Archives of Gerontology and Geriatrics Plus 1 (2024) 100008

Contents lists available at ScienceDirect

Archives of Gerontology and Geriatrics Plus

journal homepage: www.sciencedirect.com/journal/archives-of-gerontology-and-geriatrics-plus

The effectiveness of technology interventions in reducing social isolation and loneliness among community-dwelling older people: A mixed methods systematic review

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ARTICLE INFO

Keywords:
Aged
Older adults
Social isolation
Loneliness
Social connectedness
Technology
Theory
Systematic review

ABSTRACT

Objectives: This study reviewed technology-based interventions targeting social isolation and loneliness in community-dwelling older adults. Specific aims were to identify theoretical perspectives, assess intervention effectiveness, and identify barriers and enablers of these interventions.

Methods: A mixed methods systematic review of intervention studies was conducted, searching six databases (PubMed, PsychINFO, Cochrane Library, CINAHL, ACM and Embase). Peer-reviewed articles describing communicative technology-based intervention studies with qualitative, quantitative, mixed-method, or observational designs, conducted in community settings with older adults (aged ≥65 years), where social isolation and/or loneliness were key outcome measures, were included. The quality of the studies was assessed using the Mixed Methods Appraisal Tool (MMAT).

Results: Nineteen studies were included in the review. Theory integration was rare in these studies' research designs. Most were small-scale pilot or feasibility studies, displaying diverse designs, small sample sizes, and variable MMAT-assessed quality. The studies highlighted significant barriers such as resource demands, participant health, literacy, and technical challenges.

Conclusion: Significant resource demands continue to impede technology-based interventions addressing social isolation and loneliness in older populations. Future study designs must adapt to overcome these challenges, tailoring approaches to marginalised and often frail communities these interventions aim to support.

Introduction

Social isolation and loneliness are critical problems for older people, with an estimated 28.5 % of older people worldwide likely to experience loneliness (Chawla et al., 2021). While social isolation and loneliness are not ubiquitous features of old age, and should not be framed as such, those who do experience them have a heightened risk of adverse outcomes, including: disturbed sleep, dementia, frailty, cardiovascular events, obesity, diminished immune system functioning, poor mental health, and cognitive functioning, increased risk of Alzheimer's disease and mortality (Choi et al., 2015; Courtin & Knapp, 2017). As societies begin to emerge from the recent experience of the COVID-19 pandemic and associated social distancing responses (Brooke & Jackson, 2020; Le Couteur et al., 2020), social isolation and loneliness remain important considerations for the physical and mental well-being of older people (Bailey et al., 2021; Tyrrell & Williams, 2020; Wu, 2020).

While social isolation can be defined as an absence of social relationships, loneliness can be defined in terms of the lived experience and perception of that absence (Chawla et al., 2021). It is problematic to equate the two unequivocally. Some adults report feeling lonely regardless of the size and nature of their social networks, while others are content with very few social ties (Cotten et al., 2013). It is important to note the distinction between social isolation and loneliness adopted in our review (de Jong Gierveld et al., 2006; Dykstra, 2009). The deficit model of loneliness, initially proposed by Weiss (1973), has generally been conceptualised as involving the presence, absence, number, and

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https://doi.org/10.1016/j.aggp.2024.100008
Received 11 December 2023; Received in revised form 30 January 2024; Accepted 31 January 2024
Available online 4 February 2024

nature of social ties (Morgan et al., 2020). In contrast, the cognitive model suggests that loneliness is not just an outcome of the number and type of social relationships but rather how individuals make sense of and experience those relationships (Dykstra & Fokkema, 2007).

Technology has the potential to address social isolation and loneliness among older adults through social media platforms and video calling applications which overcome the barrier of physical distance (Chen & Schulz, 2016). Also, online groups can provide a sense of community and belonging for individuals (Lawless et al., 2022). Furthermore, technology can provide access to events and activities, such as online classes, which can provide meaningful and enjoyable experiences, and healthcare services which provide resources for maintenance of well-being. Overall, technology interventions can help mitigate social isolation and loneliness among older adults by providing opportunities for support, engagement and social connection. Various barriers and enablers can influence the effectiveness of interventions. It is essential to consider the use of relevant theories to understand these.

Literature review

Technology has frequently been advocated as an enabler to assist vulnerable groups in alleviating loneliness and social isolation (Neves et al., 2017; Pauly et al., 2019; Pinero De Plaza et al., 2021). Recognition of the concept of the digital divide within society (differential access to technology), along with the so-called "second digital divide" (the presence of differential skills and knowledge concerning technology), has long highlighted that not all people benefit equally from information and communication technology (ICT) initiatives (Schulz et al., 2015). Although preliminary findings support the potential for technology-based interventions to successfully address social isolation and loneliness among older people (Balki et al., 2022; Doring et al., 2022), given the extreme heterogeneity in both the digital capability present within this group (Martins Van Jaarsveld, 2020) and nature and quality of the interventions delivered (Balki et al., 2022; Doring et al., 2022; Jin et al., 2021; Wister et al., 2021), a definitive conclusion remains elusive.

Several recent reviews have focused on the effectiveness of communicative technology-based interventions in addressing loneliness and social isolation among older people (Baker et al., 2018; Ibarra et al., 2020; Noone et al., 2020; Shah et al., 2021; Thangavel et al., 2022). However, these previous reviews are characterised by some shortcomings. Firstly, most of the reviews on the topic did not explicitly assess whether included studies drew on theoretical frameworks to inform the study (Fakoya et al., 2020). This gap is concerning because of the important role of theory in guiding healthcare practice, health promotion, and implementation science and research (Alderson, 1998; Kislov et al., 2019). This is a persistent omission, first highlighted by a much earlier review (Khosravi & Ghapanchi, 2016). A focus on the theoretical underpinnings of digital interventions is pivotal: theory can provide a framework for intervention design and evaluation, enabling the accumulation of evidence to predict and explain outcomes in new contexts and inform successful implementation (Dalgetty et al., 2019; Michie & Prestwich, 2010). Secondly, few previous reviews have systematically sought to identify the barriers and enablers of implementing technological interventions to address social isolation and loneliness among older adults. In addition, many of the previous studies, while providing relevant insights, are now out of date due to the rapid pace of technological change.

Consequently, our review aimed to address the following questions:

1) What theoretical perspectives inform current interventions exploring the potential for technology to address social isolation and loneliness among older people?
2) What is the effectiveness of technology-based interventions on social isolation and loneliness?
3) What are the key barriers and enablers for such interventions?

The intent for the development of the review was to identify interventions where technology was rapidly deployed with limited requirements for tailoring to specific settings, subgroups, or populations.

Method

Search strategy

The review was conducted according to the PRISMA guidelines (Page et al., 2021) . We conducted a mixed methods systematic review with a convergent integrated approach to synthesis and integration since the review question could be addressed through qualitative research (e.g., through a phenomenological study of older adults' perceptions of technology) as well as quantitative research (e.g., through a survey with older adults as part of a cross-sectional study). In June 2020, database searches included PubMed, CINAHL, PsycINFO, Cochrane Reviews and Trials, Embase and ACM Guide to Computing Literature. Qualitative, quantitative, and mixed method studies in the English language published since inception and available online in full text that met the inclusion criteria were considered. Table 1 presents an example of the keywords used. The search was updated in August 2022.

Study selection

The inclusion criteria were 1) peer-reviewed articles published in English; 2) studies with primary empirical, interpretive, and/or qualitative and quantitative study designs; 3) mean and/or median age of participants ≥65 years; 4) undertaken within community settings 5) social isolation and/or loneliness as outcome or key measures; 6) technological applications that are rapidly deployable on a broad scale and widely available to the general population for purposes of communication (e.g. videoconferencing, social media, internet use).

Purpose-designed, bespoke applications (e.g., residential care facilities with internal video conferencing systems), programs designed for e-health delivery (telemedicine, training etc.), exergames and assistive robotics applications were not included, as was usage outside the scope of general communication (online shopping, banking, pornography, online dating). Further, as our review intended to assess older people's engagement with technology, passive use such as smart home technology was considered outside the scope of this review. We excluded articles if they focused on subgroups of older people with any health condition (e.g., dementia or psychosis). We excluded articles if they were unpublished works, published in a language other than English, or did not specifically target or report on older people as technology users. Discussion papers, editorials, systematic and umbrella reviews, study protocols and grey literature were excluded.

Data extraction and synthesis

All extracts were uploaded into Covidence online systematic review software, and duplicates were removed. A team of five experienced reviewers conducted title and abstract, followed by full-text screening, with two independent reviewers per record. Data extraction and quality assessment were conducted by a team of five experienced reviewers and

Table 1
Exemplar keywords used in the systematic literature search.

Older people	Social isolation/ loneliness	Digital Initiatives
MeSH: aged; aged, 80 and over	MeSH: loneliness, social isolation	MeSH: Social media, Internet, Online social networking, Videoconferencing
Keywords: elder*, older people, older adult*, senior*, retire*, geriatric*	Keywords: loneliness, social isolation	Keywords: information communication technology, social media, internet, digital, ICT, e-intervention, video

two novice reviewers, with two independent extractors per record plus a third consensus reviewer. Any disagreements were resolved through discussion by reviewers. The quality assessment used the Mixed Methods Appraisal Tool v. 2018 (MMAT) (Hong et al., 2018), rating all studies against seven key quality criteria. Due to the heterogeneity of the study designs and outcome measures, a narrative synthesis without meta-analysis was conducted (Mays et al., 2005).

Results

Search results

The initial database search results identified 990 studies. After removing 235 duplicates, 755 studies were screened. Screening of titles and abstracts resulted in most studies being excluded ($n = 632$). After eligibility and critical appraisal of the full text records ($n = 123$), 15 studies were identified as interventions and thus met the inclusion criteria for data extraction and synthesis. Following the updated search in August of 2022, an additional four studies were included from an updated search (Fig. 1), resulting in 19 included studies.

Study characteristics

Of the 19 included studies (Table 2), eight studies (42 %) were conducted in the United States. Additionally, there were two studies each conducted in Australia, the UK and Canada. The remaining studies were conducted various European countries and within Israel. Thirteen studies addressed both loneliness and social isolation. Two studies solely focused on loneliness, while another two solely targeted social isolation. Among the 17 studies addressing loneliness, 13 (77 %) utilised a variant of the UCLA Loneliness Scale (Russell et al., 1978), three (18 %) used a variant of the De Jong Gierveld Loneliness Scale (de Jong-Gierveld & Kamphuis, 1985), and one employed a self-reported measure to assess loneliness. In contrast, measures of social isolation displayed greater heterogeneity.

The included studies employed a variety of research designs, inclusive of quantitative non-randomised studies ($n = 8$), mixed-methods studies ($n = 7$) and randomised controlled trials (RCTs) ($n = 4$). Many of the studies were small pilot or feasibility studies, predominantly with pre-post design. Most studies focused on computer-based training ($n = 9$), use of social media and/or videoconferencing on tablets ($n = 8$) and smartphones ($n = 3$), with some studies including multiple devices. Most studies ($n = 11$) reported on interventions conducted entirely within the context of a group intervention or which included a sub-analysis set in a group context. A further four studies were hybrid studies, conducting an element of the intervention in a group context initially and later following up with one-on-one training or mentoring. Four studies were conducted entirely in a one-on-one training basis.

Quality review of the included studies

The quality of included studies was assessed using the MMAT framework, in which different study designs are rated against different criteria (Table 3), e.g., RCT studies are assessed against a different set of criteria than the mixed method studies. MMAT scores varied widely for the included studies, ranging from one to seven stars (average of 3.8 stars) (Table 3). RCT and quantitative non-randomised studies (e.g., pre-post analyses) tended to receive higher MMAT item ratings than the included mixed methods studies. Mixed methods studies tended to score lower than the other studies, with one exception (Juris et al., 2022), which scored 7 stars (Table 3), however this study had a small sample size a small sample size ($n = 9$) (Table 2).

RQ1. Use of theory within included studies

Of the 19 included studies, just over one-third ($n = 7$) explicitly referenced a theory or combination of theories (Table 4). A wide range of theories was referenced, with seven studies referencing 16 different theories (Table 4), but only one theory was referenced by more than one study (Social Capital Theory; Bourdieu, 1986). The citations for the included theories within each article are displayed in Supplementary

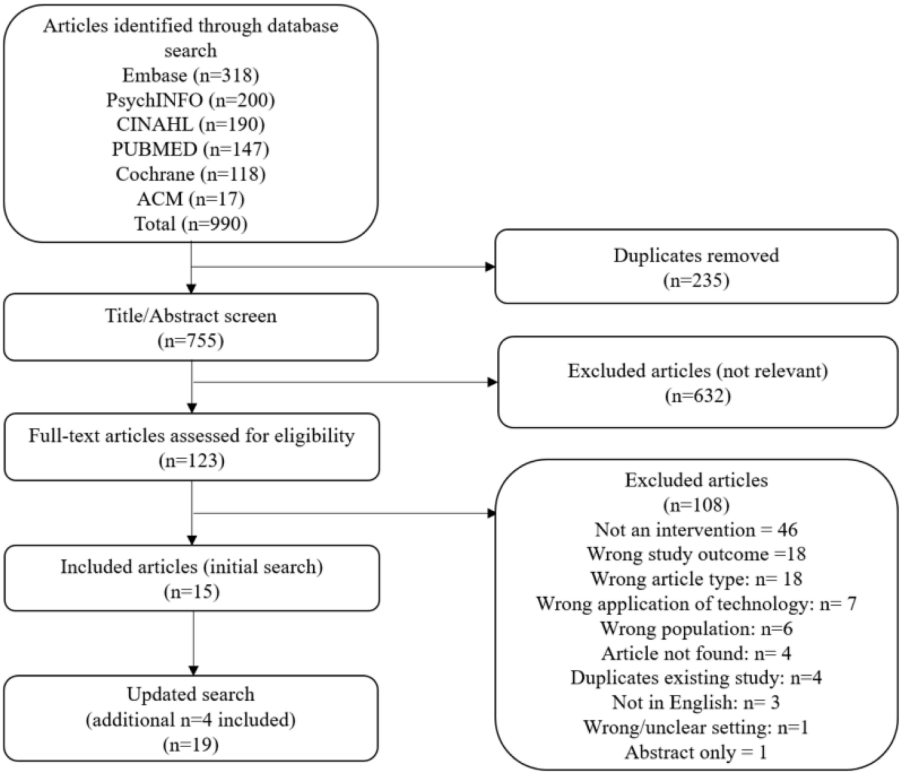

Fig. 1. Study PRISMA diagram.

Table 2
Intervention study description.

Study name	Design	Setting	Participants	Outcome measures	Intervention	Frequency and duration	Results
Banbury et al. (2017)	MM; Group	Regional setting, Australia	24 community-dwelling adults aged 50+ years with at least one long-term condition. Mean age = 73 years (SD = 6.0, range= 61- 84), 50 %F	Social network analysis tool (no. network members) used to measure social isolation.	Videoconferencing using customised tablets. Facilitated by health promotion professional with support from IT specialist. Pre- and Post-measures taken.	5 x weekly group meetings (45 – 90 min) via videoconference from home	Mean no. of network members increased by 2.0 (SD 3.9). Significance not calculated.
Blažun et al. (2012)	QNR; Group	Finland and Slovenia	58 older people (Finland: community college attendees; Slovenia: research project participants living in homes for the elderly) aged 57+ years. Mean age = 72.9 years (SD = 7.1, range = 61–85); 52.6 % F	Self-reported level of loneliness; not a standardised measure. Self-reported no. of members in social network; not a standardised measure.	Facilitated, in-person group computer and ICT training (group size between 5 and 15 older people); task-based teaching covering use of the computer, documents, email etc. Delivered by a facilitator (Finland) or a training 'multiplier' (Slovenia). Pre- and Post-measures taken.	3 x weekly computer training courses of 3–4 h duration with breaks. Located at either a community college (Finland) or older persons' home (Slovenia).	Statistically significant decrease in loneliness between baseline and follow up. Significant results also found for email use and increase in size of social network.
Delello and McWhorter (2017)	MM; Group	Senior living centre in South-western United States	19 participants who were residents of the senior living centre. Mean age not stated; 84.2 % F.	Participants were asked about connecting with social networks; no formal outcome measures.	Training sessions focused on use of iPads for email, social networking, photo sharing, videoconferencing etc. Delivered by two University lecturers. Pre- and Post- measures taken.	6 x bi-weekly 90 min group training session on site at the centre.	No formal statistical analysis conducted. Participants reported that the program had allowed them to make contact with family and friends, but measures were not compared pre- and post-intervention.
Dow et al. (2008)	MM; Group (Virtual)	Rural community setting, Australia	14 older carers/care recipients living in a rural area, mean age = 65.5 years (range 50 - 81 years); 86 % F. Geriatric Depression Scale >= 5; not having a computer at home; without access to respite care.	UCLA Loneliness Scale v3. 20 item	Participants provided with refurbished computer (kept post-intervention) and Internet access. Training focused on use of computer, email, Internet. Occupation/ status of trainer not specified. Pre- and Post-measures taken.	4 x weekly 3-hour group training session (group size: 8) in-person at local venue.	Loneliness scores decreased for 11 of 14 (78.6 %) participants from baseline to post intervention. Statistical testing not conducted.
Fields et al. (2020)	QRCT; 1:1	San Francisco Bay area, United States	83 (intervention 44), control=39) isolated or lonely older adults who were clients of a local community organisation. Mean age = 75 years (SD = 7.9), 30 % F.	UCLA Loneliness Scale 3 item Perceived social support: Subset of Inter-personal Support Evaluation List	Participants provided with tablet and Internet access. Training focused on use of tablet, including use for email, social media etc. Delivered by trained volunteers. Participants randomised into intervention and waitlist groups.	8 x weekly 1:1 in-home training sessions.	No change in loneliness from baseline to 2 months within either study arm. Improvement observed in perceived social support within the intervention arm but was not significant.
Fokkema and Knipscheer (2007)	QNR; Hybrid	Eindhoven, The Netherlands	15 participants: living alone, socially isolated, participating in home visiting scheme, not yet a computer/internet user but with no negative attitudes towards the technology; sufficient capacity to participate. Mean age (years): *I* = 66; C = 68; *I* = 91.7 % F; C = 50 % F.	de Jong Gierveld Loneliness Scale 11 item	Participants given a computer and peripherals for study period. Data collection at baseline, 2 years and 3 years. Virtual control group also used. Training provided in-home by trained volunteers. Intervention and (virtual) control group had pre and post measures taken. Not randomly assigned.	Initial 2 × 5 hour training session followed by 3 years x 1:1 in-home training session delivered every 2–3 weeks.	Loneliness scores significantly decreased at 2 and 3 years for I group. Significant difference in loneliness score change between I and C groups.
Gadbois et al. (2022)	MM; 1:1	Rhode Island, United States	21 participants recruited in two waves from local	UCLA Loneliness Scale 3 item Lubben Social	One-on-one technology training and assistance provided to participants	First 4 weeks: in-home training session 90 – 120 min. Next 8 weeks:	Decreased participant feelings of loneliness and

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Table 2 (*continued*)

Study name	Design	Setting	Participants	Outcome measures	Intervention	Frequency and duration	Results
			service provider. Inclusion criteria were receiving meals, aged 60+ years, homebound. Mean age = 73 years (range = 61 - 93), 62 % F.	Network Scale (LSNS-6)	in their homes by trained volunteers. Participants given tablet and hotspot internet connection for one year	telephone support call of 30 min duration. Final two weeks: telephone support available on request.	increased technology use, non-significant.
Jones et al. (2015)	QNR; Group and 1:1	Plymouth, UK	144 community-dwelling participants aged 65+ years (71.5 % F). One on one program (n = 58): mean (SD) age = 79.0 years (7.5). Small group program (n = 86): mean (SD) age =74.3 years (8.2)	UCLA Loneliness Scale Revised, 20 item Social network activity index	Computer training covered ICT use, social media, internet search etc. Support was provided for participants to source their own computers and internet access. Training provided by trained volunteers. Pre- and Post-measures were taken.	1:1 program: 12 h in-home training provided over 8 visits. Group training: 12 h of training provided. More physically isolated participants allocated to 1:1 program	All participants significantly increased social networks and reduced loneliness. When disaggregated by intervention type, only the group attendees had significantly reduced loneliness.
Juris et al. (2022)	MM; 1:1 (Virtual)	Seven-county area in rural Appalachia, United States	9 community-dwelling participants aged 50+ years recruited through local community group (mean age = 73.5 years, range = 61–86).	UCLA Loneliness Scale 3 item Lubben Social Network Scale (LSNS-6)	Participants were paired with technology mentors (trained university student volunteers). Mentors offered support to participants via phone or video conferencing across a range of devices. Pre- and Post- measures were taken.	Participants received 1–4 mentoring sessions over 3 months (average length 90 min).	Reduction in loneliness observed, no change in social isolation
Larsson et al. (2016)	QRCT; Hybrid	Mid-sized northern city, Sweden	30 participants allocated to 2 groups. Aged 60+ years, retired, self-reporting as lonely/socially isolated, not accessing home care, internet users with access to a computer with internet at home. Regular social media users excluded. Mean age = 71.2 years (range 61–89), 80 % F	UCLA Loneliness Scale Revised, 20 item Social Network Online and Offline Questionnaire	Intervention addressed social internet-based activities (SIBAs) via computer. Occupational therapists provided the intervention. Participants randomised to I/C (intervention then control) or C/I (control then intervention).	Over a 3 month period, participants attended a mix of in-person and group meetings (max 90 min), held weekly, inclusive of remote support at home. Frequency & delivery adapted to participant needs.	Loneliness significantly decreased in both groups. Satisfaction with social contacts online significantly increased in one group.
Lee and Kim (2018)	MM; Group	Public university, south-eastern city of the United States	Participants were drawn from senior centres and housing facilities. Of 55 participants completing the intervention, mean age = 73.8 years (SD =12.3), 63.6 % F.	UCLA Loneliness Scale 3 item Perceived Social Isolation measure Perceived Lack of Social Support measure 6-item (non-standardised measure)	Tutorials addressed use of health information technology and social networking sites via smartphones/tablets. Training provided by trained undergraduate students. Pre- and Post-measures taken.	Six sessions (average 3.5 h per participant) held at seniors' centres in groups of 6–8 participants.	Loneliness scores significantly decreased following the intervention. Perceived lack of social support decreased but was not significant. Social isolation decreased.
Morton et al. (2018)	QRCT; 1:1	United Kingdom	121 clients of not-for-profit organisation, without internet access, receiving supported care in community or residential care. Intervention group: mean age = 80.3 years (SD=6.5), range 70 to 93, 59.1 % F. Comparison group: mean age = 82.6 years (SD=5.9), range 70 to 93, 65.4 % F.	UCLA Loneliness Scale Revised, 20 item Social network activity index	Stepped training via a customised computer interface across 3 months addressed computer use, social media, Internet. Qualified, trained carers provided training. 2 (training, control) x 2 (domiciliary vs residential participants) x 2 (time: baseline, follow-up) design.	Month 1: Thrice-weekly F2F training session of approx. 90 min duration (in-person). Month 2: Fortnightly F2F sessions (max 60 min) with phone/email contact in off-week. Month 3: No scheduled visits. Independent use with remote (email/phone) support.	Increased social network activity observed in intervention group.
Neil-Sztramko et al. (2020)	QNR; Group	Canada	32 older English-speaking adults. Mean age = 76.3	De Jong Gierveld Loneliness Scale Duke Social Support	Training addressed use of iPad and applications. Facilitated by instructor	6 x weekly 2-hour group education	No significant differences observed

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Table 2 (*continued*)

Study name	Design	Setting	Participants	Outcome measures	Intervention	Frequency and duration	Results
			years (SD =8.6), range 64–94; 63 % F.	Index 12 Item Lubben Social Network Scale	supported by 2–4 volunteer mentors. Pre- and Post- measures taken.	sessions, delivered in various settings.	in social isolation or loneliness
Pauly et al. (2019)	QNR; Hybrid	Vancouver, Canada	92 community-dwelling older adults participating in a research study. Required cognitive & physical capacity to use device. Mean age = 67.7 years (SD = 8.7), range 51–85. 64 % F.	Revised UCLA Loneliness Scale 8 item (Modified)	Training covered use of tablet (iPad mini). Occupation of trainer unspecified. Pre- and Post- measures taken.	Two on-site training sessions delivered 10 days apart. Participants then used tablets for 6+ months, reported on usage every fortnight via an app. During this period, almost all participants also attended a tailored 3-hour workshop focusing on iPad functions of their choice.	No change in social and emotional loneliness scores.
Quinn (2021)	QRCT; Group	Midwestern United States	Participants (n = 36) were novice social media users living in independent living communities and the community. Inclusion criteria: aged 65+; cognitively intact; little to no recent Facebook use; no significant visual impairment. Mean age = 76.8 years range 67 – 86 years. 69 % F.	UCLA Loneliness Scale Revised, 20 item Social Connectedness Scale	Participants randomised into either an intervention or 'wait-list' control group. 4-week social media training workshop in classroom setting using laptops. Sessions conducted by researcher supported by research assistant.	Six groups met once per week over four weeks (2 hour training session).	No significant main effects for the intervention in reported feelings of loneliness were observed The social connectedness measure showed no significant change over time.
Rolandi et al. (2020)	QNR; Group	Abbiategrasso region, Milan, Italy	Participants (n = 130) were recruited from a longitudinal study cohort, not depressed, able to use smartphones, no cognitive impairment, no prior experience using social networking sites. Mean (SD) age = 81.8 (1.4) years, 52 % F.	UCLA Loneliness Scale 3 item Lubben Social Network Scale (LSNS-6)	Participants randomised to one of three conditions: 1) training course on social networking site use (intervention); 2) waiting list (inactive control group) 3) lifestyle education course (active control group). Content addressed use of social networking sites. Participants provided with smartphones. Two trainers provided face to face tutoring in final weeks along with messaging support. Participants followed up by phone one-year post-intervention.	Five interactive group sessions held twice per week.	No significant differences observed with respect to loneliness or social engagement.
Shapira et al. (2007)	QNR; Group	Israel	22 Hebrew-speaking attendees at day centres for the elderly or nursing home residents. Intervention group = mean age = 80.3 years (SD=6.5), range 70 to 93, 59.1 % F. Comparison group = mean age = 82.6 years (SD=5.9), range 70 to 93, 65.4 % F.	UCLA Loneliness Scale Revised, 20 item	Training program focused on ICT skills, Internet, email, discussion forums. Provided in dedicated rooms on site. Instructors were experienced trainers with skills in teaching ICT to older people, assisted by volunteers. Intervention and control group study. Assigned on willingness to participate rather than randomisation.	Intervention group: 15 weeks x 1–2 group lessons per week, of approx. 60 min duration. Control group: alternative, non-ICT focused group activity provided over 15 weeks.	Significantly lower feelings of loneliness recorded within the intervention group
White et al. (1999)	MM; Hybrid	Retirement community, United States	23 residents with little to no computing experience. Intervention group (n = 15): mean age	UCLA Loneliness Scale Revised, 20 item Duke Social Support Index 11 item	Training covered basic ICT use, Internet, email and was conducted by a computer consultant. Help desk run by university and high	Training was delivered in groups of six, with two participants per computer. Three computers placed in common area.	Intervention group showed significant decrease in loneliness 2 weeks post-training No change detected

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Table 2 (*continued*)

Study name	Design	Setting	Participants	Outcome measures	Intervention	Frequency and duration	Results
			= 77 (SD=7); 84 % F. Comparison group (n = 8): mean age = 80 (SD= 8); 75 % F.		school students also provided. Help desk provision tapered over the study from 3 to 4 h per week to 1 hr/week in the last few months. Control group placed on wait list for training. Not randomly assigned to groups.	Participants given 24-hour access over 5 months.	in Social Support Index.
Woodward et al. (2013)	QNR; Group	Michigan, United States	Participants (n = 19) aged 60+ years participating in a control group for a 6-month computer training program were recruited into a second phase of the study. Mean age = 72.9 years (SD = 7.1, range 61–85); 52.6 % F.	De Jong Gierveld and Van Tilburg 6 item loneliness scale. Social network data collected along with the Multi-dimensional Scale of Perceived Social Support	Trained older peer tutors participating in the first phase of the study delivered the training. Mix of specific topic and general focus. Topics covered computer, social media, videoconferencing. Pre- and Post- measures taken.	20 x weekly group training session. Learners divided into beginner (n = 8) or intermediate (n = 11) group depending on previous experience.	No change in mental health and social support outcomes observed.

Abbreviations: MM = Mixed Methods; QNR = Quantitative Non-randomised; QRCT Quantitative randomised controlled trial.

Table 3
Quality review using Mixed Methods Appraisal Tool (MMAT) criteria.

Study name	Study type	S1	S2	Q1	Q2	Q3	Q4	Q5	MMAT score
Banbury et al. (2017)	MM	Y	Y	N	N	?	?	N	**
Blažun et al. (2012)	QNR	Y	Y	?	N	N	?	?	**
Delello and McWhorter (2017)	MM	Y	Y	N	N	N	Y	N	***
Dow et al. (2008)	MM	Y	?	N	N	N	N	N	*
Fields et al. (2020)	QRCT	Y	?	?	Y	N	N	N	**
Fokkema and Knipscheer (2007)	QNR	Y	Y	?	Y	Y	Y	?	*****
Gadbois et al. (2022)	MM	?	Y	N	N	N	N	Y	**
Jones et al. (2015)	QNR	Y	N	?	Y	N	N	Y	***
Juris et al. (2022)	MM	Y	Y	Y	Y	Y	Y	Y	*******
Larsson et al. (2016)	QRCT	Y	Y	Y	Y	Y	Y	Y	*******
Lee and Kim (2018)	MM	Y	Y	N	N	N	Y	Y	****
Morton et al. (2018)	QRCT	Y	Y	Y	Y	Y	N	N	*****
Neil-Sztramko et al. (2020)	QNR	Y	Y	?	Y	Y	?	Y	*****
Pauly et al. (2019)	QNR	Y	Y	Y	Y	Y	Y	Y	*******
Quinn (2021)	QRCT	Y	Y	?	N	N	?	?	**
Rolandi et al. (2020)	QNR	Y	Y	Y	Y	Y	Y	Y	*******
Shapira et al. (2007)	QNR	?	Y	N	Y	N	N	N	**
White et al. (1999)	MM	Y	N	N	N	N	?	N	*
Woodward et al. (2013)	QNR	Y	Y	?	Y	Y	Y	Y	******

Abbreviations: MM = mixed methods; QNR = quantitative non-randomised; QRCT quantitative randomised controlled trial. Results: Y = yes, N = no, ? = can't tell. * Number of 'Y' responses received. S1 = Supplementary table 1 Theory Identified, S2 = Supplementary table 2 Instrument identified. Q1-Q5 = MMAT Methodological quality criteria.

Table S1. Application of theory by the included intervention studies was applied in a range of ways. Six studies (31.6 %) (Table 4) referenced theory to support the rationale for the study, while six studies applied theory to inform the intervention design and/or implementation. Five studies (26.3 %) (Table 4) related the results to theoretical constructs within the discussion section. Only three studies (16 %) used theory to underpin all aspects (rationale, intervention, and discussion) of the study, all of which were published within the previous five years (Table 4).

RQ2. Effectiveness of technology for reducing loneliness and social isolation among older people

Most of the studies (n = 16, 84.2 %) conducted statistical analyses to evaluate intervention effectiveness. Of these, five studies reported a significant loneliness reduction, one reported a significant social isolation reduction or increased social network size, and three studies reported a significant change in both outcome measures. Participants in the interventions reporting a significant reduction in loneliness (average n = 45, range 9–144 participants), had a mean age ranging between 66 and 83 years, and attended a range of training regimes delivered in different formats, including group, hybrid and one-on-one sessions. In addition to the loneliness reductions, Lee and Kim's (2018) study reported a significant decrease in social isolation, while three studies reported a significant increase in the size of participants' social networks (Table 2). In contrast, seven studies recorded no significant impact on study outcomes (Table 2). Of the three studies not conducting statistical analyses, all reported results favourable to intervention (Table 2).

RQ3. Barriers and enablers

The included studies found barriers and enablers to feasibility of the interventions. In terms of barriers, resourcing for the interventions was often substantial due to the need for hardware, software, people, travel,

Table 4
Theories identified within the included intervention studies and their application.

Theory or framework	Discipline	Rationale	Intervention	Discussion	All
Cognitive theory of loneliness	Psychology	Fokkema and Knipscheer (2007)	Fokkema and Knipscheer (2007)	X	X
Context dynamics in aging framework	Psychology	Pauly et al. (2019)	Pauly et al. (2019)	X	X
Intergroup contact theory	Psychology	Juris et al. (2022)	Juris et al. (2022)	Juris et al. (2022)	Juris et al. (2022)
Life course theory	Psychology, sociology, public health	Quinn (2021)	X	Quinn (2021)	X
Metaliteracy framework	Library and information science	Delello and McWhorter (2017)	X	Delello and McWhorter (2017)	X
Occupational therapy intervention process model	Occupational therapy	X	Larsson et al. (2016)	X	X
Relational theory of loneliness	Psychology	Fokkema and Knipscheer (2007)	X	X	X
Selective optimisation with compensation model	Psychology	X	X	Pauly et al. (2019)	X
Self-determination theory	Psychology	Morton et al. (2018)	Morton et al. (2018)	Morton et al. (2018)	Morton et al. (2018)
Social capital theory	Sociology	Juris et al. (2022); Quinn (2021)	Quinn (2021)	Quinn (2021)	Quinn (2021)
Social identity theory	Psychology	Morton et al. (2018)	Morton et al. (2018)	Morton et al. (2018)	Morton et al. (2018)
Socioemotional selectivity theory	Psychology	X	X	Pauly et al. (2019)	X
Structural holes theory	Sociology	X	X	Quinn (2021)	X
Successful ageing model	Psychology	Pauly et al. (2019)	Pauly et al. (2019)	X	X
Two-dimensional loneliness theory	Psychology	Fokkema and Knipscheer (2007)	Fokkema and Knipscheer (2007)	X	X
Weak ties theory	Sociology	X	X	Quinn (2021)	X

NB: Citations for theories noted above are listed within Supplementary Files.

and venue costs (Dow et al., 2008; Jones et al., 2015). Community-based programs and services were frequently under-resourced (Nilsen et al., 2018), with some studies relying on volunteers to deliver training (Fields et al., 2021; Gadbois et al., 2022; Jones et al., 2015). Some participants needed intensive training support due to reduced learning speed, memory difficulties, and lower baseline computer skills (Blažun et al., 2012; Delello & McWhorter, 2017; Dow et al., 2008; Jones et al., 2015; Quinn, 2021; Woodward et al., 2013), requiring more frequent or intensive training (Jones et al., 2015; Lee & Kim, 2018). Further, some studies reported participants having limited access to devices and/or poor internet connectivity (Fields et al., 2020; Nilsen et al., 2018; Quinn, 2021; Rolandi et al., 2020; Woodward et al., 2013) or holding privacy concerns that made them reluctant to engage in video conferencing at home (Banbury et al., 2017; Rolandi et al., 2020). Lastly, poor health status led to relatively high rates of attrition in some studies (Fields et al., 2020; White et al., 1999; Woodward et al., 2013).

Included studies identified enablers relating to participant characteristics (Table 2) such as high motivation to engage socially (Quinn, 2021; Rolandi et al., 2020), higher digital literacy (Blažun et al., 2012; Quinn, 2021) and higher education levels (Fokkema & Knipscheer, 2007). Other enablers included explaining how platforms could be used for social engagement (Morton et al., 2018), offering hybrid options for attendance (Jones et al., 2015), involving peers/volunteers (Fields et al., 2020; Jones et al., 2015; Woodward et al., 2013) or health service professionals as trainers (Larsson et al., 2016), building relationships with trainers in person (Gadbois et al., 2022), and establishing partnerships with community organisations (Dow et al., 2008; Fields et al., 2020; Nilsen et al., 2018).

Discussion

In this systematic review, we appraised evidence from intervention studies exploring the use of technological interventions to address social isolation and loneliness among older adults. Our principal findings are discussed below.

Theoretical perspectives

To the best of our knowledge, ours is one of only two reviews on this topic analysing the application of theory within technological interventions to address social isolation and loneliness among this population (Baker et al., 2018). While previous studies have examined the effectiveness of technology interventions in reducing social isolation and loneliness in older adults (Table 2), this review aims to consider the extent to which intervention studies applied theories and provide a comprehensive understanding of the design and implementation of technological interventions. Most of the theories referenced drew from psychology or sociology (Table 4), with limited representation from other disciplines, pointing to a potential for future research that might incorporate conceptual frameworks, models, and theories from other disciplines such as public health, community development, and human-computer interaction. The lack of consensus on which theoretical underpinning is most appropriate also suggests the need for the development of an integrative theoretical framework (Colquhoun et al., 2013). There is scope for developing more robust and comprehensive theories that combine psychological and sociological theory with user-centred design approaches to inform effective and scalable technology-supported interventions.

Effectiveness of interventions

The question of whether technological interventions are effective in addressing social isolation and loneliness among older people remains unresolved, as has been noted in previous studies (Jin et al., 2021; Wister et al., 2021). Our review found that previous intervention studies on this topic were characterised by significant heterogeneity in study design, and small sample size. Further, despite calls to improve the quality of the evidence base, our review found only three RCTs (Table 3). However, two demonstrated promising results and were relatively well designed, drawing on theory to inform elements of the study design and receiving high MMAT quality ratings (Table 3). Additionally, these studies were published within the last few years, suggesting that the quality of intervention design has been improving

over time. Mixed methods studies tended to score lower than the other studies due to a lack of integration between the qualitative and quantitative findings and/or a lack of perceived quality to either the qualitative or quantitative component (or both). Overall, the relative paucity of RCTs indicates a continuing research gap. Future studies also need to consider extending their scope beyond effectiveness and collect data relating to the feasibility of implementation. This could include collection of qualitative data to explore the perspectives of older adults in using the technology. This considers the potential for older adults not familiar or comfortable with technology. To understand the lasting effects of investing resources in interventions, studies could be designed with longer follow up periods. Future studies could also improve rigor and highlight viability by incorporating objective outcome measures such as social network size and frequency of interactions.

Barriers and enablers

A key focus of this review was identifying barriers and enablers for using technology to address social isolation and loneliness in older adults. Cost of equipment (i.e., computer hardware) and internet (Jones et al., 2015) were frequently identified as being an issue in the interventions and remains a significant barrier despite technology becoming more affordable over time. This has limited the scale and effectiveness of interventions. Targeting participants and tailoring interventions to individual needs and preferences will be essential to achieve rigorous outcomes and overcome health or literacy barriers. This could involve education on the health benefits of technology and training older adults to better use social networking apps. Training in the use of personal devices (e.g., smartphones) could be a more cost-effective solution than relying on desktop/laptop computers. As has been found in prior research (Jones et al., 2015) apps are cost effective and convenient for participants in health interventions.

Strengths and limitations

Our review has several strengths. We examined the adoption of theoretical frameworks by the studies we reviewed, analysed quantitative data on intervention effectiveness, and conducted a thematic synthesis to determine barriers and enablers. Our identification of stated barriers and enablers offers insight into how technological interventions to address social isolation and loneliness among older people can be improved in the future. Limitations of this review include the absence of grey literature and the exclusion of studies focused on subgroups with specific conditions where technology interventions may be beneficial. Due to significant heterogeneity within the included research designs and the relatively small sample size of the studies, we were restricted to a narrative summary of the study findings rather than conducting a meta-analysis. Nonetheless, the flexibility of the narrative structure allowed us to deliver a comprehensive overview of study findings and consider theoretical groundings and ease of implementation.

Implications for policy and practice

The review suggests that additional large-scale, high-quality studies are needed, and replication of successful interventions should be prioritised. Studies should be based on a robust theoretical foundation, and theory should be transparently integrated into research results reporting. Policymakers would benefit from research focusing on the feasibility, sustainability, and scalability of interventions, considering factors such as infrastructure, resources, and workforce needs, as well as the potential to build upon existing programs and technologies. While there is merit in exploring technology-based solutions, they should not be favoured at the expense of non-technological alternatives that may prove more practical in addressing the issue. Additionally, this review highlights the diversity in digital literacy and experience amongst older adults. Future efforts in exploring technology-based interventions to alleviate loneliness and social isolation should take this diversity into account and adapt their approaches accordingly by providing support for older adults. This could take the form of combining technology interventions along with social support and/or community engagement initiatives. Fostering digital literacy among older adults and promoting accessibility of technology could provide equitable access to interventions.

Statement of ethical approval

Ethical approval was not required as this was a review of published literature.

CRediT authorship contribution statement

R.C. Ambagtsheer: Writing – review & editing, Writing – original draft, Supervision, Methodology, Formal analysis, Conceptualization. **K. Borg:** Writing – review & editing, Writing – original draft, Data curation. **L Townsin:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Formal analysis, Conceptualization. **M.A. Pinero de Plaza:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Conceptualization. **L.M. O'Brien:** Writing – review & editing, Data curation. **R. Kunwar:** Writing – original draft, Data curation. **M.T. Lawless:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Investigation, Formal analysis, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Financial support

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.aggp.2024.100008.

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