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ARTICLE

Internet use, social isolation and loneliness in older adults

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Abstract

The aim of this study was to explore associations between internet/email use in a large sample of older English adults with their social isolation and loneliness. Data from the English Longitudinal Study of Ageing Wave 8 were used, with complete data available for 4,492 men and women aged ⩾ 50 years (mean age = 64.3, standard deviation = 13.3; 51.7% males). Binomial logistic regression was used to analyse cross-sectional associations between internet/email use and social isolation and loneliness. The majority of older adults reported using the internet/email every day (69.3%), fewer participants reported once a week (8.5%), once a month (2.6%), once every three months (0.7%), less than every three months (1.5%) and never (17.4%). No significant associations were found between internet/email use and loneliness, however, non-linear associations were found for social isolation. Older adults using the internet/email either once a week (odds ratio (OR) = 0.60, 95% confidence interval (CI) = 0.49–0.72) or once a month (OR = 0.60, 95% CI = 0.45–0.80) were significantly less likely to be socially isolated than every day users; those using internet/email less than once every three months were significantly more likely to be socially isolated than every day users (OR = 2.87, 95% CI = 1.28–6.40). Once every three months and never users showed no difference in social isolation compared with every day users. Weak associations were found between different online activities and loneliness, and strong associations were found with social isolation. The study updated knowledge of older adults' internet/email habits, devices used and activities engaged in online. Findings may be important for the design of digital behaviour change interventions in older adults, particularly in groups at risk of or interventions targeting loneliness and/or social isolation.

Keywords: internet; email; older adult; loneliness; social isolation

Introduction

Population ageing is a global phenomenon, and older adults (⩾50 years) make up a substantial and growing proportion of the population. In Europe, 40 per cent of the population are aged 50 and older (Eurostat, 2018), and in the United Kingdom it is 35.4 per cent (self-calculated using data from Office for National Statistics, 2017), and these figures are projected to increase over the coming years (Office for National Statistics, 2018*b*). Although people are living longer, the number of disability-adjusted life years is increasing (Murray *et al.*, 2012) and quality of life is not guaranteed (Beard *et al.*, 2016). In addition, older adults are at greater risk of social isolation (Iliffe *et al.*, 2007) and feelings of loneliness (Shankar *et al.*, 2011). The reasons for this are complex and multifactorial but include widowhood, having no (surviving) children, living alone, deteriorating mental or physical health, retirement, relocation and bereavement – which are commonly experienced in later life (Peplau, 1985; Grenade and Boldy, 2008; Cotten *et al.*, 2013; Courtin and Knapp, 2017; Age UK, 2018*a*). Understanding the factors associated with social isolation and loneliness in later life is important for identifying those at greatest risk and informing targeted interventions.

Social isolation refers to the objective status of a person's social relationships including network size, diversity and frequency of contact, whereas loneliness refers to the subjective psychological experience of the gap between a person's desired and actual levels of social contact (Peplau and Perlman, 1982; Perlman and Peplau, 1984; Peplau, 1985; Hawkley and Cacioppo, 2007; Cacioppo *et al.*, 2011; Shankar *et al.*, 2011; Steptoe *et al.*, 2013*b*; Age UK, 2018*b*; Kobayashi and Steptoe, 2018). Although the two constructs have been shown to be positively correlated (Cornwell and Waite, 2009*a*, Shankar *et al.*, 2011, Steptoe *et al.*, 2013*b*; Petersen *et al.*, 2016*a*), persons who are socially isolated may not experience loneliness whilst loneliness may occur without social isolation (Perlman and Peplau, 1984; Peplau, 1985; de Jong Gierveld and Havens, 2004; Hawkley and Cacioppo, 2007, 2010; Cornwell and Waite, 2009*b*; Coyle and Dugan, 2012; Beneito-Montagut *et al.*, 2018; Kobayashi and Steptoe, 2018). Prevalence estimates of loneliness among older adults (60–80 years) in Europe range from 8.1 to 46.8 per cent (Hansen and Slagsvold, 2016). It is estimated that up to 30.0 per cent of older adults (⩾50 years) in Europe are socially isolated (Cantarero-Prieto *et al.*, 2018).

Social isolation and loneliness are important issues because they are reciprocally related to health and wellbeing; that is, they are both a risk factor for and a consequence of poor health (Hawkley, 2017). For instance, a scoping review found both social isolation and loneliness can detrimentally affect the physical and mental health of older adults (Courtin and Knapp, 2017). However, physical and mental health problems can lead also to increased risk of social isolation and/or loneliness (Fokkema and Knipscheer, 2007).

The health risks associated with social isolation and loneliness are many and varied, and may also be due to having a negative effect on health behaviours (Lauder *et al.*, 2006). Loneliness is associated with increased risk of premature all-cause mortality in older adults (Luo *et al.*, 2012; Perissinotto *et al.*, 2012; Rico-Uribe *et al.*, 2018). Compared with never lonely older adults, those reporting often feeling lonely had a 130 per cent increased risk of cardiovascular disease risk

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and 22 per cent increased risk of ischaemic heart disease, even when controlling for age and sex (Patterson and Veenstra, 2010). Loneliness is also an independent risk factor for cognitive decline in older adults – for instance poorer cognitive performance, hastened cognitive decline, poorer executive functioning, slower processing speed and poorer memory (Wilson *et al.*, 2007; Cacioppo and Hawkley, 2009; Boss *et al.*, 2015) – and is associated with 17 per cent higher odds of having a mental health condition in older adults (⩾50 years) (Coyle and Dugan, 2012). Loneliness has been shown to be a risk factor for sedentariness and lower likelihood of engaging in physical activity, and increased likelihood of discontinuing physical activity (Hawkley *et al.*, 2009; Netz *et al.*, 2013; Hawkley and Kocherginsky, 2017), and is also a risk factor for obesity, smoking and alcohol abuse (Hawkley and Kocherginsky, 2017).

Social isolation is a predictor of mortality, independent of experiencing loneliness (Steptoe *et al.*, 2013*b*). Social isolation has been independently associated with cardiovascular disease risk in older adults (Grant *et al.*, 2009; Leigh-Hunt *et al.*, 2017) and is associated with increases in systolic and diastolic blood pressure (Shankar *et al.*, 2011). People who are socially isolated are also less likely to engage consistently in moderate-to-vigorous physical activity at least once a week, and are more likely to be overweight or obese and smoke (Kobayashi and Steptoe, 2018).

One possible means of reducing social isolation and loneliness in old age is the use of modern technology, in particular the internet. Geographical distance to friends or family, mobility issues and time-consuming roles (*e.g.* care-giver) may impair older adults' ability to engage socially, leaving them vulnerable to social isolation and feelings of loneliness (Leist, 2013). However, using the internet may help foster social support, keeping in contact, development of social networks and improve self-confidence among older adults (Chen and Schulz, 2016). Using technology provides a low-cost and accessible means for communication that has the potential to reduce loneliness and social isolation in older adults (Chipps and Jarvis, 2016).

A systematic review showed technologies – such as social networking sites, general information communication technology (ICT), video games, chat rooms, 3D virtual environments – can be useful for reducing social isolation in older adults (⩾50 years) (Khosravi *et al.*, 2016). Another systematic review of 25 studies showed that the use of ICT– such as Skype, Windows Live Messenger and telephone – increased social support, social connectedness and reduced social isolation among the elderly (age range 66–83 years), although the effects rarely lasted more than six months post-intervention, and even with adequate training some ICT interventions were not suitable for every older adult (Chen and Schulz, 2016). Many of the included interventions were only tested at one time-point, usually short term, and used a relatively small number of participants, thus the authors suggest a need for more well-designed studies (Chen and Schulz, 2016).

In a cross-sectional study of 11,000 older adults (⩾65 years) living in Europe, loneliness was reported less frequently by those who used the internet daily or sometimes compared with never users, and social isolation was less common among those who used the internet every day and sometimes compared with never users (Lelkes, 2013). Despite indications that interventions using technology, particularly the internet, can reduce social isolation and loneliness, there is limited

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up-to-date information investigating associations between older adults' current internet/email use in relation to their social isolation and loneliness.

Therefore, the present study used data from the English Longitudinal Study of Ageing (ELSA) to explore (a) the prevalence of internet/email use in older adults, particularly devices used and online activities engaged in; and (b) the associations between frequency of internet/email use with social isolation and loneliness. It was hypothesised that older adults who more frequently engage with the internet/email would be less likely to be socially isolated or to report feeling lonely, and that associations would be stronger for those who used technology most frequently.

Methods

Population

ELSA is a longitudinal survey of a representative cohort of adults aged ⩾50 years old living in England. The study began in 2002, with data collected via computer-assisted personal interviews and self-completion questionnaires in biennial waves (Steptoe *et al.*, 2013*a*). To ensure the most current technology usage possible in a rapidly changing industry, cross-sectional data from the most recent wave, Wave 8 (collected 2016/2017), were used. Moreover, longitudinal analysis was considered not feasible due to attrition reducing the sample size within individual categories of internet/email use even further, leading to problems with statistical power. Complete data on all variables of interest were available for 4,492 of the total sample of 8,445 participants. Ethical approval was obtained from the London Multi-centre Research Ethics Committee and all participants provided full informed consent.

Measures

Outcome variables: social isolation and loneliness

Social isolation was computed using a five-item index as used in previous literature (Shankar *et al.*, 2011; Steptoe *et al.*, 2013*b*; Kobayashi and Steptoe, 2018; Jackson *et al.*, 2019*a*). One point was assigned to each of the following: if they reported having less than monthly contact (including face-to-face contact, telephone and written/email/text messaging contact) with children, other family members and friends, if they did not belong to a social organisation or club, and if they lived alone. Scores ranged from 0 to 5, with higher scores indicating a greater degree of social isolation. As in previous studies, scores were dichotomised at ⩾2 *versus* <2 points to indicate high *versus* low levels of social isolation (Steptoe *et al.*, 2013*b*; Jackson *et al.*, 2019*a*).

Loneliness was self-reported using a three-item short form of the Revised University of California Los Angeles (UCLA) Loneliness Scale (Russell, 1996). Questions included: 'How often to you feel you lack companionship?', 'How often do you feel left out?' and 'How often do you feel isolated from others?'. Response options were 'hardly ever or never' = 1, 'some of the time' = 2 or 'often' = 3. Total scores ranged from 3 to 9, with higher scores indicating greater loneliness. As in previous papers, these were dichotomised at ⩾6 *versus* <6 to indicate high *versus* low loneliness (Steptoe *et al.*, 2013*b*; Jackson *et al.*, 2019*c*).

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Exposure variable: internet/email use

Frequency of internet/email use was assessed in the self-completion questionnaire, with the question 'On average, how often do you use the internet or email?' Response options were 'every day, or almost every day', 'at least once a week (but not every day)', 'at least once a month (but not every week)', 'at least once every three months' or 'never'.

Those who responded that they accessed the internet/email more than every three months were asked about the devices they used to access the internet: 'On which of the following devices do you access the internet?' Response options included desktop computer, laptop computer, tablet (*e.g.* iPad, Samsung Galaxy Tab), smartphone (*e.g.* iPhone, Android phone), other device, or do not access internet. In addition, participants were asked 'For which of the following activities did you use the internet in the last three months? Tick all that apply'. Response options included 'sending/receiving emails', 'telephoning over the internet/video calls (via webcam) over the internet', 'searching for information for learning, research, fact finding', 'finances (banking, paying bills)', 'shopping/buying goods or services', 'selling goods or services over the internet *e.g.* via auctions', 'use social networking sites (Facebook, Twitter, MySpace)', 'creating, uploading or sharing content (YouTube, blogging or Flickr)', 'news/newspaper/blog websites', 'streaming/downloading live or on demand TV/radio (BBC iPlayer, 4OD, ITV Player, Demand 5), music (iTunes, Spotify), or eBooks', 'games', 'looking for jobs or sending a job application', 'using public services (*e.g.* obtaining benefits, paying taxes)', 'other' or 'none of the above'.

Covariates

Covariates were selected *a priori* on the basis of previous studies showing associations between these variables and the exposure and outcomes of interest. Covariates assessed in this study were age and sex, as they are both independently associated with differences in internet use (Hogeboom *et al.*, 2010; Choi and Dinitto, 2013; Berner *et al.*, 2017; Bol *et al.*, 2018; Office for National Statistics, 2018*a*; Quintana *et al.*, 2018), loneliness and social isolation (Kobayashi and Steptoe, 2018). Sex was reported as male or female. Age was input in categories of 50–59, 60–69, 70–79, 80–89 and 90+ years. Marital status (married/living as married *versus* single) has also been associated with internet use (Hogeboom *et al.*, 2010; Berner *et al.*, 2017), social isolation and loneliness (Peplau, 1985; Grenade and Boldy, 2008; Steptoe *et al.*, 2013*b*; Hawkley and Kocherginsky, 2017; Kobayashi and Steptoe, 2018). Socio-economic status (SES) was assessed using household non-pension wealth as this has been identified as an appropriate indicator of SES in older adults (Banks *et al.*, 2004) and used in previous studies utilising the ELSA data-set (Hamer *et al.*, 2014; Smith *et al.*, 2015; Quintana *et al.*, 2018; Jackson *et al.*, 2019*a*, 2019*b*). This was entered as a covariate as it has previously been associated with internet use (Hogeboom *et al.*, 2010; Berry, 2011), social isolation and loneliness (Choi and Dinitto, 2013; Steptoe *et al.*, 2013*b*; Kobayashi and Steptoe, 2018).

Limiting long-standing illness has previously been associated with internet use (Hogeboom *et al.*, 2010; Choi and Dinitto, 2013), social isolation and loneliness (Grenade and Boldy, 2008). Participants were asked if they had any long-standing

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(meaning anything that has troubled them over a period of time, or that is likely to affect them over a period of time) illness, disability or infirmity. Response options were yes or no. Those answering yes were then asked if these illness(es) or disability (ies) limit their activities in any way. Response options were yes or no. Participants responding yes to the second question were categorised as having a limiting long-standing illness, otherwise participants were categorised as not having a limiting long-standing illness.

Depression has been associated with internet use (Cotten *et al.*, 2012, 2014), social isolation and loneliness (Perlman and Peplau, 1984; Peplau, 1985; Cacioppo *et al.*, 2006, 2010; Cornwell and Waite, 2009*b*; Coyle and Dugan, 2012; Victor and Yang, 2012; Cotten *et al.*, 2013; Domenech-Abella *et al.*, 2017) in older adults so was included as a covariate. The eight-item Center for Epidemiologic Studies Depression Scale (CES-D) was used to identify people at risk of depression, although one question was excluded to avoid overlap with loneliness scores meaning a total of seven questions were used; scores were dichotomised as high risk $\geqslant 3$ and low risk <3, in line with previous literature (Turvey *et al.*, 1999; Steptoe *et al.*, 2013*b*; Kobayashi and Steptoe, 2018; White *et al.*, 2018). Questions included: '(much of the time during the past week) you felt depressed, you felt that everything you did was an effort, your sleep was restless, you were happy, you enjoyed life, you felt sad, you could not get going?', to which participants could respond yes or no. The CES-D has acceptable psychometric properties in older adults (Cosco *et al.*, 2019).

Physical activity was entered as a covariate as individuals who are socially isolated and/or lonely tend to be less physically active (Lauder *et al.*, 2006; Hawkley *et al.*, 2009; Hawkley and Kocherginsky, 2017; Kobayashi and Steptoe, 2018). Currently, there is no literature on associations of physical activity and internet use in older adults. Level of physical activity was assessed at interview with questions on the frequency of mild, moderate and vigorous physical activity in which the participants engaged. Responses included 'more than once a week', 'once a week', 'one to three times a month' and 'hardly ever or never'. It was not possible to calculate and then dichotomise physical activity based on the recommended guidelines of 150 minutes per week of moderate-to-vigorous physical activity, due to the information available from the ELSA Wave 8 data-set. Responses were dichotomised as physically active if moderate and/or vigorous intensity physical activity once or more a week and inactive as less than once a week, in line with previous literature in this cohort regarding physical activity and health outcomes (Hamer *et al.*, 2009, 2014; Demakakos *et al.*, 2010; Smith *et al.*, 2015; Kobayashi and Steptoe, 2018).

Statistical analysis

Data were weighted to correct for sampling probabilities and non-response to the self-completion questionnaire. Characteristics of the study population, devices used to access the internet and online activities were summarised using descriptive statistics. Differences in covariates, devices and internet activities according to internet/email use were analysed using Pearson's chi-square analysis. Differences in devices and internet activities according to loneliness and social isolation were

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also analysed using Pearson's chi-square analysis. Results were presented as p values with Cramer's V effect sizes. Binomial logistic regressions were used to analyse associations between internet/email use and social isolation and loneliness, and were adjusted for covariates listed above. Daily use was chosen as the reference group as it was hypothesised that this group would be lowest risk. Results were reported as odds ratios (OR) with 95 per cent confidence intervals (95% CI). All data were analysed in IBM SPSS Statistics v24. Statistical significance was accepted at $p \leqslant 0.05$.

Results

The initial sample comprised 8,445 older adults, however, the exclusion of older adults with missing data resulted in a final analytical sample of 4,492 men and women (mean age = 64.3, standard deviation = 13.3; 51.7% males). The majority of older adults reported using the internet/email every day (69.3%), fewer participants reported once a week (8.5%), once a month (2.6%), once every three months (0.7%), less than every three months (1.5%) and never (17.4%). Overall, 19.4 per cent of the sample reported high levels of loneliness and 32.9 per cent were classified as socially isolated.

Table 1 summarises sample characteristics in relation to frequency of internet/email use. Significant differences were found in all characteristics when comparing internet/email use groups. Compared with less-frequent users, older adults who used the internet/email every day were more likely to be younger, male, married/living as married, in richer SES quintiles, have no limiting long-standing illness, exhibit high levels of depressive symptoms, be physically active, not lonely and not socially isolated. Those never using the internet/email were more likely to be older, female, married/living as married, in the poorest SES quintile, have a limiting long-standing illness, exhibit high levels of depressive symptoms, be physically active, not lonely but socially isolated. Although both every day and never users were more likely to be married/living as married, have high depression and be physically active, never users had a higher proportion of people who were single, had high levels of depression and were physically inactive compared with every day users. Compared with other frequencies of internet/email use, those who reported using the internet/email once every three months had the highest prevalence of loneliness and social isolation.

Unadjusted logistic regressions found once a week users were significantly less likely to experience loneliness than every day users (OR = 0.63, 95% CI = 0.52–0.76) and the same was found when only adjusting for social isolation (OR = 0.76, 95% CI = 0.63–0.92); however, this became non-significant when adjusted for covariates (OR = 1.11, 95% CI = 0.89–1.37) (Table 2). Less than once every three months users were significantly more likely to be lonely when adjusting for covariates (OR = 2.49, 95% CI = 1.05–5.90), but became non-significant when additionally adjusting for social isolation. No significant associations were found between other frequencies of internet/email use and loneliness in either the unadjusted or any adjusted regression model.

In the unadjusted and all adjusted models, once a week (adjusted for loneliness and covariates OR = 0.60, 95% CI = 0.49–0.72) and once a month users (adjusted

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Table 1. Sample characteristics in relation to internet/email use

		Frequency of internet/email use						χ^2	
	All	Every day	Once a week	Once a month	Once every 3 months	Less than every 3 months	Never	*p*	Cramer's V
N (%)	4,492	3,113 (69.3)	384 (8.5)	115 (2.6)	32 (0.7)	66 (1.5)	781 (17.4)		
Age (mean, SD):	64.3 (13.3)	62.9 (8.8)	67.6 (11.3)	68.5 (12.3)	66.5 (9.5)	65.9 (13.3)	67.5 (24.0)	<0.001	0.25
Age:									
50–59	1,436 (32.0)	1,265 (40.6)	73 (19.0)	12 (10.3)	11 (36.0)	18 (26.3)	57 (7.3)	<0.001	0.25
60–69	1,543 (34.4)	1,176 (37.8)	139 (36.3)	48 (42.1)	10 (30.9)	23 (35.1)	146 (18.7)		
70–79	1,003 (22.2)	550 (17.7)	115 (30.1)	34 (29.2)	6 (20.2)	16 (24.5)	281 (36.0)		
80–89	429 (9.6)	113 (3.6)	53 (13.8)	20 (17.1)	4 (12.9)	8 (12.5)	232 (29.6)		
90+	80 (1.8)	10 (0.3)	3 (0.8)	1 (1.3)	0	1 (1.5)	65 (8.3)		
Sex:									
Men	2,322 (51.7)	1,678 (53.9)	191 (49.9)	52 (45.7)	14 (45.2)	29 (43.1)	357 (45.6)	<0.001	0.07
Women	2,170 (48.3)	1,435 (46.1)	192 (50.1)	62 (54.3)	17 (54.8)	38 (56.9)	425 (54.4)		
Marital status:									
Unmarried	1,274 (28.4)	702 (22.5)	113 (29.4)	51 (44.7)	9 (27.0)	22 (33.7)	376 (48.2)	<0.001	0.22
Married	3,218 (71.6)	2,411 (77.5)	271 (70.6)	64 (55.3)	23 (73.0)	44 (66.3)	405 (51.8)		
SES quintile:									
1 (poorest)	782 (17.4)	400 (12.9)	54 (14.0)	32 (27.5)	5 (16.9)	24 (36.4)	266 (34.1)	<0.001	0.15
2	837 (18.6)	511 (16.4)	79 (20.5)	28 (24.1)	4 (12.6)	16 (24.0)	200 (25.6)		
3	935 (20.8)	636 (20.4)	87 (22.8)	25 (21.5)	14 (44.8)	9 (13.5)	164 (21.0)		

4	961 (21.4)	712 (22.9)	105 (27.3)	21 (18.1)	4 (11.3)	12 (18.6)	108 (13.9)		
5 (richest)	976 (21.7)	854 (27.4)	59 (15.5)	10 (8.7)	5 (14.4)	5 (7.5)	43 (5.5)		
Limiting long-standing illness:									
No	3,046 (67.8)	2,321 (74.6)	251 (65.4)	65 (56.6)	19 (60.3)	34 (51.7)	355 (45.4)	<0.001	0.24
Yes	1,446 (32.2)	792 (25.4)	113 (34.6)	50 (43.4)	13 (39.7)	32 (48.3)	426 (54.6)		
Depression:									
Low	2,385 (53.1)	1,806 (58.0)	182 (47.5)	42 (36.3)	19 (59.4)	25 (37.9)	311 (39.8)	<0.001	0.16
High	2,107 (46.9)	1,308 (42.0)	201 (52.5)	73 (63.7)	13 (40.6)	41 (62.1)	471 (60.2)		
Physical activity:									
Inactive	932 (20.8)	451 (14.5)	81 (21.2)	26 (22.4)	7 (20.7)	25 (37.2)	343 (43.9)	<0.001	0.28
Active	3,559 (79.2)	2,663 (85.5)	302 (78.8)	89 (77.6)	25 (79.3)	42 (62.8)	438 (56.1)		
Loneliness:									
Low	3,619 (80.6)	2,573 (82.6)	300 (78.3)	90 (77.9)	22 (68.4)	49 (73.4)	585 (74.9)	<0.001	0.08
High	873 (19.4)	540 (17.4)	83 (21.7)	25 (22.1)	10 (31.6)	18 (26.4)	196 (25.1)		
Social isolation:									
Not isolated	3,015 (67.1)	2,249 (72.2)	265 (69.0)	62 (54.1)	12 (39.2)	43 (65.2)	384 (49.1)	<0.001	0.20
Isolated	1,476 (32.9)	864 (27.7)	119 (31.0)	53 (45.9)	19 (60.8)	23 (34.8)	398 (50.9)		

Notes: Values are number of participants (percentages) within each category of internet/email frequency use unless otherwise stated. SD: standard deviation. SES: socio-economic status.

Table 2. Older adults' frequency of internet/email use in relation to self-reported loneliness

Frequency of internet/email use	High loneliness											
	OR[1]	95% CI	*p*	OR[2]	95% CI	*p*	OR[3]	95% CI	*p*	OR[4]	95% CI	*p*
Every day (69.3%)	1.00 (Ref.)			1.00 (Ref.)			1.00 (Ref.)			1.00 (Ref.)		
Once a week (8.5%)	0.63	0.52–0.76	<0.001	0.76	0.63–0.92	0.01	1.11	0.89–1.37	0.36	1.16	0.94–1.45	0.17
Once a month (2.6%)	0.83	0.62–1.11	0.20	0.98	0.73–1.32	0.91	1.24	0.91–1.71	0.18	1.32	0.96–1.81	0.09
Once every 3 months (0.7%)	0.85	0.53–1.35	0.48	0.88	0.55–1.42	0.59	0.89	0.54–1.46	0.63	0.90	0.54–1.48	0.67
Less than once every 3 months (1.5%)	1.38	0.64–2.95	0.41	1.28	0.59–2.78	0.54	2.49	1.05–5.90	0.04	2.30	0.97–5.45	0.06
Never (17.4%)	1.08	0.61–1.90	0.79	1.25	0.70–2.76	0.45	1.27	0.69–2.33	0.44	1.34	0.73–2.47	0.35

Notes: 1. Unadjusted. 2. Adjusted for social isolation. 3. Adjusted for covariates sex, age, wealth, moderate-to-vigorous physical activity, marital status, limiting long-standing illness, depression. 4. Adjusted for social isolation and covariates sex, age, wealth, moderate-to-vigorous physical activity, marital status, limiting long-standing illness, depression. OR: odds ratio. CI: confidence interval. Ref.: reference group.

for loneliness and covariates OR = 0.60, 95% CI = 0.45–0.80) were significantly less likely to be socially isolated than every day users (Table 3). In contrast, those using the internet less than once every three months were more likely than every day users to experience high levels of social isolation, but only in the covariate adjusted and loneliness plus covariate adjusted model (adjusted for loneliness and covariates OR = 2.87, 95% CI = 1.28–6.40). Never users in the unadjusted and loneliness adjusted models were less likely to be socially isolated than every day users (unadjusted OR = 0.51, 95% CI = 0.30–0.87; loneliness adjusted OR = 0.50, 95% CI = 0.29–0.85), however, this became non-significant when covariates were adjusted for. Once every three months were no more likely than every day users to experience high levels of social isolation in any of the adjusted or unadjusted models (adjusted for loneliness and covariates OR = 0.95, 95% CI 0.61–1.45).

Among all older adults, the tablet (47.5%), smartphone (47.4%) and laptop (47.0%) were the most commonly mentioned devices used to access the internet/email (Table 4). Every day users were most likely to use a smartphone compared to less-frequent users, whereas a laptop was most commonly used among less-frequent users. Significant differences between internet/email use frequency and the devices used to access the internet among all devices were found.

Smartphones were the most commonly reported device used among those with high loneliness (41.6%) and low social isolation (54.1%), whereas a tablet was most common in those with low loneliness (49.7%) and a laptop amongst those who were socially isolated (41.0%) (Table 5). Weak associations were found between all devices and loneliness, however, strong associations were found for social isolation.

Searching for information, sending/receiving emails and shopping/buying were the three most common internet activities in the last three months among all participants, and even when split by internet/email frequency use (Table 6). However, every day users more frequently reported sending/receiving emails than searching for information. Significant differences between the frequency of internet/email use groups were seen among all internet activities.

Weak associations were found between loneliness and all types of activities engaged with online, excluding job searching/application which showed moderate association with loneliness (Table 7). All online activities were strongly associated with social isolation status. A larger proportion of those with low loneliness engaged with most of the online activities compared with the proportion of those with high loneliness, excluding creating, uploading and sharing content (high = 11.0%; low = 8.8%), job searching/application (high = 13.6%; low = 7.8%) and other online activities (high = 7.0%; low = 5.7%). The same was true in job searching/application for social isolation status (high = 9.4%; low = 8.7%).

Discussion

The aim of this study was to explore associations between internet/email use in a large sample of older English adults with their social isolation and loneliness. The use of internet/email was highly prevalent in the study population; 69.3 per cent of older adults (⩾50 years) use the internet/email every day and 77.8

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Table 3. Older adults' frequency of internet/email use in relation to self-reported social isolation

Frequency of internet/email use	High social isolation											
	OR[1]	95% CI	*p*	OR[2]	95% CI	*P*	OR[3]	95% CI	*p*	OR[4]	95% CI	*p*
Every day (69.3%)	1.00 (Ref.)			1.00 (Ref.)			1.00 (Ref.)			1.00 (Ref.)		
Once a week (8.5%)	0.37	0.32–0.44	<0.001	0.39	0.33–0.45	<0.001	0.60	0.50–0.73	<0.001	0.60	0.49–0.72	<0.001
Once a month (2.6%)	0.43	0.33–0.56	<0.001	0.43	0.33–0.56	<0.001	0.60	0.46–0.81	0.001	0.60	0.45–0.80	<0.001
Once every 3 months (0.7%)	0.82	0.55–1.21	0.32	0.84	0.56–1.25	0.38	0.94	0.61–1.44	0.77	0.95	0.61–1.45	0.80
Less than once every 3 months (1.5%)	1.50	0.73–3.09	0.28	1.44	0.69–3.01	0.34	2.96	1.34–6.56	0.007	2.87	1.28–6.40	0.01
Never (17.4%)	0.51	0.30–0.87	0.01	0.50	0.29–0.85	0.01	0.60	0.34–1.07	0.09	0.59	0.33–1.06	0.08

Notes: 1. Unadjusted. 2. Adjusted for loneliness. 3. Adjusted for covariates sex, age, wealth, moderate-to-vigorous physical activity, marital status, limiting long-standing illness, depression. 4. Adjusted loneliness and covariates sex, age, wealth, moderate-to-vigorous physical activity, marital status, limiting long-standing illness, depression. OR: odds ratio. CI: confidence interval. Ref.: reference group.

Table 4. Devices used to access the internet in the last three months categorised by internet/email usage

	Frequency of internet/email use					χ^2	
Device	All	Every day	Once a week	Once a month	Once every 3 months	*p*	Cramer's V
N (%)	4,492	3,113 (69.3)	384 (8.5)	115 (2.6)	32 (0.7)		
Desktop	1,745 (38.9)	1,590 (51.1)	123 (31.9)	30 (26.3)	3 (9.8)	<0.0001	0.72
Laptop	2,109 (47.0)	1,865 (59.9)	185 (48.1)	44 (38.6)	16 (49.7)	<0.0001	0.71
Tablet	2,133 (47.5)	1,913 (61.4)	170 (44.3)	42 (36.2)	9 (29.2)	<0.0001	0.72
Smartphone	2,127 (47.4)	1,992 (64.0)	105 (27.4)	24 (21.0)	6 (19.9)	<0.0001	0.73
Other	110 (2.5)	101 (3.2)	3 (0.7)	5 (4.6)	1 (4.0)	<0.0001	0.71

Note: Values are number of participants (percentages) within each category of internet/email frequency use unless otherwise stated.

Table 5. Older adults' device use in relation to loneliness and social isolation

	Loneliness		χ^2		Social isolation		χ^2	
Device	High	Low	*p*	Cramer's V	High	Low	*p*	Cramer's V
N	873	3,619			1,476	3,015		
Desktop (38.9%)	259 (29.7)	1,487 (41.1)	<0.001	0.10	498 (33.7)	1,248 (41.4)	<0.001	0.17
Laptop (47.0%)	355 (40.7)	1,754 (48.5)	<0.001	0.08	605 (41.0)	1,505 (49.9)	<0.001	0.17
Tablet (47.5%)	335 (38.4)	1,798 (49.7)	<0.001	0.10	543 (36.8)	1,591 (50.4)	<0.001	0.19
Smartphone (47.4%)	363 (41.6)	1,764 (48.7)	<0.001	0.08	496 (33.6)	1,631 (54.1)	<0.001	0.22
Other (2.5%)	21 (2.4)	89 (2.5)	<0.001	0.07	27 (1.8)	83 (2.8)	<0.001	0.17

Note: Values are number of participants (percentages) within each category of loneliness/social isolation unless otherwise stated.

Table 6. Internet activities in the last three months categorised by internet/email usage

	Frequency of internet/email use					χ^2	
Internet activity	All	Every day	Once a week	Once a month	Once every 3 months	*p*	Cramer's V
N (%)	4,492	3,113 (69.3)	384 (8.5)	115 (2.6)	32 (0.7)		
Sending/receiving emails	3,307 (73.6)	2,949 (94.7)	280 (73.0)	66 (57.8)	12 (36.6)	<0.001	0.75
Telephoning/video calls (via webcam)	1,184 (26.3)	1,137 (36.5)	37 (9.5)	9 (7.5)	2 (5.8)	<0.001	0.72
Searching for information	3,317 (73.8)	2,915 (93.6)	309 (80.5)	76 (66.3)	17 (54.5)	<0.001	0.73
Finances	2,260 (50.3)	2,131 (68.4)	113 (29.5)	15 (13.3)	1 (1.9)	<0.001	0.74
Shopping/buying	2,831 (63.0)	2,598 (83.4)	182 (47.5)	39 (33.9)	12 (37.8)	<0.001	0.75
Selling	413 (9.2)	394 (12.6)	14 (3.8)	4 (3.3)	1 (2.1)	<0.001	0.71
Social networking	1,742 (38.8)	1,604 (51.5)	110 (28.7)	25 (21.5)	3 (9.9)	<0.001	0.72
Creating, uploading or sharing content	848 (18.9)	391 (12.5)	18 (4.8)	4 (3.8)	0	<0.001	0.71
News	1,945 (43.3)	1,844 (59.2)	83 (21.6)	15 (13.1)	2 (7.1)	<0.001	0.74
Streaming/downloading	1,653 (36.8)	1,595 (51.2)	48 (12.6)	6 (5.6)	3 (10.2)	<0.001	0.74
Games	1,089 (24.2)	982 (31.7)	86 (22.3)	14 (11.9)	2 (6.5)	<0.001	0.71
Job searching/application	400 (8.9)	376 (12.1)	16 (4.2)	4 (3.8)	4 (13.5)	<0.001	0.71
Using public services	899 (20.0)	868 (27.9)	25 (6.5)	6 (4.8)	0	<0.001	0.72
Other	267 (5.9)	235 (7.5)	20 (5.2)	11 (9.5)	1 (4.1)	<0.001	0.71

Note: Values are number of participants (percentages) within each category of internet/email frequency use unless otherwise stated.

Table 7. Older adults' internet activities in the last three months in relation to loneliness and social isolation

	Loneliness		χ^2		Social isolation		χ^2	
Internet activity	High	Low	*p*	Cramer's V	High	Low	*p*	Cramer's V
N	873	3,619			1,476	3,015		
Sending/receiving emails (73.6%)	581 (66.6)	2,726 (75.3)	<0.001	0.08	915 (62.0)	2,391 (79.3)	<0.001	0.19
Telephoning/video calls (via webcam) (26.3%)	171 (19.6)	1,013 (28.0)	<0.001	0.09	224 (15.2)	959 (31.8)	<0.001	0.22
Searching for information (73.8%)	583 (66.8)	2,734 (75.5)	<0.001	0.08	919 (62.3)	2,398 (79.5)	<0.001	0.19
Finances (50.3%)	362 (41.5)	1,897 (52.4)	<0.001	0.09	616 (41.7)	1,644 (54.5)	<0.001	0.18
Shopping/buying (63.0%)	486 (55.7)	2,345 (64.8)	<0.001	0.08	778 (52.7)	2,053 (68.1)	<0.001	0.18
Selling (9.2%)	55 (6.3)	358 (9.9)	<0.001	0.08	92 (6.2)	321 (10.6)	<0.001	0.18
Social networking (38.8%)	323 (37.0)	1,419 (39.2)	<0.001	0.07	427 (28.9)	1,315 (43.6)	<0.001	0.19
Creating, uploading or sharing content (18.9%)	96 (11.0)	317 (8.8)	<0.001	0.08	90 (6.1)	323 (10.7)	<0.001	0.18
News (43.3%)	322 (36.9)	1,622 (44.8)	<0.001	0.08	475 (32.2)	1,470 (48.8)	<0.001	0.20
Streaming/downloading (36.8%)	257 (29.4)	1,396 (38.6)	<0.001	0.09	420 (28.5)	1,233 (40.9)	<0.001	0.18
Games (24.2%)	176 (20.1)	913 (25.2)	<0.001	0.08	294 (19.9)	795 (26.4)	<0.001	0.17
Job searching/application (8.9%)	119 (13.6)	281 (7.8)	<0.001	0.12	139 (9.4)	261 (8.7)	<0.001	0.18
Using public services (20.0%)	174 (19.9)	725 (20.0)	<0.001	0.07	217 (14.7)	682 (22.6)	<0.001	0.18
Other (5.9%)	61 (7.0)	206 (5.7)	<0.001	0.08	77 (5.2)	190 (6.3)	<0.001	0.17

Note: Values are number of participants (percentages) within each category of loneliness/social isolation unless otherwise stated.

per cent at least once a week. This means that using the internet/email as a method to deliver behaviour change interventions (*e.g.* physical activity, dietary, smoking cessation) has potential in this population, particularly those who may be harder to reach such as those who are socially isolated, without much additional cost.

No associations between frequency of internet/email use and loneliness were found in the present study when adjusted for covariates and social isolation; however, previous studies found greater use of the internet was associated with lower loneliness in older adults (Erickson and Johnson, 2011; Cotten *et al.*, 2013; Heo *et al.*, 2015; Chopik, 2016), as measured by the 20-item UCLA Loneliness Scale (Russell *et al.*, 1980), three-item UCLA Loneliness Scale (Russell, 1996) or the 11-item short scale for measuring loneliness in large surveys (Hughes *et al.*, 2004). One explanation for the null findings in the present study may be that loneliness is perceived by some older adults as a complex and private matter (Kharicha *et al.*, 2017), so self-completion questionnaire answers may not reflect true feelings of loneliness. The three-item UCLA questionnaire to measure loneliness was selected to minimise this in the present study, rather than using the direct questions available in the ELSA data-set that explicitly mention loneliness (Campaign to End Loneliness, 2015). In addition, the UCLA three-item questionnaire only uses negative wording in the questions which may lead to participants providing the same answer for each question without properly considering what they are being asked (Campaign to End Loneliness, 2015). Equally, the use of different measures of loneliness may also provide reasoning for the different findings between previous studies and the present study.

A previous study found older adults' online communities were most heavily used on afternoon weekdays, and fewer interactions occurred at weekends or during the Christmas holidays (Nimrod, 2010). This suggests that when face-to-face interactions are available (*e.g.* with family members who work full-time), older adults choose these over online communities. Therefore, loneliness may only be associated with time spent with real-world connections, rather than online connections in older adults, hence the null findings in the present study. Loneliness in older adults is related to the quality rather than quantity of relationships (Holt-Lunstad *et al.*, 2010; Russell *et al.*, 2012; Beneito-Montagut *et al.*, 2018), and relationships among older adults in online communities seem mostly superficial and rarely extend to offline domains (Nimrod, 2010), so there is also potential that the objective measure of frequency of internet/email use in the present study has no bearing on the quality of a relationship for older adults.

The types of activities engaged in whilst online may, however, impact loneliness. In the present study, weak associations were found between most online activities and loneliness status. Loneliness was previously significantly negatively correlated with internet use for communication among older adults, whereas internet use for information, entertainment or total internet use was not correlated with loneliness, measured with the 20-item UCLA Loneliness Scale (Erickson and Johnson, 2011). In older adults (⩾52 years) Facebook use was not associated with loneliness, measured with the 20-item UCLA Loneliness Scale (Bell *et al.*, 2013), which although it could be seen as a communication tool, may suggest older adults use Facebook for other reasons such as entertainment or information. Video calls are a useful tool for overcoming barriers to connect people who cannot

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meet face to face (*e.g.* geographic distance, time constraints) (Khalaila and Vitman-Schorr, 2018), however, they mostly foster established relationships, rather than creating new ones. Elderly residents of a nursing home showed significantly lower loneliness scores, measured using the 20-item UCLA Loneliness Scale, after three months of video-conferencing with relatives for five minutes per week (Tsai *et al.*, 2010). Previous research showed the number of outgoing telephone calls was not associated with loneliness in older adults, however, the number of incoming calls was negatively associated with loneliness (Petersen *et al.*, 2016*b*), measured using the 20-item UCLA Loneliness Scale (Russell *et al.*, 1980). Communicating via the internet with family and friends has been shown to reduce older adults' (⩾55 years) feelings of loneliness (Sum *et al.*, 2008), measured using the Social and Emotional Loneliness Scale (DiTommaso *et al.*, 2004), which may suggest the type of online activity and the relationship with whom they are communicating may be an important factor. Future studies should therefore consider investigating the quality of these online and offline relationships when researching loneliness.

Older adults using the internet/email once a week or once a month were less likely to be socially isolated than every day users. Conversely, a previous study found that social isolation was reported less frequently in older adults using the internet every day compared with never and sometimes users (Lelkes, 2013). A previous study that gave older adults computers with internet access for three years found that participants were able to stay in touch with their real-world contacts whilst suffering illness (Fokkema and Knipscheer, 2007). Thus, it may be that participants in the present study who are unable to reduce their social isolation, however, remain in contact with the outside world through these means (Chen and Schulz, 2016). There is also the possibility that it may encourage isolation due to convenience.

In a similar way to loneliness, explanations for the associations between social isolation and frequency of internet/email use may come from specific online activities. Strong associations were found between social isolation and all online activities in the present study. Communicating with family and friends via the internet reduced older adults' (⩾55 years) social isolation, but when used often, for long durations and to communicate with strangers was associated with greater social isolation (Sum *et al.*, 2008). Therefore, using internet/email as complementary, rather than replacement, of face-to-face social meetings may protect against social isolation and potentially loneliness (Fokkema and Knipscheer, 2007; Cornejo *et al.*, 2013; Lelkes, 2013). Another explanation for the findings in the present study could be that every day users may either be online too frequently and/or for long durations, which may lead to greater social isolation. Once a week and once a month users in the present study may have a better balance, *e.g.* they are too busy with real-world contacts and activities to spend as much time online, leading to reduced social isolation. Future interventions targeting social isolation in older adults may utilise the internet for cost-effectiveness, however, in addition to real-world interactions to reduce the increased risk of loneliness. Previous research suggests that sharing content online can enhance conversations and promote real-world interactions that strengthen older adults' networks, particularly intergenerationally (Cornejo *et al.*, 2013). Future research should consider exploring the

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frequency and duration of internet use, in addition to online activities, when exploring associations with social isolation and loneliness.

Those using internet/email less than once every three months were more likely to be socially isolated than every day users. Explanations for this could be poor access to internet/email services, lack of internet/email education or even a purposeful decision to live 'offline'. Future digital interventions should thus consider the frequency and duration of use and time spent in face-to-face interactions to ensure quality relationships are fostered/maintained in order to reduce social isolation and feelings of loneliness in older adults.

One limitation of the present study is the data are self-reported, which although useful for gathering sensitive information such as loneliness and social isolation, may include bias and potential under- or overestimations of reported behaviours (Prince *et al.*, 2008; Lee *et al.*, 2011; Scharkow, 2016; Araujo *et al.*, 2017). When split by frequency of internet/email use, some groups include low numbers of participants, which may potentially lead to type 1 statistical error. One purpose of internet use involves communication with others, which was also captured in the social isolation measures including written/email/text messaging contact, therefore there may be some overlap between these variables. In addition, the single-item question relating to internet/email use may not provide enough information to gain true insight into the duration of time spent online, via which device and for which activities. Therefore, future studies should aim to elicit more detailed information, including duration of use per day as total time and in bouts of use, in self-report questionnaires on technology use. The present study explores associations, and whilst speculations can be made, causation regarding internet use, social isolation and loneliness in older adults requires further research.

Conclusion

The present study found older adults' perceived loneliness is not associated with their frequency of internet/email use; however, social isolation is associated with frequency of internet/email use, but not linearly. This suggests that internet use bears no impact on the perceived quality of relationships for older adults and is often used to keep contact with established real-world connections. The study also highlights that 69 per cent of older adults use the internet/email every day and 78 per cent at least once a week, and that smartphones and tablets are more popular with every day users whereas less-frequent users tend to use laptops or tablets. This may have important implications for future digital behaviour change interventions for health, specifically in older adults.

Ethical standards. Ethical approval was obtained from the London Multi-centre Research Ethics Committee and all participants provided full informed consent.

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