008) developed a special software for seniors to support social connectivity, memory and leisure activities, called the Personal Reminder Information and Social Management (PRISM) System. In their study they evaluated the impact of the PRISM system on social isolation and loneliness. Their initial results showed promising benefits regarding this simple software application (see Table 6).

3.8. Koffee Klatch (chat room) intervention

Hill, Weinert, and Cudney (2006) conducted a randomized controlled trial study about an asynchronous, peer-led support chat room (Koffee Klatch) and its effect on loneliness among chronically ill women. Koffee Klatch provides an opportunity for women to chat about various health topics in the presence of health-care experts. Although findings showed significant improvement on the social support score there were no significant differences found in the level of loneliness (Table 7).

3.9. Tele-Care interventions

The Tele-Care system uses ICT to evaluate health status and deliver care anytime and anywhere (Chau et al., 2012). Tele-Care provides monitoring, communication and support for seniors (Chumbler, Mann, Wu, Schmid, & Kobb, 2004). It promotes the delivery of social and health services by decreasing the cost of

Table 4
Robotics.

Source	Participants	Method	Intervention/ technology	Findings	Subjective effectiveness score
Bickmore et al. (2005)	21 participants aged 62–84	Quasi-experimental study; Participants were asked to use the system daily during the 2-month study period	Robot, Relational agents	No significant differences between two groups	1
Kanamori, Suzuki, and Tanaka, (2002)	3 senior participants	Case study; Interaction with robot in 20 sessions	Pet robot	Decreased stress and loneliness	2
Beer and Takayama (2011)	12 volunteer participants (ages 63–88)	Experimental study; Interview	Mobile presence system	Reducing travel costs and social isolation	2
Ring, Barry, Totke, and Bickmore, (2013)	14 participants (3 Male, 11 Female)	Experimental study; longitudinal	Computer conversational agent-based system, participants used the system for a week	Participants felt a sense of companionship with the agent; using the system reduced perceived loneliness	2
Banks, Willoughby, and Banks, (2008)	Seniors in nursing home	Randomized controlled trial; 30-min session each week for 8 weeks	Pet robot (AIBO)	Interaction with robotic dog reduced loneliness	3
Robinson, MacDonald, Kerse, and Broadbent, (2013)	40 participants; age range 55–100 years; control group n = 20; intervention group n = 20	Randomized controlled trial; sessions took place twice a week for an hour over 12 weeks	Pet robot (PARO)	Significant decreases in loneliness over the period of the trial	3
Kanamori, Suzuki, Oshiro, and Tanaka, (2003)	5 females at the mean age of 68.2 in a nursing home and 1 one male 84 years at home	Intervention study; the activities with pet-type robots were carried out for 7 weeks	Pet robot (AIBO)	Loneliness after the intervention was significantly lower than before	2
Ring, Shi, Totzke, and Bickmore, (2015)	14 seniors age between 56 and 73 years old	Intervention study for a week	Robot, relational agents	Participants who interacted with the agent longer reported feeling less lonely at the end of the study	2

Table 5
Video game.

Source	Participants	Method	Intervention/ technology	Findings	Subjective effectiveness score
Kahlbaugh et al. (2011)	35 individuals (M = 82 years) 16 Wii, 12 TV Controls, and 7 No Visit Control	Randomized controlled trial; Playing Wii for 10 weeks	Video game	The elderly playing Wii had lower loneliness compared to the television group	3

health care everywhere. Three studies in our final pool evaluated the role of Tele-Care in mitigating loneliness among the elderly. All of these studies found a decrease in the level of loneliness, demonstrating the usefulness of this tool for seniors dealing with social isolation (Table 8).

3.10. 3D virtual environments

A 3D virtual environment is an innovative technology where participants are represented by an avatar. This environment allows users to see other members of the group represented as avatars, mimicking face-to-face interaction. The 3D environment provides additional support to other forms of online communication such as emotional experience of support which may reduce social isolation. O'Connor, Arizmendi, and Kaszniak (2014) conducted an intervention study with seven participants and found that using a 3D virtual environment reduced the level of loneliness (Table 9).

4. Discussion

IT has made a significant impact on individuals' lives (Khosravi & Rezvani, 2012; Khosravi, Rezvani, & Ahmad, 2013; Rezvani, Khosravi, & Ahmad, 2012; Rezvani, Khosravi, Subasinghage, & Perera, 2012; Tennyson & Sisk, 2011; Yao & Zhong, 2014). Many studies to date have investigated the various effects of IT on well-being (Ahn & Shin, 2013; Khosravi, Ghapanchi, & Blumenstein, 2015; Morahan-Martin & Schumacher, 2003). Evidence regarding the effect of technologies applied to alleviate loneliness or social isolation are mixed. This systematic review synthesized empirical studies with the purpose of examining various technological interventions and their effectiveness in dealing with seniors' social isolation and loneliness. Although a number of studies exist concerning the use of technologies to tackle social isolation and loneliness, little is known about the variety of technological interventions and their effectiveness when dealing with this issue.

To answer RQ 1, our research identified eight main categories of technological interventions dealing with loneliness and social isolation among seniors: general ICTs, video games, robotics, PRISM, asynchronous peer support chat rooms, SNSs, Tele-Care and 3D virtual environments (as shown in Fig. 4). In order to answer RQ 2 we assessed the results of selected studies and, based on the average of the subjective effectiveness scores, compared the effectiveness of various technological interventions aimed to alleviate social isolation and loneliness among seniors. Table 10 reports on the effectiveness of the eight different technological interventions.

Only a limited number of studies assessed the effectiveness of new technologies, such as 3D virtual environments, and most of the studies used low sample sizes, suggesting more research is needed in this area. Video games and PRISM were the most effective, with an average score of 3. Both categories contain one study and both studies were randomized controlled trials with good sample sizes. However, by considering only one study in each of the above categories it is not reasonable to generalize the effectiveness of those technologies. Therefore, future studies should examine those technologies taking into account users' specific contextual and individual characteristics to provide more robust conclusions. The next most effective category which shows a promising result to alleviate loneliness is Tele-Care, with an average score of 2.3. General ICT is the next most effective category, with an average score of 2.2. Twelve out of fifteen studies in this category reported significant changes in the level of isolation or loneliness. The next most effective category, with an average score of 2.14, is robotics. Six out of seven studies with robotics interventions reported a reduction in loneliness among seniors; there are no randomized controlled trial studies in this category. Lastly, an asynchronous

Table 6
Personal reminder information and social management system.

Source	Participants	Method	Intervention	Findings	Subjective effectiveness score
Weinert et al. (2008)	300 older adults, aged 64–98 years, who lived alone and at risk for being isolated	Randomized controlled trial; 22-week intervention	Personal Reminder Information and Social Management System (Special software designed for seniors)	Use of software reduced loneliness	3

Table 7
Koffee Klatch.

Source	Participants	Method	Intervention/technology	Findings	Subjective effectiveness score
Hill et al. (2006)	183 participants (chronically ill women); 3 groups and 61participants in each group	Randomized controlled trial; 22-week intervention	Asynchronous peer-led support chat room (Koffee Klatch) for duration 22 weeks	There were no significant differences found in loneliness	1

Table 8
Tele-care.

Source	Participants	Method	Intervention/technology	Findings	Subjective effectiveness score
Arnaert and Delesie, (2007)	71 participants 60 years and older	Intervention study; 6 months	Video-telephone nursing care	Level of loneliness in participants decreased after the study	2
Tsai and Tsai, (2011)	Experimental (n = 40) and control (n = 50) group	Quasi-experimental study; 3 months	Videoconference for older nursing home residents	Experimental group had a significantly lower mean loneliness level after intervention compared to control group	3
Van de Heide et al., (2012)	130 participants with the average age of 73.2 years	Intervention study; one-year trial period	Care TV	Feeling of loneliness significantly decreased after intervention	2

Table 9
3D virtual environment.

Source	Participants	Method	Intervention/technology	Findings	Subjective effectiveness score
O'Connor et al., (2014)	7 participants aged between 54 and 70 years old	Intervention study	3D virtual environment in an 8-week support group	Lower levels of depression and loneliness across participants	2

Table 10
Effectiveness of various technologies.

Technology	Average of the subjective effectiveness scores	Frequency of papers (very effective)	Frequency of papers (effective)	Frequency of papers (not effective)
General ICT	2.2	6	6	3
Robotics	2.14	2	5	1
Social network sites	1.6	0	2	3
Tele-care	2.3	1	2	0
3D virtual environments	2	0	1	0
Video games (Wii)	3	1	0	0
PRISM	3	1	0	0
Asynchronous peer-led support chat rooms (Koffee Klatch)	1	0	0	1

peer-led support chat room, Koffee Klatch, showed no improvement in loneliness among seniors.

Our study demonstrates that, in general, some technologies used to alleviate social isolation and loneliness among seniors have a positive impact on seniors' lives and wellbeing. Possible explanations for studies that show no effect include the methodological quality, poorly-developed interventions and lack of proper theoretical basis.

The use of a comprehensive search strategy in various databases and the inclusion of different methodological designs (including randomized controlled trials, quasi-experimental designs, surveys, etc.) allowed us to extract data from more studies and evaluate the wider effectiveness of various technologies for reducing loneliness and social isolation among seniors. Only seven studies used randomized controlled trials and the remaining were quasi-experimental or used a survey, making it challenging to deliver robust conclusions. To provide more robust findings concerning the effectiveness of various technologies future studies should use randomized controlled trials.

Consistent with our inclusion criteria, all of the studies in the final pool assessed the effectiveness of technologies. Seventy percent of studies in the final pool showed changes in the level of loneliness or isolation. However, technologies might have an adverse effect on a senior's life with long-term usage. Therefore, future studies should consider the adverse effect of technologies and conduct longitudinal studies to find out the positive or negative effect of technologies.

It is crucial to design and conduct a study based on theoretical frameworks to provide an explanation for hypothesised associations (March & Smith, 1995). However, most of the studies in this review were not based on a theoretical framework and this may prevent researchers from building on or testing established theories in this area, or from following a systematic approach. Future studies should be designed based on the theoretical frameworks specific to this context.

Most of the studies in this review assessed the association between using the Internet for general purposes and loneliness/social isolation. Despite the promising benefits of new technologies, such as robotics or specific software designed for seniors, there were only a few studies available in these areas. More studies are required to provide robust conclusions regarding the effectiveness of these new technologies.

5. Implications for practice

Evaluation of various technologies and their benefits in alleviating loneliness and social isolation discussed in this study provide a number of implications for practice. Practitioners should promote the benefits of using new technologies, such as a decrease in the degree of loneliness, to the elderly, their family members and health care providers. Governments and policy-makers should consider financial support for implementing new technologies and increasing ICT literacy among seniors. Loneliness and social isolation have a direct and negative impact on seniors' health and their quality of life and, consequently, contribute to increased costs in health care. It is therefore essential for health care providers and

governments to assist in providing wellbeing to seniors by promoting and introducing them to new technologies; hence reducing health care costs in the long term. Researchers and practitioners should identify barriers and enablers to promote ICT literacy among seniors. It is also important to consider seniors' motivations and provide content suitable for them. Lastly, this study shows how different technologies offer various opportunities to alleviate seniors' loneliness. Therefore, practitioners should consider using appropriate technologies to overcome this issue.

6. Conclusion

This study used a systematic literature review to assess various technologies and their effectiveness to alleviate seniors' loneliness and social isolation. This study identified eight different technologies that have been used with seniors and assessed their effectiveness. Findings from this study show that various technologies offer different possibilities and ways of engagement and, generally, most of them can be used to reduce social isolation and loneliness among seniors. Although most of the studies showed the positive effect of technologies on loneliness more research is needed regarding the effectiveness of new technologies. It is vital to develop new technologies or new software that suit seniors' needs and provide sufficient training to familiarize seniors with the use of these technologies.

References

Aarts, S., Peek, S., & Wouters, E. (2014). The relation between social network site usage and loneliness and mental health in community-dwelling older adults. *International Journal of Geriatric Psychiatry*. http://dx.doi.org/10.1002/gps.4241.

Ahn, D., & Shin, D.-H. (2013). Is the social use of media for seeking connectedness or for avoiding social isolation? Mechanisms underlying media use and subjective well-being. *Computers in Human Behavior, 29*(6), 2453–2462.

Archer, N., Keshavjee, K., Demers, C., & Lee, R. (2014). Online self-management interventions for chronically ill patients: cognitive impairment and technology issues. *International Journal of Medical Informatics, 83*(4), 264–272.

Arnaert, A., & Delesie, L. (2007). Effectiveness of video-telephone nursing care for the homebound elderly. *CJNR (Canadian Journal of Nursing Research), 39*(1), 20–36.

Ballantyne, A., Trenwith, L., Zubrinich, S., & Corlis, M. (2010). 'I feel less lonely': what older people say about participating in a social networking website. *Quality in Ageing and Older Adults, 11*(3), 25–35.

Banks, M. R., Willoughby, L. M., & Banks, W. A. (2008). Animal-assisted therapy and loneliness in nursing homes: use of robotic versus living dogs. *Journal of the American Medical Directors Association, 9*(3), 173–177.

Beer, J. M., & Takayama, L. (2011). Mobile remote presence systems for older adults: acceptance, benefits, and concerns. In *Proceedings of the 6th international conference on human-robot interaction, 2011*. ACM.

Bell, C., Fausset, C., Farmer, S., Nguyen, J., Harley, L., & Fain, W. B. (2013). Examining social media use among older adults. In *Proceedings of the 24th ACM conference on hypertext and social media. 2013*. ACM.

Bickmore, T. W., Caruso, L., Clogh-Gorr, K., & Heeren, T. (2005). 'It's just like you talk to a friend': relational agents for older adults. *Interacting with Computers, 17*(6), 711–735.

Blažun, H., Saranto, K., & Rissanen, S. (2012). Impact of computer training courses on reduction of loneliness of older people in Finland and Slovenia. *Computers in Human Behavior, 28*(4), 1202–1212.

Bradley, N., & Poppen, W. (2003). Assistive technology, computers and Internet may decrease sense of isolation for homebound elderly and disabled persons. *Technology and Disability, 15*(1), 19–25.

Brandtzæg, P. B. (2012). Social networking sites: their users and social implications—A longitudinal study. *Journal of Computer-Mediated Communication, 17*(4), 467–488.

Cacioppo, J. T., & Hawkley, L. C. (2009). Perceived social isolation and cognition. *Trends in Cognitive Sciences, 13*(10), 447–454.

Chau, J. P.-C., Lee, D. T., Chow, A. Y., Yu, W. C., Chair, S. Y., Lai, A. S., et al. (2012). A feasibility study to investigate the acceptability and potential effectiveness of a Tele-Care service for older people with chronic obstructive pulmonary disease. *International Journal of Medical Informatics, 81*(10), 674–682.

Chumbler, N. R., Mann, W. C., Wu, S., Schmid, A., & Kobb, R. (2004). The association of home-telehealth use and care coordination with improvement of functional and cognitive functioning in frail elderly men. *Telemedicine Journal & E-Health, 10*(2), 129–137.

Cotten, S., Anderson, W., & McCullough, B. (2012). The impact of ICT use on loneliness and contact with others among older adults. *Gerontechnology, 11*(2), 161.

Cotten, S. R., Anderson, W. A., & McCullough, B. M. (2013). Impact of Internet use on loneliness and contact with others among older adults: cross-sectional analysis. *Journal of Medical Internet Research, 15*(2), e39.

Cotten, S. R., Ford, J., Ford, S., & Hale, T. M. (2012). Internet use and depression among older adults. *Computers in Human Behavior, 28*(2), 496–499.

Cotten, S. R., Ford, G., Ford, S., & Hale, T. M. (2014). Internet use and depression among retired older adults in the united states: a longitudinal analysis. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 69*(5), 763–771.

Erickson, J., & Johnson, G. M. (2011). Internet use and psychological wellness during late adulthood. *Canadian Journal on Aging (La Revue Canadienne du Vieillissement), 30*(02), 197–209.

Fischer, S. H., David, D., Crotty, B. H., Dierks, M., & Safran, C. (2014). Acceptance and use of health information technology by community-dwelling elders. *International Journal of Medical Informatics, 83*(9), 624–635.

Fokkema, T., & Knipscheer, K. (2007). Escape loneliness by going digital: a quantitative and qualitative evaluation of a Dutch experiment in using ECT to overcome loneliness among older adults. *Aging and Mental Health, 11*(5), 496–504.

Hawkley, L. C., Preacher, K. J., & Cacioppo, J. T. (2010). Loneliness impairs daytime functioning but not sleep duration. *Health Psychology, 29*(2), 124.

Hawkley, L. C., Thisted, R. A., Masi, C. M., & Cacioppo, J. T. (2010). Loneliness predicts increased blood pressure: 5-year cross-lagged analyses in middle-aged and older adults. *Psychology and Aging, 25*(1), 132.

van der Heide, L. A., Loek, A., Willems, C. G., Speeuwenberg, M. D., Rietman, J., & de Witte, L. P. (2012). Implementation of CareTV in care for the elderly: the effects on feelings of loneliness and safety and future challenges. *Technology and Disability, 24*(4), 283–291.

Hill, W., Weinert, C., & Cudney, S. (2006). Influence of a computer intervention on the psychological status of chronically ill rural women: preliminary results. *Nursing Research, 55*(1), 34.

Holt-Lunstad, J., Smith, T. B., & Layton, J. B. (2010). Social relationships and mortality risk: a meta-analytic review. *PLoS Medicine, 7*(7), e1000316.

Holwerda, T., Beekman, A. T., Deeg, D. J., Stek, M. L., van Tilbury, T. G., Visser, P. J., et al. (2012). Increased risk of mortality associated with social isolation in older men: only when feeling lonely? Results from the Amsterdam Study of the Elderly (AMSTEL). *Psychological Medicine, 42*(4), 843–853.

Hutto, C., & Bell, C. (2014). Social media gerontology: understanding social media usage among a unique and expanding community of users. In *System sciences (HICSS), 47th Hawaii international conference, 2014*. IEEE.

James, B. D., Boyle, P. A., Yu, L., & Bennett, D. A. (2013). Internet use and decision making in community-based older adults. *Frontiers in Psychology, 4*.

de Jong Gierveld, J., & Havens, B. (2004). Cross-national comparisons of social isolation and loneliness: introduction and overview. *Canadian Journal on Aging (La Revue canadienne du vieillissement), 23*(2), 109–113.

Kahlbaugh, P. E., Sperandio, A. J., Carlson, A. L., & Hauselt, J. (2011). Effects of playing Wii on well-being in the elderly: physical activity, loneliness, and mood. *Activities, Adaptation & Aging, 35*(4), 331–344.

Kanamori, M., Susuki, M., Oshiro, H., & Tanaka, M. (2003). Pilot study on improvement of quality of life among elderly using a pet-type robot. In *Computational intelligence in robotics and automation, proceedings, 2003*. IEEE.

Kanamori, M., Suzuki, M., & Tanaka, M. (2002). Nihon Ronen Igakkai zasshi [Maintenance and improvement of quality of life among elderly patients using a pet-type robot]. *Japanese Journal of Geriatrics, 39*(2), 214–218.

Khosravi, P., & Ghapanchi, A. H. (2015). Investigating the effectiveness of technologies applied to assist seniors: a systematic literature review. *International Journal of Medical Informatics, 85*(1), 17–26.

Khosravi, P., Ghapanchi, A. H., & Blumenstein, M. (2015). Investigating various technologies applied to assist seniors. *Health Information Science*, 202–212.

Khosravi, P., & Rezvani, A. (2012). Individuals' absorptive capacity in enterprise system assimilation. In *ACIS 2012: Location, location, location: Proceedings of the 23rd Australasian conference on information systems, 2012*. ACIS.

Khosravi, P., Rezvani, A., & Ahmad, M. N. (2013). Does organizational identification lead to information system success? *World Applied Sciences Journal, 21*(3), 402–408.

Kross, E., Verduyn, P., Demiralp, E., Park, J., Lee, D. S., Lin, N., et al. (2013). Facebook use predicts declines in subjective well-being in young adults. *PloS One, 8*(8), e69841.

Langa, K., Valenstein, M. H., Fendrick, A. M., Kabeto, M. U., & Vijan, S. (2004). Extent and cost of informal caregiving for older Americans with symptoms of depression. *The American Journal of Psychiatry, 161*(5), 857–863.

Lehnert, T., Heider, D., Leicht, H., Heinrich, S., Corrieri, S., Luppa, M., et al. (2011). Review: health care utilization and costs of elderly persons with multiple chronic conditions. *Medical Care Research and Review, 68*(4), 387–420.

Leist, A. K. (2013). Social media use of older adults: a mini-review. *Gerontology, 59*(4), 378–384.

March, S. T., & Smith, G. F. (1995). Design and natural science research on information technology. *Decision Support Systems, 15*(4), 251–266.

Moher, D., Liberati, A., Tetzlaff, J., & Altman, D. (2009). Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *Annals of Internal Medicine, 151*(4), 264–269.

Morahan-Martin, J., & Schumacher, P. (2003). Loneliness and social uses of the Internet. *Computers in Human Behavior, 19*(6), 659–671.

Morrison, L. G., Yardley, L., Powell, J., & Michie, S. (2012). What design features are used in effective e-health interventions? A review using techniques from Critical Interpretive Synthesis. *Telemedicine and e-Health, 18*(2), 137–144.

Nguyen, C., McElroy, L. M., Abecassis, M. M., Holl, J. L., & Ladner, D. P. (2015). The use of technology for urgent clinician to clinician communications: a systematic review of the literature. *International Journal of Medical Informatics, 84*(2), 101–110.

O'Connor, M.-F., Arizmendi, B. J., & Kaszniak, A. W. (2014). Virtually supportive: a feasibility pilot study of an online support group for dementia caregivers in a 3D virtual environment. *Journal of Aging Studies, 30*, 87–93.

Obi, T., Ishmatova, D., & Iwasaki, N. (2013). Promoting ICT innovations for the ageing population in Japan. *International Journal of Medical Informatics, 82*(4), e47–e62.

Rezvani, A., Khosravi, P., & Ahmad, M. N. (2012). Assessing the role of transactional and transformational leadership. In *Continuance intentions of enterprise resource planning, 2012*. PACIS.

Rezvani, A., Khosravi, A., Subasinghage, M., & Perera, M. (2012). How does contingent reward affect enterprise resource planning continuance intention? the role of contingent reward transactional leadership. In *Location, location, location: Proceedings of the 23rd Australasian conference on information systems, 2012*. ACIS.

Ring, L., Barry, B., Totke, K., & Bickmore, T. (2013). Addressing loneliness and isolation in older adults: proactive affective agents provide better support. In *Affective computing and intelligent interaction (ACII), 2013 humaine association conference, 2013*. IEEE.

Ring, L., Shi, L., Totzke, K., & Bickmore, T. (2015). Social support agents for older adults: longitudinal affective computing in the home. *Journal on Multimodal User Interfaces, 9*(1), 79–88 pp. 1–10.

Robinson, H., Macdonald, B., Kerse, N., & Broadbent, E. (2013). The psychosocial effects of a companion robot: a randomized controlled trial. *Journal of the American Medical Directors Association, 14*(9), 661–667.

Russell, D., Peplau, L. A., & Ferguson, M. L. (1978). Developing a measure of loneliness. *Journal of Personality Assessment, 42*(3), 290–294.

Rust, R. T., & Cooil, B. (1994). Reliability measures for qualitative data: theory and implications. *Journal of Marketing Research, 31*(1), 1–14.

Şar, A. H., Göktürkb, G. Y., Turac, G., & Kazazd, N. (2012). Is the Internet use an effective method to cope with elderly loneliness and decrease loneliness symptom? *Procedia-Social and Behavioral Sciences, 55*, 1053–1059.

Shankar, A., McMunn, A., Banks, J., & Steptoe, A. (2011). Loneliness, social isolation, and behavioral and biological health indicators in older adults. *Health Psychology, 30*(4), 377.

Shapira, N., Barak, A., & Gal, I. (2007). Promoting older adults' well-being through Internet training and use. *Aging & Mental Health, 11*(5), 477–484.

Shiovitz-Ezra, S., & Ayalon, L. (2010). Situational versus chronic loneliness as risk factors for all-cause mortality. *International Psychogeriatrics, 22*(03), 455–462.

Slack, W. V., Kowaloff, H. B., Davis, R. B., Delbanco, T., Locke, S. E., Safran, C., et al. (2012). Evaluation of computer-based medical histories taken by patients at home. *Journal of the American Medical Informatics Association, 19*(4), 545–548.

Slegers, K., Van Boxtel, M. P., & Jolles, J. (2008). Effects of computer training and Internet usage on the well-being and quality of life of older adults: a randomized, controlled study. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 63*(3), P176–P184.

Stokes, J. P. (1983). Predicting satisfaction with social support from social network structure. *American Journal of Community Psychology, 11*(2), 141–152.

Stokes, J. P. (1985). The relation of social network and individual difference variables to loneliness. *Journal of Personality and Social Psychology, 48*(4), 981.

Sum, S., Mathews, R. M., Hughes, I., & Campbell, A. (2008). Internet use and loneliness in older adults. *CyberPsychology & Behavior, 11*(2), 208–211.

Tennyson, R. D., & Sisk, M. F. (2011). A problem-solving approach to management of instructional systems design. *Behaviour & Information Technology, 30*(1), 3–12.

Toepoel, V. (2013). Ageing, leisure, and social connectedness: how could leisure help reduce social isolation of older people? *Social Indicators Research, 113*(1), 355–372.

Tsai, H.-H., & Tsai, Y.-F. (2011). Changes in depressive symptoms, social support, and loneliness over 1 year after a minimum 3-month videoconference program for older nursing home residents. *Journal of Medical Internet Research, 13*(4).

United Nations. (2013). *Profiles of ageing by country or area*. World Population Ageing 2013. Available at: http://www.un.org/esa/population/publications/worldageing19502050/.

Victor, C., Scambler, S., Bond, J., & Bowling, A. (2000). Being alone in later life: loneliness, social isolation and living alone. *Reviews in Clinical Gerontology, 10*(4), 407–417.

Wagner, N., Hassanein, K., & Head, M. (2010). Computer use by older adults: a multi-disciplinary review. *Computers in Human Behavior, 26*(5), 870–882.

Weinert, C., Cudney, S., & Hill, W. (2008). Rural women, technology, and self-management of chronic illness. *The Canadian Journal of Nursing Research (Revue Canadienne De Recherche En Sciences Infirmieres), 40*(3), 114–134.

White, H., McConnell, E., Clipp, E., Branch, L. G., Sloane, R., Pieper, C., et al. (2002). A randomized controlled trial of the psychosocial impact of providing Internet training and access to older adults. *Aging & Mental Health, 6*(3), 213–221.

Wilson, R. S., Krueger, K. R., Arnold, S. E., Schneider, J. A., Kelly, J. F., Barnes, L. L., et al. (2007). Loneliness and risk of Alzheimer disease. *Archives of General Psychiatry, 64*(2), 234–240.

Winstead, V., Anderson, W. A., Yost, E. A., Cotton, S. R., Warr, A., & Berkowsky, R. W. (2013). You can teach an old dog new tricks a qualitative analysis of how residents of senior living communities may use the web to overcome spatial and social barriers. *Journal of Applied Gerontology, 32*(5), 540–560.

Woodward, A. T., Feddolino, P. P., Blaschke-Thompson, C. M., Wishart, D. J., Bakk, L., Kobayashi, R., et al. (2011). Technology and aging project: training outcomes and efficacy from a randomized field trial. *Ageing International, 36*(1), 46–65.

Yao, M. Z., & Zhong, Z.-J. (2014). Loneliness, social contacts and Internet addiction: a cross-lagged panel study. *Computers in Human Behavior, 30*, 164–170.

Young, C. M. Y., & Lo, B. C. Y. (2012). Cognitive appraisal mediating relationship between social anxiety and Internet communication in adolescents. *Personality and Individual Differences, 52*(1), 78–83.