



The Impact of an Internet Use Promotion Programme on Communication, Internet Use, and the Extent of Social Networks among Low-Income Older Adults

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Abstract

We examined whether an internet use promotion intervention influences low-income older adults' communication modes, internet use, and social networks using existing data collected for an intervention. Participants living in public senior housing facilities in the United States ($n = 77$) completed surveys before and after a 12-week computer and internet training. The six-item Lubben Social Network Scale (LSNS-6) was used to measure the extent of older adults' social networks. The primary mode of communication shifted from more traditional means to internet-based communications ($p < .0005$ in a Fisher's exact test). The frequency of internet use significantly increased ($p < .00005$ in a one-sided Sign test). Overall, the LSNS-6 score increased by 4.1 points ($p < .00005$ in a Welch's t-test). The LSNS-6 score increase was significantly larger among African Americans than Whites, controlling for gender ($p < .05$ in negative binomial regression). Moderate ($p < .005$) and frequent internet users ($p < .05$) had higher LSNS-6 scores than rare internet users at posttest when gender and race were controlled for in linear regression. Comparatively more improvement in the extent of social networks among African Americans suggests greater benefits of such interventions for population groups of disadvantaged backgrounds. Larger social networks among moderate and frequent internet users than rare users suggest positive impacts of internet communications on social networks.

Keywords Older adults · Internet use · Intervention · Social networks · Programme evaluation

Though the importance of developing and maintaining good social networks increases with age (Nahm & Resnick, 2001; Nahm et al., 2004), older adults are increasingly likely to become socially isolated as their social networks decrease due

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to various factors, including the death of families and friends, disability, reduced mobility, and geographic relocation (Livingston, 2019; Mellor et al., 2008; Nahm & Resnick, 2001; Nahm et al., 2004). The internet can help older adults improve their social networks by circumventing some restrictions in communication (Aggarwal et al., 2020; Choi et al., 2012; Woodward et al., 2011). During the COVID-19 pandemic, however, many older adults have experienced both digital and social exclusions, since their lack of access to and skill with digital technologies has increased their social isolation (Seifart et al., 2021).

Social networks have been used as a measure of social connectedness, in the sense that social networks allow for the provision of social support (Coreil, 2010). Social isolation is a related concept that is the opposite of social connectedness. Social isolation refers to the absence of contact with other people, social support, or social connectedness (Hawthorne, 2006). Lubben defined social networks as both family and friends, with whom one could connect, utilizing different types of social support (Lubben, 1988; Lubben et al., 2006). With Lubben's social network measures, individuals with social networks that are smaller than a cutoff point are considered socially isolated (Lubben et al., 2006). In this study, we refer to the extent of social networks based on Lubben's work (Lubben, 1988; Lubben et al., 2006).

Although older adults are less likely than their younger peers to engage in computer and internet usage (Anderson & Perrin, 2017; Macdonald & Huler, 2021; Zickuhr & Madden, 2012), such technological skills can be learned and adopted (Rosenthal, 2008; Sayago et al., 2013; Winstead et al., 2013). Many computer and internet intervention programmes have been shown to positively influence participants' social networks or social connectedness (Aggarwal et al., 2020; Chen & Schulz, 2016; Gardiner et al., 2018; Ibarra et al., 2020).

In this paper, we review the literature on internet use among older adults and the effect of intervention programmes on older adults' internet use and social networks. Building upon the literature, we evaluate the impact of a computer/internet training programme on communication, internet use, and social networks using data collected from low-income older adults in the United States, including racial minorities.

Digital Divide

Studies have shown that a digital divide exists by age, in that older adults are less likely to use computers and the internet than younger adults (Anderson & Perrin, 2017; Smith, 2014b; Zickuhr & Madden, 2012; Zickuhr & Smith, 2012). In 2018, approximately 90 per cent of all adults in the United States used the internet, as compared to 66 per cent of those ages 65 and older (Pew Research Center, 2018). The divide appears to increase further in senior years, with those 70 and older involved in even less computer and internet activity (Friemel, 2016). This is a problem not only for older adults having physical access to technology, but also their attitudes and acceptance of such technologies, as well as their skill levels in using it (Broady et al., 2010; Chen & Chan, 2011).

The depth and breadth of computer and internet usage also seems to differ by age. Older adults tend to have more limited expectations and goals compared to

younger adults (Loges & Jung, 2001) and use fewer computer and internet applications than their younger peers (Carpenter & Buday, 2007; Czaja & Lee, 2007; Gatto & Tak, 2008; Loges & Jung, 2001). The reasons for this difference include cognitive decline (der Wardt et al., 2012) and concerns about the risks of being online (Kim & Gray, 2016; White et al., 2017).

In addition to age, a digital divide has been found to exist by other demographic factors (Anderson & Perrin, 2017; Choi & DiNitto, 2013; DiMaggio et al., 2004; Grossman et al., 2019; Smith, 2014a; Werner et al., 2011; Yoon et al., 2020; Zickuhr & Smith, 2012). Older adults in the United States who have an average household income of at least \$75,000 or more and those who are college graduates are more likely to use the internet than their poorer and less educated peers (Anderson & Perrin, 2017; Smith, 2014a, b). A Swedish study (Olsson et al., 2019) reported a similar pattern where more resourced older adults in terms of income and education used a broader array of online platforms and devices with greater frequency.

Digital divides by race and ethnicity also exist (DiMaggio et al., 2004; Lorence et al., 2006; Smith, 2014a; Werner et al., 2011). Among all U.S. adults, internet use was 87 per cent among Whites and 80 per cent among Blacks in 2013 (Smith, 2014a). The digital divide by race is larger among older adults than the general adult population (Mitchell et al., 2019; Werner et al., 2011). In 2013, 63 per cent of White older adults compared to 45 per cent of Black counterparts used the internet, and 51 per cent of White compared to 30 per cent of Black older adults had broadband at home (Smith, 2014a).

Impacts of Intervention Programmes on Computer and Internet Usage

Computer and internet training for older adults has shown that it can assist them in using the computer and internet more regularly for communication purposes, which can serve to decrease the digital divide (Bertera et al., 2007; Damnee et al., 2019; Fields et al., 2020; Ma et al., 2020; Woodward et al., 2011; Xie & Bugg, 2009). In a randomized field trial for older adults (60 years and older) of a 6-month computer and internet training programme (Woodward et al., 2011), participants in the experimental group demonstrated improvements in computer usage self-efficacy. They also used a greater number of information and communication technologies, including the internet and email (Woodward et al., 2011). A tablet-PC training intervention with 13 community-based older adults through 10 sessions over a 5-month period demonstrated statistically significant improvements in participants' internet and information communication technology acceptance and skills (Damnee et al., 2019). In an in-home technology training programme in which tablets, broadband, and individualized training were provided to socially isolated older adults (Fields et al., 2020), participants were randomized into the treatment ($n = 44$) and wait-list ($n = 39$) groups. Results showed that the intervention group demonstrated statistically significant improvements in technology use, and marginally significant improvements in technology confidence and social support (Fields et al., 2020).

Despite the diversity of the older population in the United States (Mather et al., 2015; Mather et al., 2019), older adults from disadvantaged backgrounds are less likely to be included in computer and internet-related interventions and evaluation studies (Kim, 2008). Besides a few exceptions (Bertera et al., 2007; Campbell, 2008; Fields et al., 2020; Jung et al., 2010), most computer and internet-related evaluation studies on non-institutionalized older adults in the United States have been conducted with more resourced populations (Kim, 2008). Participants in evaluated programmes tend to be well educated or overwhelmingly White (Berkowsky et al., 2013; Billipp, 2001; White et al., 2002). Since older adults from disadvantaged backgrounds tend to have additional barriers to internet use, including less access to the internet, low literacy, less experience with technology, limited financial resources, and disabilities (Choi & DiNitto, 2013; Kaye, 2000; Kim, 2008), the impact of training programmes on computer and internet use for disadvantaged populations may be different from that for their more well-resourced counterparts.

Impacts of Internet Training on Social Networks

One of primary objectives of internet training interventions is to improve older adults' social wellbeing through various mechanisms including expansion of social networks or improvement of social connectedness (Chen & Schulz, 2016; Gardiner et al., 2018; Ibarra et al., 2020). The literature indicates positive impacts of such interventions on social connectedness in general (Banbury et al., 2017; Czaja et al., 2018; Isaacson et al., 2019; Morton et al., 2018; Neves et al., 2019). In randomized controlled trials, interventions involving internet training reduced social isolation (Czaja et al., 2018) and increased social network activities (Morton et al., 2018). In uncontrolled pre-posttest design studies using video conferencing techniques, the mean number of network members increased (Banbury et al., 2017) and the size of social networks expanded (Isaacson et al., 2019) post intervention among community dwelling older adults. Qualitative data from a small sample of retirement home residents (Neves et al., 2019) indicated increased interactions with family and friends in general and an increase in social connectedness among participants with relatives living in distant locations.

Alternatively, other studies demonstrated no significant improvement in social networks or social connectedness after an intervention (Mellor et al., 2008; Myhre et al., 2017; Slegers et al., 2008). A study with community dwelling older adults (Slegers et al., 2008) found that internet and computer training did not have significantly consistent effects on social network development when measured 4 and 12 months post training. Similarly, in another study (Mellor et al., 2008), twenty older adults from a retirement village in a computer and internet training programme did not demonstrate improvement in social connectedness 12 months after the training. An intervention with participants from two

retirement communities (Myhre et al., 2017), showed no improvement in social connectedness after participating in 3-session Facebook trainings.

Impacts of Internet Use on Social Networks and Psychological Wellbeing

Two main theses that explain how online interactions affect social networks and psychological wellbeing are the social augmentation and social displacement theses (Bessière et al., 2008). The social augmentation thesis posits that internet communications strengthen social resources by providing an additional channel for social interactions and expanded social networks (Bessière et al., 2008; Boase et al., 2006; Quan-Haase et al., 2005; Wellman et al., 2001). Multiple studies support this perspective. A study using cross-sectional data from older adults of European countries (Lelkes, 2013) indicated that internet contact did not crowd out in-person social contact. The study also suggested that the most disadvantaged groups may benefit the most from internet use. Internet use among older adults with lower education was associated with a greater decrease in social isolation than among those with higher education, although the same association was not found with respect to income groups (Lelkes, 2013). Another cross-sectional study using data from U.S. adults (Boase et al., 2006) found that emails did not substitute or replace other forms of contact such as in-person and phone contact in maintaining social ties. Instead, as emails were used to contact a higher percentage of significant social ties, all other means of communication, including phone and in-person contact, were used at a higher percentage (Boase et al., 2006). A survey with North American adults (Wellman et al., 2001) demonstrated that online interactions supplemented face-to-face and telephone communication without affecting it either positively or negatively. Moreover, more internet activities were associated with increased offline participation in voluntary organizations and political activities (Wellman et al., 2001). More recent studies demonstrated positive effects of internet use and digital communication on social connectedness and loneliness without decreasing other forms of social contact (Burholt et al., 2020; Yu et al., 2021). In a cross-sectional study with community dwelling older adults in the United Kingdom, the degree of social isolation among those with infrequent face-to-face contact with relatives decreased if text or email communications were used more frequently (Burholt et al., 2020). A longitudinal study with a nationally representative sample of U.S. older adults found that internet use was related to decreased loneliness (Yu et al., 2021). Over 8 years, the overall frequency of social contact with people in their social networks did not decrease among internet users while it decreased among non-internet users (Yu et al., 2021).

The social displacement thesis, on the other hand, suggests that the psychological wellbeing of internet users deteriorates as internet communications displace other forms of social interactions (Kraut et al., 1998; Nie, 2001; Shklovski et al., 2004). In a longitudinal study, greater internet use was associated with decreased family communication and more limited social networks, as well as

increases in depression and loneliness (Kraut et al., 1998). Another study using longitudinal data (Shklovski et al. 2004) also demonstrated a negative impact of internet use on in-person interactions regardless of the measures of internet use (the frequency of use, the breadth of use, and number of years of internet use). The social displacement thesis appears to be in accord with research findings that indicate lower-quality psychological values of online social interactions compared to those from in-person interactions; and a lack of strong ties or enduring social support from online interactions (Bessièrè et al., 2008; Cummings et al., 2002; Weiser, 2001).

Evidence also suggests that internet use does not have the same effect on social and psychological wellbeing (Bessièrè et al., 2008; Kraut et al., 2002; Nakagomi et al., 2020; Szabo et al., 2019). Whether internet use leads to social augmentation or displacement may depend on the purpose of use, personality, and the initial social resources of the user (Bessièrè et al., 2008; Kraut et al., 2002; Nie & Hillygus, 2002; Shklovski et al., 2004). Internet use for communication with friends and family was associated with decreased depression or social loneliness (Bessièrè et al., 2010; Nakagomi et al., 2020; Sum et al., 2008; Szabo et al., 2019) while informational (e.g., finding health-related information) and instrumental uses (e.g., banking) did not have such positive associations (Nakagomi et al., 2020; Szabo et al., 2019) or were associated with negative outcomes such as depression (Bessièrè et al., 2010). A longitudinal study of those using the internet for communication showed improved psychological wellbeing among extroverts and individuals with more social support (Kraut et al., 2002). Increased internet use, however, had a negative effect on social and psychological wellbeing among introverts and those with less social support (Kraut et al., 2002). A large panel study on the association of internet use among retired older adults, however, indicated the largest reduction of depression among older adults who were living alone than those who were living with someone (Cotten et al., 2014).

Research evidence of the effect of internet use on social connectedness and psychological wellbeing is inconclusive due to methodological limitations, inconsistency in outcomes and interpretations, and a lack of representativeness and long-term effects (Choi et al., 2012; Dickinson & Gregor, 2006; Forsman & Nordmyr 2017; Gardiner et al., 2018; Ibarra et al., 2020; van der Wardt et al., 2012; Wagner et al., 2010). This study therefore evaluates whether participation in a computer/internet training programme influences social networks of low-income older adults including racial minorities using a validated social network measure.

The aim of this study was to examine: (a) whether internet use affects the extent of social networks among low-income older adults; and (b) whether the changes in the extent of social networks vary by demographic characteristics.

Methods

Study Design

This study used existing data collected for an intervention with a one-group-pre-and-post design. The authors conducted a post hoc evaluation without involvement

in study design or data collection. The data were collected from participants before and after a 12-week computer and internet training programme conducted in a US Midwestern location. Participants completed a pretest before the training and a post-test within a month after completion of the training. Upon completion of the training, participants received a free laptop computer for their individual use. The training was part of a pilot intervention programme designed to address multiple barriers to computer and internet use among low-income older adults and people with disabilities living in public senior housing facilities. It provided public computer stations in a computer lab and Wi-Fi access in common areas in the buildings as the intervention started. Three levels of computer and internet skills training (beginner, intermediate, and advanced) were offered based on an initial proficiency test. The training was delivered in a one-hour session per week over the course of 12 weeks and was designed to accommodate participants with various needs including those with low literacy and educational levels. Written lessons, which were projected on a screen in the computer learning center, began with very basic computer skills and advanced to higher-level skills.

Participants

Seventy-seven low-income older adults completed questionnaires both before and after a 12-week computer and internet skills training programme. The participants were from 12 multi-unit public housing buildings. The research protocol and consent process were reviewed and approved by the university institutional review board. Prior to administration of the baseline survey, the purposes of the study and the procedures involved in participation were explained, and informed consent was obtained.

Instrument

The hard copy, self-administered questionnaire included questions on demographic characteristics, prior experience with computers and the internet, current computer ownership and access to the internet, communication modes, internet use, and social networks.

The primary mode of communication with relatives and friends included four response categories: face-to-face/in-person visits, mail, phone, and email/internet. Response choices for the frequency of internet use were rarely/never, once per month, once per week, several times per week, once per day, and several times per day.

An abbreviated version of the Lubben Social Network Scale (LSNS-6) (Lubben & Girona, 2000) was used to measure the extent of older adults' social networks. The LSNS-6 includes questions on the number of relatives and friends one sees or hears from at least once per month, feels close enough to call on for help, and feels at ease enough to talk about private matters. The 6 questions have the following 6-point Likert-type response choices: 0 = none, 1 = one, 2 = two, 3 = three or four, 4 = five

through eight, and 5 = nine or more. The sum of 6 item scores (ranging from 0 to 30) is used to measure the extent of overall social networks (Lubben et al., 2006). A person with a LSNS-6 score less than 12 is considered socially isolated (Lubben et al., 2006). The LSNS-6 is known to have good validity and reliability in validation studies (Chang et al., 2018; Jang et al., 2020; Myagmarjav et al., 2019; Sansoni et al., 2010). Rasch and classical factor analyses using data from the same sampling pool demonstrated an adequate performance of the LSNS-6 as an overall measure of social networks in community-residing older adults (Gray et al., 2016).

Hypotheses Based on the social augmentation thesis (Boase et al., 2006; Quan-Haase et al., 2005; Wellman et al., 2001) and existing empirical research (Lelkes, 2013), the following hypotheses were tested.

Hypothesis 1: The extent of participants' social networks increases between the pretest and the posttest.

Hypothesis 2: More frequent internet use is associated with more extensive social networks among participants.

Hypothesis 3: Social networks improve to a larger extent among participants with less resources, such as those with lower education and income and racial minorities.

Hypotheses 1 and 2 are based on the social augmentation thesis that the extent of social networks expands as internet communication is added to other forms of social interactions (Boase et al., 2006; Quan-Haase et al., 2005; Wellman et al., 2001). Hypothesis 3 is based on a study finding that the most socially disadvantaged older adult groups benefited the most from internet use (Lelkes, 2013).

Analysis

Sample characteristics and the distribution of variables were examined, using a mean, standard deviation, and a range for a continuous variable and percentages and Fischer's exact tests for discrete variables (Mehta & Patel, 1983). The main variables of interest were the primary mode of communication (4 categories), the frequency of internet use (3 categories), and the LSNS-6 total score.

Internet use frequencies were recategorized from the original six groups into three (rare use = rarely/never or once per month; moderate use = once per week or several times per week; and frequent use = once per day or several times per day) to reduce the cells with no observations. Given the presence of five or fewer cases in some cells, a Fisher's exact test was used to examine the differences in communication mode and internet use frequency by gender, age, race, education, and income group at each pretest and posttest.

The difference in the extent of social networks (measured by the LSNS-6 total score) by demographic characteristics, primary mode of communication, and internet use frequency was investigated using a t-test or analysis of variance (ANOVA) for each pretest and posttest score. The LSNS-6 total score at each pretest and posttest was normally distributed as indicated by the Shapiro-Wilk

normality test ($p > .05$) (StataCorp, 2011a). When the groups compared had unequal variances, the Welch's t-test (Ruxton, 2006) was also used. The Welch's t-test can be used in place of the usual (Student's) t-test for variables with a normal distribution but with unequal variances between groups (Ruxton, 2006). The Welch's t-test is superior to the Student's t-test when there are extreme discrepancies in sample sizes and variances between two groups and the total sample size is small (e.g., less than 30) (Zimmerman, 2004). The Welch's t-test does not pool variances in computation of an error term and alters the degree of freedom to prevent inflated Type I error and stabilize Type II error (Zimmerman, 2004).

The pre-post difference in primary mode of communication was tested using a Fisher's exact test. A pre-post difference in the frequency of internet use was examined using a Sign test for matched pairs. The non-parametric test compares scores of matched or paired samples (e.g., pre and post observations of individuals) without requiring the outcome's distribution to be normal or symmetric (Hald, 2003). The Sign test produces the results of three hypothesis tests: whether the median of the differences between paired observations is positive, negative, and zero (StataCorp, 2011a). The pre-post difference in the LSNS-6 total score was examined using both paired t-test and Welch's t-test because of the unequal variances of the pretest and posttest scores (Hypothesis 1). An effect size was examined to determine practical significance of the change in LSNS-6 score between pre- and posttests using Glass's Delta (Ialongo, 2016; Maher et al., 2013). In addition, the pre-post difference in the LSNS-6 total score was examined for each demographic subgroup using a paired t-test for groups with equal variances and a Welch's t-test for groups with unequal variances.

ANOVA was used to test whether the LSNS-6 total score differs by internet use frequency at each pretest and posttest (Hypothesis 2). LSNS-6 total scores had equal variance between internet use frequency subgroups at each pretest and posttest indicated by Bartlett's test ($p > .05$). When an ANOVA result was significant, the Bonferroni and Scheffé tests (Savin, 1980) were used to identify specific pairs of categories that were statistically different from one another. Linear regression was used to examine whether an association between the internet use frequency and LSNS-6 total score remains the same when demographic variables were controlled for.

In examining the change in the extent of social networks, negative binomial regression was used because the changes in the LSNS-6 total score between the pretest and the posttest were not normally distributed and skewed to the right. Between two alternative regression models for this type of distribution, Poisson and negative binomial regression, the latter was found to be better. A likelihood ratio test of the overdispersion parameter alpha showed that negative binomial regression was more appropriate for the data than Poisson regression ($p < .01$) (Long & Freese, 2001). Simple negative binomial regression was used to examine whether the change in the LSNS-6 total score between the pretest and the posttest varies by each education (less than high school, high school diploma, and more than high school), income (annual income at least \$5000 or not) and race (African American or not) (Hypothesis 3). Multiple negative binomial regression was used to examine whether a significant association between an independent variable and the change in the LSNS-6

total score holds when another demographic variable is controlled for. All analyses were performed using Stata version 12 (StataCorp, 2011b).

Results

Sample Characteristics

Table 1 presents the participants' socio-demographic information and computer and internet use experience. The majority of the sample was female (63.6%) with a mean age of 73.8 (ranging from 65 to 91 years). One quarter (24.7%) was African American with the remainder being White. Over one quarter of the sample had obtained a high school degree or equivalent (28.6%), and over one third

Table 1 Sample Characteristics ($n=77$)

	<i>n</i>	%
Gender		
Female	49	63.6
Male	27	35.1
Missing	1	1.3
Race		
White	58	75.3
African-American	19	24.7
Age ^a		
65-69	26	33.8
70-79	33	42.9
80+	18	23.4
Education		
< High school	29	37.7
High school or equivalent	22	28.6
Some college+	26	33.8
Income		
< \$5000	19	24.7
\$5000-\$15000	41	53.2
\$15001+	9	11.7
Missing	8	10.4
Prior computer use		
Yes	26	33.8
No	44	57.1
Missing	7	9.1
Prior Internet use		
Yes	39	50.6
No	34	44.2
Missing	4	5.2

^aMean age = 73.8. Standard deviation = 6.8. Range: 65-91

(33.8%) had completed some college or higher education. Since the participants resided in public housing facilities, the income distribution was relatively homogenous with almost 8 out of 10 earning \$15,000 or less. At pretest, 33.8 per cent reported ever using a computer, and 50.6 per cent ever using the internet.

Communication-related Variables

Table 2 presents the distributions of computer ownership, internet access, the primary mode of communication, and the frequency of internet use at pretest and posttest. Computer ownership and internet access increased from 74 to 97.4 per cent and from 48 to 70.1 per cent respectively between pre and posttest. The primary mode of communication with relatives was similar across demographic groups at each pre and posttest (results not shown). The primary mode of communication with friends could not be examined due to a lack of usable data: most participants did not answer the question. It was probably because they thought it was the same question as the prior question on communication with relatives. The frequency of internet use was

Table 2 Communication-related Variables at Pretest and Posttest ($n=77$)

		Pretest		Posttest		<i>p</i> value
		<i>n</i>	%	<i>n</i>	%	
Own a computer						
	Yes	57	74.0	75	97.4	
	No	18	23.4	0	0	
	Missing	2	2.6	2	2.6	< .0005 ^a
Internet access						
	Yes	37	48.0	54	70.1	
	No	17	22.1	0	0	
	Missing	23	29.9	23	29.9	< .0005 ^a
Communication mode ^b						
	Face-to-face	33	42.9	15	19.5	
	Mail	7	9.1	3	3.9	
	Phone	29	37.7	24	31.2	
	Email/Internet	4	5.2	31	40.3	
	Missing	4	5.2	4	5.2	< .0005 ^a
Internet use frequency						
	Rare	22	28.6	5	6.5	
	Moderate	13	16.9	26	33.8	
	Frequent	24	31.2	28	36.4	
	Missing	18	23.4	18	23.4	< .00005 ^c

^aFrom a Fisher's exact test.

^bPrimary mode of communication with relatives.

^cFrom a one-sided Sign test examining if the median of the differences between the pre and posttest is positive

also similar across demographic groups with one exception: the frequency of internet use at pretest was significantly lower among those with very low income (annual income less than \$5000) compared to those with higher income (\$5000 or more) (results not shown). Approximately two-thirds (66.7%) of the participants with very low income were rare users while a little over one quarter (27.5%) of those with income \$5000 or more were rare users at pretest (results not shown).

The percentage of people who communicated with their relatives primarily through face-to-face meetings, postal mails, or phone calls decreased by 54.5, 57.1, and 17.2 per cent from the pretest to the posttest, respectively. Those who used emails or the internet as the primary communication channel increased by 675 per cent from 5.2 per cent at pretest to 40.3 per cent at posttest. The frequency of internet use also increased. The percentage of rare users considerably decreased from 28.6 per cent at pretest to 6.5 per cent at posttest, while that of moderate users doubled from 16.9 to 33.8 per cent. There was a slight increase in the percentage of frequent users from 31.2 to 36.4 per cent. A Sign test demonstrated statistically significant increases in the frequency of internet use. A one-sided Sign test showed that the median of the differences between paired observations was positive ($p < .00005$). Those with very low income were more likely to show an increase in internet use frequency between pretest and posttest (66.7%) than those with higher income (30.9%) in a Fisher's exact test ($p < .005$) (results not shown).

LSNS-6 Total Score

Table 3 compares the LSNS-6 total score at pretest and posttest and lists the scores of demographic subgroups. LSNS-6 total scores could be calculated for 72 participants who completed all LSNS-6 items at both pretest and posttest. The mean LSNS-6 total score 15.6 at pretest was slightly lower than 16.2 of an older female sample in Southern California (mean age 81) (Crooks et al., 2008) and 16.1 to 17.9 of European samples of similar ages (mean age 74) (Lubben et al., 2006). On average, the LSNS-6 total score increased by 4.1 points from pretest to post-test (Hypothesis 1). The change was statistically significant ($p < .00005$) in both two-sided paired t-test and Welch's t-test. The results from a paired t-test and a Welch's t-test were similar in terms of significance because the two groups (i.e., pretest and posttest) had the same sample size, the difference in variances between two groups was not extreme, and the total sample was not small ($n=144$). The change was also practically significant as indicated by Glass's Delta 0.93 (confidence interval 0.57 to 1.23), which is considered large for an effect size (Maher et al. 2013). The increase is a little larger than that reported in an Israeli intervention (4.1 vs. 3.9 points) with older adults (mean age 85.9) (Isaacson et al., 2019). Sign tests indicated upward changes in the responses to individual items of the LSNS-6 scale: the median of the differences between pre-post paired observations was positive for all 6 items ($pI < .00005$) (results not shown). The LSNS-6 total score significantly increased from the pretest to posttest in all non-missing subgroups regardless of whether a paired t-test or a Welch's t-test was used.

Table 3 Lubben Social Network Scale-6 Total Score at Pretest and Posttest ($n=72$)

	<i>n</i>	Pretest ^a	Posttest ^a	<i>p</i> value
All	72	15.6 (6.3)	19.7 (4.3)	< .00005 ^b
Gender				
Female	46	16.9 (5.9)	20.7 (3.9)	< .001 ^b
Male	25	13.1 (6.5)	17.8 (4.5)	< .00005 ^c
Missing	1	21.0 (0)	22.0 (0)	- ^d
Race				
White	54	16.3 (5.5)	20.0 (3.9)	< .0005 ^b
African American	18	13.5 (8.1)	18.8 (5.3)	< .00005 ^c
Education				
< High school	28	15.6 (6.4)	19.8 (4.3)	< .01 ^b
High school or equivalent	21	16.2 (4.9)	19.9 (3.5)	< .00005 ^c
Some college+	23	15.1 (7.4)	19.4 (5.1)	< .00005 ^c
Annual income				
Income < \$5000	17	13.7 (7.1)	18.6 (4.8)	< .00005 ^c
Income \$5000+	48	15.8 (6.0)	19.7 (4.2)	< .0005 ^b
Missing	7	19.3 (4.7)	22.6 (3.5)	< .005 ^c

^aMean (standard deviation)

^bFrom a Welch's t-test comparing the means of the scores at pre and posttest when variances were unequal

^cFrom a two-sided paired t-test comparing the means of the scores at pre and posttest when variances were equal

^dA *p* value could not be calculated due to a lack of variability for the subgroup

The extent of social networks, measured by the LSNS-6 total score, was similar across all demographic characteristics at each pre- and posttest except for gender (results not shown). The LSNS-6 score was higher among women than men at both pretest ($p < .05$) and posttest ($p < .01$) in a t-test. The extent of social networks was not associated with computer ownership, internet access, or communication modes at either pretest or posttest (results not shown).

Although the extent of social networks did not vary by internet use frequency at pretest, it did at posttest (Table 4). In ANOVA, moderate users had the highest LSNS-6 total score (mean 22.1), followed by frequent users (mean 19.6) and rare users (mean 15.0) at posttest ($p < .001$ from ANOVA) (Hypothesis 2). Pairwise comparisons using Bonferroni and Scheffé tests demonstrated a significant difference in LSNS-6 total score between moderate users and rare users ($p < .005$) with no other pairwise differences (results not shown). In multiple linear regression, both moderate users ($p < .005$) and frequent users ($p < .05$) had higher LSNS-6 total scores than rare users when gender and race were controlled for (results not shown).

Table 4 Lubben Social Network Scale-6 Total Score by Internet Use Frequency ($n = 72$)

	<i>n</i>	Mean (standard deviation)	<i>p</i> value
Internet use frequency at pretest			
Rare user	18	16.4 (6.6)	
Moderate user	13	18.0 (4.7)	
Frequent user	24	15.6 (7.0)	
Missing	17	13.0 (5.6)	
Total	72	15.6 (6.3)	> .05 ^a
Internet use frequency at posttest			
Rare user	5	15.0 (2.8)	
Moderate user	24	22.1 (3.4)	
Frequent user	26	19.6 (4.8)	
Missing	17	18.0 (3.2)	
Total	72	19.7 (4.3)	< .001 ^a

^aFrom analysis of variance comparing mean Lubben Social Network Scale-6 scores of 4 internet use frequency groups

Variation in the Changes of the LSNS-6 Total Score by Subgroup

Although the LSNS-6 total score increased across all subgroups, the change was significantly larger among African Americans than among Whites (Hypothesis 3). Compared to a 3.7-point increase among Whites, African Americans demonstrated a 5.3-point increase on average (Table 3). This larger improvement in social networks among African Americans than Whites remained significant even when gender was controlled for in a negative binomial regression model (incidence rate ratio (IRR) = 1.45, $p < .05$) (Table 5). The result (IRR = 1.45) means that African American participants are likely to improve approximately 1.45 points in the LSNS-6 total score between the pretest and posttest while White counterparts show a 1-point increase in the LSNS-6 total score regardless of gender. There was no significant difference in the change of the LSNS-6 score by each education or income level (results not shown) (Hypothesis 3).

Table 5 Results for the Pre-Post Change in the Lubben Social Network Scale-6 Total Score from Negative Binomial Regression ($n=71$)

Independent variable	Incidence rate ratio	95% CI	<i>p</i> value
Gender (ref: female)			
Male	1.19	0.90, 1.57	> .05
Race (ref: White)			
African-American	1.45	1.07, 1.95	< .05

CI: confidence interval

Discussion

Our data indicate an overall positive impact of the intervention on social networks. The results demonstrate a shift in communication modes, an increase in internet use, and improved social networks among low-income older adults upon participation in an internet use promotion intervention. The primary mode of communication shifted from more traditional means such as face-to-face meetings, postal mails, and phone calls, to digital communications through the internet. The frequency of internet use significantly increased. These findings are consistent with past studies that demonstrated increased internet use for communication among older adults after training participation (Bertera et al., 2007; Damnee et al., 2019; Fields et al., 2020; Ibarra et al., 2020; Woodward et al., 2011). Hypotheses 1 and 3 were supported, and Hypothesis 2 was partially supported. The extent of social networks improved overall (Hypothesis 1), and more so among African Americans than among Whites (Hypothesis 3). Moderate and frequent internet users reported larger social networks than rare users at posttest (Hypothesis 2).

Larger social networks among moderate and frequent users than rare users at posttest seem to partially support the social augmentation thesis: this posits that internet communications expand social networks and strengthen social resources (Boase et al., 2006; Lelkes, 2013; Quan-Haase et al., 2005). The reason why it is considered partial support is that the extent of social networks did not increase linearly with an increase in the frequency of internet use. The LSNS-6 total score of moderate users (once per week or several times per week) was significantly higher than that of rare users (rarely/never or once per month), but not statistically lower than that of frequent users (once per day or more). Two factors may explain this non-linear pattern: the imprecise measure and short-term evaluation. First, the frequency of internet use was measured using an imprecise ordinal measure that cannot gauge a precise distance between categories. Second, there was not sufficient time for the participants to become frequent users and experience the effect of this because the posttest measurement was taken within a month after training completion.

Comparatively more improvement in the extent of social networks among African Americans suggests greater benefits of such interventions for population groups of disadvantaged backgrounds. This finding is in line with a study done with European older adults (Lelkes, 2013) where the most disadvantaged groups appeared to benefit the most from internet use. In the study, internet use among older adults with lower education was associated with a greater decrease in social isolation than among those with higher education.

The larger improvement in the extent of social networks among African Americans than Whites found in our data could be related to the fact that African Americans were more likely to have very low income (< \$5000) compared to Whites (72.2% vs. 11.8%, $p < .001$ in Fisher's exact test) and that participants with very low income (< \$5000) were more likely to show an increase in internet use between pre- and posttest than those with higher income (66.7% vs. 30.0%, $p < .05$ in Fisher's exact test) (results not shown). When an income variable was added to the regression model for the change in LSNS-6 score, the effect of being African American

became not significant. This suggests that having very low income partially explains why African Americans showed greater improvement in social networks than Whites.

Based on these observations, it is possible to conjecture that African American participants had limited social networks at baseline partly due to restrictions in communication (e.g., limited long distance call uses due to cost concerns). Although not statistically significant due to a small sample size, African Americans showed a tendency of having lower LSNS-6 scores than Whites (13.5 vs. 16.3) at pretest. This is similar to the studies that found smaller social networks among African Americans than Whites in the United States. (Ajrouch et al., 2001; Barnes et al., 2004; Cornwell et al., 2008).

With acquisition of computer/internet use skills and access to free broadband internet services, African American participants may have become able to communicate with their relatives and friends more freely due to an added communication channel (i.e., the internet), which in turn improved their social networks to a larger degree than among Whites. In semi-structured interviews with individuals from the same sampling pool as this study (Kim & Gray, 2016), several respondents indicated their reticence to make long distance calls due to their limited income. Long distance phone bills were a significant burden that limited regular communication. The respondents appreciated the opportunity to communicate free-of-charge by using the internet access offered in the intervention (Kim & Gray, 2016).

Limitations

Several study limitations should be noted. As stated previously, the authors conducted a post hoc evaluation without involvement in study design or data collection, and therefore could not influence the study design. Due to the lack of a control group, comparisons could not be made between those who had and had not completed the intervention. Long-term effects could not be evaluated given the posttest was given within one month after the completion of the computer/internet skills training. The generalizability of the results may be limited because our results are based on a small number of programme participants who were living in multi-unit public housing buildings in a specific geographic area. The participants are likely to be healthier, without severe disabilities, and more proactive than non-participants since they volunteered to participate. The living environment itself (i.e., multi-unit public housing buildings) where the participants could practice and apply what they have learned together may have affected the outcomes in a positive way. The study's small sample size limited the number of variables that could be controlled in regression analysis, and sizable missing cases in some variables (i.e., income, internet access status, internet use frequency) prohibited an understanding of the whole picture.

Implications

Our findings point to a few issues to consider in planning intervention programmes to encourage internet use among low-income older adults and to improve social connectedness. Given the positive impact of the multi-component intervention on low-income older adults' social networks, programmes targeting similar population groups should provide access to free computer devices and seamless internet connectivity as well as internet skills training as standard protocol. A related qualitative study (Kim & Gray, 2016) demonstrated the value of computer and internet skills training in helping participants connect through the internet with the relatives and friends who previously could not be reached. The study also indicated the importance of providing free individual devices and internet access in promoting continued internet use, particularly for low-income groups (Kim & Gray, 2016).

Additionally, low-income older adults may need support in order to develop and sustain both online and in-person networks. A study using longitudinal analyses (Shklovski et al., 2004) suggests that in-person contact tends to be more critical than internet communications in maintaining social networks. The study demonstrated that in-person contact led to more internet communications (i.e., more emails), but emails did not induce more phone calls or in-person visits (Shklovski et al., 2004). Subsequently, in addition to supporting low-income older adults to expand and deepen their social networks through online modalities, such individuals should be aided in developing and maintaining in-person connections (e.g., through social services). In this fashion, both modes of social support can bolster each other. For example, while in-person social support can allow for instrumental support (e.g., assistance with transportation), online social support can improve frequency of contact (e.g., contact via email, instant chat, and Skype-type programmes) (Shklovski et al., 2004).

It is important to add that the internet provides much more than social networking. It is a portal to conduct transactions (e.g., shopping, banking), as well as to search for information and entertainment, among other things. The participants in this study, however, tend to be much more conservative in their use of the internet, compared to that of the general population. In a related study, the authors found that such participants encountered many barriers in internet use, for various reasons, such as fear of technology, fear of or misconceptions about cyber security, and low literacy (Kim & Gray, 2016).

In order to follow-up on this study's findings, future research is needed with a larger and more diverse sample, conducted over a longer time period to assess the sustainability of internet use and its impact on social networks and applicability of our findings to other population groups. To examine the retention of regular internet use as well as to what extent participants' social networks are expanded, follow-up data collection beyond a posttest at training completion, such as those at 6 and 12 months, will be needed.

The research also will need to examine how older adults of different income groups and in different living arrangements respond to an internet use promotion intervention with regard to the extent of social networks. Since this study's

intervention was conducted in a multi-unit public housing setting, there was little variation in income and programme participants had opportunities to interact with other participants in the building. Due to the narrow income range, the difference in improvement of social networks by income level could not be properly tested. Their living arrangement (i.e., living in a multi-unit building) also could have acted as a confounder in affecting social networks. In addition to increased digital communication, learning and applying the skills in a group setting itself could have improved social networks (Werner et al., 2011; White et al., 2002).

Declarations

Ethical Statement The study was approved by the institutional review board of Northern Illinois University (No. HS10-0449).

Conflict of Interest The authors declare that there is no conflict of interest.

Informed Consent Informed consent was obtained from study participants after the purposes of the study and the procedures involved in participation were explained.

Ethical Treatment of experimental subject (Animal and Human) All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee (University Institutional Review Board, #HS10-0449) and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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