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Research Article

Improving Social Support for Older Adults Through Technology: Findings From the PRISM Randomized Controlled Trial

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Abstract

Objectives: Information and communication technology holds promise in terms of providing support and reducing isolation among older adults. We evaluated the impact of a specially designed computer system for older adults, the Personal Reminder Information and Social Management (PRISM) system.
Design, Setting, and Participants: The trial was a multisite randomized field trial conducted at 3 sites. PRISM was compared to a Binder condition wherein participants received a notebook that contained paper content similar to that contained in PRISM. The sample included 300 older adults at risk for social isolation who lived independently in the community (M_{age} = 76.15 years). Primary outcome measures included indices of social isolation, social support, loneliness, and well-being. Secondary outcome measures included indices of computer proficiency and attitudes toward technology. Data were collected at baseline and at 6 and 12 months post-randomization.
Results: The PRISM group reported significantly less loneliness and increased perceived social support and well-being at 6 months. There was a trend indicating a decline in social isolation. Group differences were not maintained at 12 months, but those in the PRISM condition still showed improvements from baseline. There was also an increase in computer self-efficacy, proficiency, and comfort with computers for PRISM participants at 6 and 12 months.
Discussion: The findings suggest that access to technology applications such as PRISM may enhance social connectivity and reduce loneliness among older adults and has the potential to change attitudes toward technology and increase technology self-efficacy.

Keywords: Social isolation, Technology

By 2050, people aged 65 and older are projected to represent 21% of the U.S. population, and those aged 85 and older will represent 5% (Ortman, Velkoff, & Hogan, 2014). Population aging, especially the increase in the "oldest old," presents opportunities and challenges for economic, social support, and health care systems.

Because of losses of mobility and health problems, changes in economic status, and loss of partners and friends due to death, social isolation is a problem for many older adults. Social isolation may be especially prevalent among older people who live alone. Currently about 28% of non-institutionalized older adults aged 65 and older live alone and about half of women aged 75 and older live alone (Administration on Aging, 2016).

Maintaining social relationships and remaining socially connected is critically important to health, quality of life, and well-being. According to Rowe and Kahn's model (Rowe & Kahn, 1998) and the Proactivity Model of Successful Aging (E. Kahana & B. Kahana, 1996, 2001), engaging in social activities and using social resources are important to "successful aging" and maintaining quality of life in older age. Pruchno, Wilson-Genderson, Rose, and Cartwright (2010) also found that having adequate social support is a component of successful aging. Social engagement may also be a protective factor against cognitive decline at older ages (Seeman, Lusignolo, Albert, & Berkman, 2001).

In contrast, social isolation is associated with lower quality of life and life satisfaction, poorer mental and physical health outcomes, and cognitive decline (Aylaz, Artürk, Erci, Öztürk, & Aslan, 2012; Ellis & Hickie, 2001; Fratiglioni, Wang, Ericsson, Maytan, & Winblad, 2002). Data from recent longitudinal studies (Steptoe, Shankar, Demakakos, & Wardle, 2013) and meta-analyses (Holt-Lunstad, Smith, & Layton, 2013) indicate that irrespective of demographic characteristics and health problems, social isolation is significantly associated with mortality. Perceived social isolation, often referred to as loneliness, is also linked to impaired cognitive functioning and poorer mental and physical health (J. T. Cacioppo & S. Cacioppo, 2014).

The abundance of evidence linking social isolation and loneliness to adverse impacts on health and quality of life points to the need to develop interventions to prevent or remediate social isolation in older people. Information and communication technologies (ICTs) such as the Internet or E-mail have potential for enhancing the social connectivity of older adults, especially those who have mobility restrictions, live alone, or live in rural locations. Findings from studies that have examined the impact of ICT access on outcomes related to quality of life and well-being in older adult populations are mixed. Some have found that providing older adults with access to technology applications has no impact on well-being (Dickinson & Gregor, 2006; Slegers, van Boxtel, & Jolles, 2008; White et al., 2002), whereas others have shown that access improves quality of life and reduces feelings of loneliness (Choi, Kong, & Jung, 2012; Cotton, Anderson, & McCullough, 2013). These discrepancies may be due to variation in study populations, technologies examined, and outcome measures. Moreover, only a few studies have used randomized designs with concurrent controls, included long-term follow-up, large diverse samples, or used systems that were designed to accommodate older adults.

The objective of this multisite trial was to gather rigorous evidence about the value of a specially designed computer system for older adults, the Personal Reminder Information and Social Management (PRISM) system, which included a software application and a robust support system with training and instructional support. The PRISM system was compared to a Binder condition wherein participants received a notebook with printed content similar to that contained in PRISM. We also gathered longitudinal data on the impact of access to the PRISM system.

PRISM included features that provided easy access to resources and information sources, and opportunities for engagement and communication. The features were preselected in terms of their potential relevance to older adults, especially those at risk for social isolation, and integrated such that it was easy to find and shift between features (e.g., E-mail, games). PRISM also included vetted links to additional sources of information topics thus facilitating information search. Older adults were involved in the development of the software, training, and instructional materials using a user-centered interactive design approach, which is not typical for most ICT systems.

We hypothesized that participants receiving PRISM would demonstrate greater improvements in social support and well-being and reduced feelings of loneliness as compared to those receiving the Binder. The trial was conducted to adhere, as far as possible, to Consort Standards for Randomized Clinical Trials. In this paper, we report the 6- and 12-month primary and secondary outcomes.

Methods

Study Design

The trial was a multisite randomized controlled trial conducted in: Miami, Florida, Tallahassee, Florida, and Atlanta, Georgia. The trial duration was 12 months. Assessments occurred at baseline and 6 and 12 months post-randomization. The Institutional Review Boards at the three sites approved the study protocol.

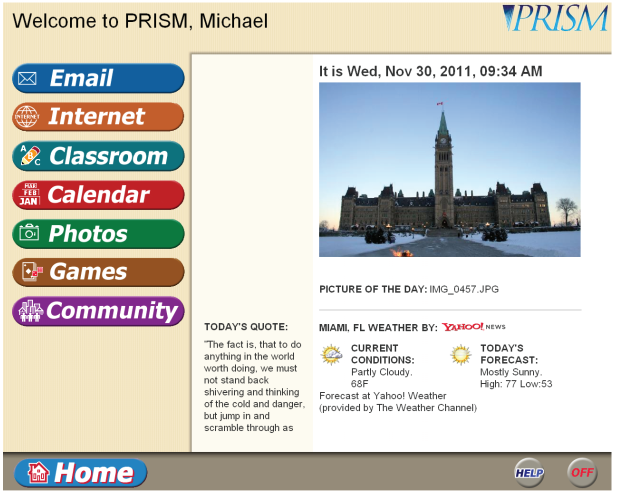

Figure 1. PRISM home page.

Participants

The sample included individuals aged 65 or older living alone in independent housing, who spoke English, had at least 20/60 vision with or without correction, and could read at the 6th grade level. They had minimal computer/Internet use, were not employed or volunteering more than 5 hr/week, or spending more than 10 hr/week at a senior center or formal organization. We chose these criteria to identify older adults at risk for social isolation. Participants were excluded if they were blind or deaf, had a terminal illness, or severe motor impairment. During the telephone screen, participants were asked about hearing, visual, or motor impairments. If they reported that they had a visual or hearing impairment that could not be corrected (e.g., with glasses or a hearing aid) or a motor impairment that would interfere with their ability to use a keyboard, they were deemed ineligible for the study. Individuals were also excluded if they were cognitively impaired (initially flagged as a Mungus corrected score of <26 on the Mini-Mental State Examination [MMSE; M. F. Folstein, S. E. Folstein, & McHugh, 1975]; the MMSE was administered during the initial home visit). A few participants (n =11) scored less than 26 on the MMSE. However, these participants did not report any memory complaints and met all other study criteria. For these participants, we administered the Fuld Object Memory Evaluation (FULD), which is culturally and educationally fair and has proven sensitivity and specificity in distinguishing between cognitively impaired and non-impaired older adults (e.g., Wall, Deshpande, MacNeill, & Lichtenberg, 1998). On the basis of the results of the FULD and a review by a board-certified clinical neuropsychologist, these individuals were permitted into the study; six were randomized to the PRISM condition and five were randomized to the Binder condition. All participants provided written informed consent.

Recruitment strategies included: advertisement in local media, interactions with agencies serving older adults (e.g., meals on wheels), posting flyers (e.g., senior housing), and participant registries.

The PRISM Condition

PRISM participants received a Lenovo “Mini Desktop” PC with a keyboard, mouse (or trackball for those who were unable to control a mouse), a 19″ LCD monitor, the PRISM software application, and a printer. Computers were linked to a secure server at the host site and free Internet access was provided through a wireless card. Participants were unable to add other applications to the system. There were no login requirements to access PRISM (Czaja et al., 2015).

PRISM included: Internet access (with vetted links to sites such as NIHSeniorHealth.Gov), an annotated resource guide, a dynamic classroom feature, a calendar, a photo feature, E-mail, games, and online help (Figure 1). The resource guide include information on: local and national organizations such as the local area agencies on aging, senior centers, the Administration on Aging; services such as transportation, meal and emergency services; cultural and educational offerings; community-based fitness programs; and events such as health fairs. Where possible links were included to facilitate access to the resources. The E-mail feature included a “buddy tab” intended to foster social connectivity. During the initial training session, participants were asked if they would like to be listed as a “PRISM Buddy.” They were informed that it would be a way for them to have contact with new people who had similar interests. The classroom feature was dynamic and updated monthly with a information on a new topic (e.g., hobbies) and included three tabs: general text that we prepared, vetted links, and videos.

PRISM was built using an iterative user-centered design approach. Older adults were actively involved in the process via a survey study, focus groups, and pilot testing (Czaja et al., 2015). Information gleaned from these activities was incorporated into the design of PRISM. The investigators also conducted a heuristic analysis using current usability guidelines (e.g., Fisk, Rogers, Charness, Czaja, & Sharit, 2009).

Binder Condition

Binder participants received a notebook with printed content similar to that within PRISM: a calendar, resource guide, games (e.g., word games), community information, and information/tip sheets on the same topics as the “classroom feature” of PRISM, which were updated monthly via mail. Participants were also provided with a sheet for listing contacts such as family/friends and were given the opportunity to be a “buddy,” which meant sharing their phone number and interests with other participants in this condition. Participants were informed that this would be a venue to have contact with new people with similar interests. They received the same number of planned contacts as those in PRISM.

Protocol and Contact Schedule

Interested participants contacted the site study coordinator and completed a telephone screening that assessed eligibility. For those eligible and interested in participation, a home baseline assessment was scheduled. During this assessment, participants provided informed consent, completed the measurement battery, and were then randomly assigned to study condition. Randomization occurred within each site.

All participants received three additional home visits for training and “check-in” calls 1 week following the third home visit to determine if they had any difficulty using the PRISM system or the notebook and at 3 and 9 months. PRISM participants were also provided with a user manual, a “help” card, and had access to a technical help line.

Participants completed follow-up assessment at 6 and 12 months.

PRISM Participants were compensated $25 per assessment. They were allowed to keep the computer following the intervention period; however, PRISM was no longer available and free Internet service was no longer provided. They were given the opportunity to switch to a commercial Internet service provider and offered help to procure and install the service.

Binder participants were compensated $25 for the baseline and 6-month assessments and $100 for the 12-month assessment, as they did not receive a computer. They were given an opportunity to receive basic computer training following the 12-month assessment.

An assessor blinded to treatment condition, administered the primary outcome measures of the assessment battery at 6 and 12 months via a telephone interview. The same assessor mailed the secondary outcome measures (e.g., computer attitudes) and other instruments that were self-administered (e.g., demographics) and administered the remainder of the follow-up assessment that needed to be completed in the home.

Measures

Primary and Secondary Outcome Measures

The primary outcome measures included changes, at 6 and 12 months, in: social isolation (Friendship Scale—Hawthorne, 2006), loneliness (Loneliness Scale—Russell, 1996), perceived social support (Interpersonal Support Evaluation List—Cohen, Mermelstein, Kamarack, & Hoberman, 1985), Social Network Size (Lubben Social Network Index—Lubben, 1988), perceptions of quality of life (Quality of Life Scale—Logsdon, Gibbons, McCurry, & Teri, 2002), and perceived vulnerability (Perceived Vulnerability Scale—Myall, Hine, Marks, & Thorsteinsson, 2009). Changes in health-related quality of life and well-being (The MOS 36-item Short-Form Health Survey [SF-36—Ware & Sherbourne, 1992]) were also examined (Table 1).

Secondary outcome measures included changes in attitudes toward technology (Jay & Willis, 1992) and computer proficiency (Boot et al., 2015). We also developed a 12-item measure that assessed perceptions of the usefulness and usability of PRISM (Technology Acceptance Questionnaire, Center for Research and Education on Aging and Technology Experience, for this trial, adapted from Davis, 1989). Responses were given on a 7-point Likert type scale ranging from strongly disagree to strongly agree.

Additional Measures

Participants completed a demographic background questionnaire, a Life Space Questionnaire (Stalvey, Owsley, Sloane, & Ball, 1999), the Test of Functional Health Literacy in Adults (STOFHLA—Baker, Williams, Parker, Gazmararian, & Nurss, 1999), the WRAT (Wilkinson, 1993) as a measure of general reading ability, and measures of cognitive abilities such as working memory and processing speed (Czaja et al., 2015).

All participants completed a System Evaluation questionnaire at 12 months, which assessed their opinions about the system they used. Responses were given on a 7-point Likert type scale ranging from strongly disagree to strongly agree.

Real-time data of PRISM usage included the number of days a participant accessed the system and accessed a feature. Time spent using the system and each feature was recorded but not included in the analyses as a feature may have been accessed but the participant could have performed other activities while leaving the feature active. Thus, time could reflect an inflated indicator of use.

Treatment Fidelity

All sites used a detailed manual of operations (MOP) and applied equivalent procedures and standardized protocols. Assessors and interventionists were trained using standardized protocols and there were cross-site monthly conference calls. Training included webinar training on the administration of the assessment battery, the protocols for both study conditions, conducting research with older adults, and familiarization with the MOP. Data were maintained at a secure server at the Miami site.

Sample

Five hundred and thirty-four individuals received the telephone screening. Of these, 192 people were excluded due to ineligibility ($N = 117$), lack of interest in participating ($N = 62$), or because they could not be reached to schedule a baseline assessment ($N = 13$). Of the 342 people who received the baseline assessment, 42 were excluded due to failure to meet the cognitive criteria (31%), significant computer/Internet experience (30%), intensity of work/volunteer activities (8%), or living arrangements (8%) (Figure 2). Three hundred participants were enrolled in the trial, 150 in each condition. The sample was primarily female (78%), ranged in age from 65 to 98 years ($M = 76.15$, $SD = 7.4$); 33% of the sample was 80 years and older and 15% was 85 and older. Participants were ethnically diverse (46% non-White) and most were of lower socioeconomic status (89% had annual household incomes <$30,000) and 39% had had a high school or less (Czaja et al., 2015).

Analyses

Primary and secondary outcomes were tested based on an intention-to-treat approach using a two-tailed level of significance set at alpha = .05. We employed a series of linear mixed-effects models in STATA (v. 11; xtmixed) to estimate the between-subject (PRISM vs. Binder)

Table 1. Sample Baseline Characteristics

Variable	PRISM (n = 150)	Binder (n = 150)	F-value or χ^2	Cronbach's α, direction
Age[a], mean (SD), years	76.9 (7.3)	75.3 (7.4)	3.69	—
Female, no. (%)	119 (79.3)	115 (76.7)	0.18	—
Hispanic, no. (%)	12 (8.0%)	15 (10.0%)	0.16	—
Education			5.60	—
≤High school, no. (%)	65 (43.3)	52 (34.7)	—	—
Some college, no. (%)	53 (35.3)	63 (42.0)	—	—
College, no. (%)	15 (10.0)	24 (16.0)	—	—
Postgraduate, no. (%)	17 (11.3)	11 (7.3)	—	—
Income			1.41	—
<$30,000, no. (%)	127 (84.7)	133 (88.6)	—	—
$30,000–$59,999, no. (%)	20 (13.1)	16 (10.6)	—	—
$60,000+, no. (%)	3 (2.2)	1 (0.8)	—	—
Social support[b], mean (SD)	25.3 (6.9)	24.9 (6.9)	0.30	.85 higher score means more social support
Friendship (social isolation)[c], mean (SD)	19.7 (3.7)	18.7 (4.1)	4.59*	.74, higher score means better social connectedness
Quality of life[d], mean (SD)	39.0 (5.6)	37.7 (6.0)	4.13*	.85, higher score means better quality of life
Loneliness[e], mean (SD)	39.8 (9.7)	40.2 (10.3)	1.51	.91, higher score means greater degree of loneliness
CES-D[f], mean (SD)	9.7 (8.3)	12.5 (9.5)	7.50**	.87, higher score means more depressive symptoms
Life engagement[g], mean (SD)	25.3 (4.1)	24.3 (4.1)	4.57*	.77, higher score means more engagement
Perceived vulnerability[h], mean (SD)	3.1 (1.1)	3.3 (2.0)	1.17	.95, higher score means more vulnerable
SF-36 Health[i], mean (SD)	68.1 (18.6)	66.1 (20.2)	0.82	.75, higher score means better general health
SF-36 Pain[j], mean (SD)	65.8 (25.1)	66.0 (24.9)	0.01	.84, higher score means less pain or limitation
SF-36 Well-being[k], mean (SD)	80.4 (18.2)	78.2 (16.1)	1.23	.784, higher score means more peaceful, happy and calm
SF-36 Social functioning[l], mean (SD)	79.7 (25.6)	78.7 (24.4)	0.12	.835, higher score means social functioning without interference
Computer attitude comfort[m], mean (SD)	16.7 (4.2)	16.6 (4.2)	0.04	.814, higher score means more computer comfort
Computer attitude interest[m], mean (SD)	20.5 (3.4)	20.6 (3.2)	0.13	.770, higher score means more computer interest
Computer attitude efficacy[o], mean (SD)	20.3 (2.9)	20.2 (3.2)	0.06	.799, higher score means more computer efficacy
Computer proficiency[p], mean (SD)	9.9 (4.1)	10.3 (4.7)	0.75	.980, higher score means more computer proficiency

Note: CES-D = Center for Epidemiologic Studies-Depression; PRISM = Personal Reminder Information and Social Management.
[a]The range for age is 65–95 years. [b]The range for possible score is 6–36. [c]The range for possible scores is 0–24. [d]The range for possible score is 13–52. [e]The range for possible score is 20–80. [f]The range for possible scores is 0–60. [g]The range for possible score is 6–30. [h]The range for possible scores is 1–6. [i]The range for possible score is 0–500. [j]The range for possible scores is 0–200. [k]The range for possible score is 0–500. [l]The range for possible scores is 0–200. [m]The range for possible score is 5–25. [n]The range for possible scores is 5–25. [o]The range for possible score is 5–25. [p]The range for possible score is 6–30.
*$p \leq .05$. **$p \leq .01$.

and the within-subject effects (Baseline vs. 6 months vs. 12 months). This approach is more tolerant of missing data and not subject to stringent assumptions of sphericity that cannot be addressed by traditional corrections associated with repeated measures analysis of variance. The models included main effects of treatment condition and time of assessment and their interactions. Control variables were baseline age (in years), baseline MMSE score, and Center for Epidemiologic Studies-Depression (CES-D) (Radloff, 1977). We included a variable to control for site baseline differences in primary outcomes (e.g., social isolation). Baseline differences in reported social isolation, lower quality of life, and life engagement disappeared when CES-D depression score was included as a covariate. We included baseline MMSE as a control variable for baseline differences as the range of MMSE was large (23–30). The sample size for the Tallahassee site was too small (n =44) to support clustering approaches.

Effect sizes for the outcome measures were calculated using Cohen's (Cohen, 1992) formula for calculating d

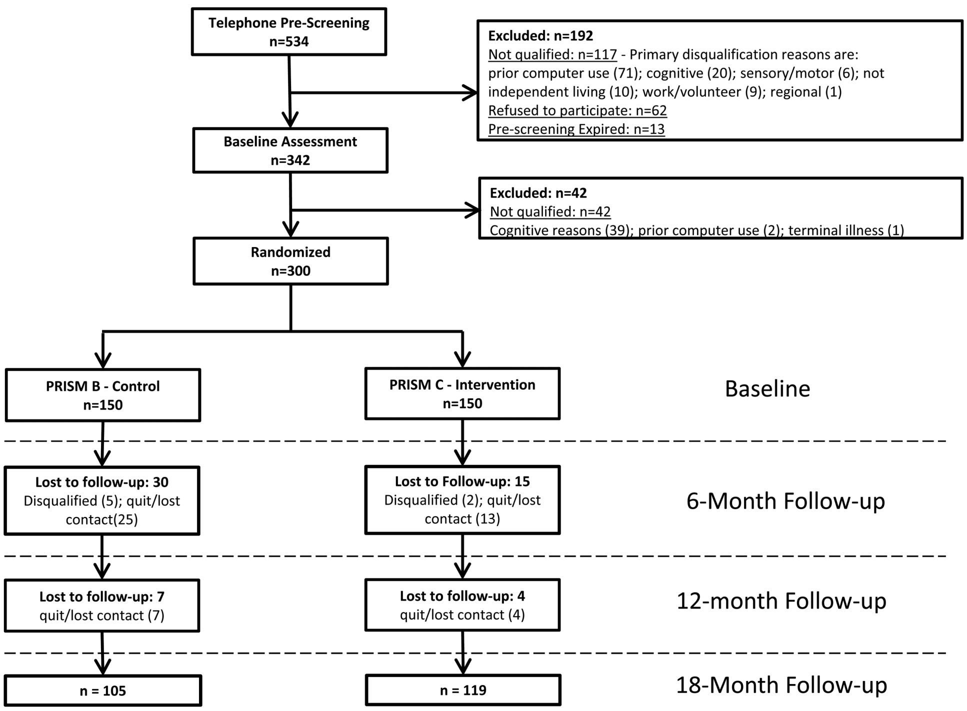

Figure 2. Consort diagram for the trial.

(i.e., Estimated Mean of Group 1 – Estimated Mean of Group 2)/Outcome *SD*). Prior to the study, we determined that a sample size of 150 participants per group with an attrition rate of 20% (thus 120/cell) would result in power exceeding 85% with an effect size for the interaction term of .15. Based on this *N*, all effect sizes exceeded this minimal threshold. Missing data were handled using restricted maximum likelihood.

Results

Despite randomization, at baseline, participants in the Binder condition tended to report more symptoms of depression [$F(1,298) = 7.50$; $p < .008$], increased social isolation [$F(1,297) = 4.59$; $p < .04$], a lower quality of life [$F(1,298) = 4.12$; $p < .05$], and less life engagement [$F(1,297) = 4.57$; $p < .04$] (Table 1). On average, most participants did not meet the cutoff on the CES-D for symptoms of depression. With respect to loneliness, on average, a score of 21 on the or higher on the Loneliness Scale indicates some or high levels of loneliness; thus, on average, our participants experienced some degree of loneliness (Russell, 1996). With respect to social isolation, a score of 18 or below on Friendship Scale indicates moderate to high levels of social isolation and on average our participants expressed feelings of isolation. For social support, a higher score on the ISEL indicates more perceived support. Although, there are no established cutoffs for this scale, on average our participants perceived that they had fairly low levels of support. There are also no established cutoffs for our measure of Quality of Life but a higher score indicates higher ratings of quality of life (range = 13–52), thus on average our participants perceived that they had moderate quality of life ($M = 39.0$, $SD = 5.6$).

Completers versus Dropouts

Attrition at the 12-months was 19%. Forty-five participants were lost to follow-up at 6 months; of these, 38 quit or could not be contacted and 7 were disqualified because they left the geographic area ($n = 5$); or there was a study protocol violation ($n = 2$). An additional 11 participants quit or were lost to follow-up at the 12-month follow-up (Figure 1). Noncompleters reported lower baseline health on the SF-36. There were no other differences between completers and drop outs on our primary or secondary outcome measures or demographic characteristics.

Primary Outcomes

We first examined the main effects of time for the primary outcome measures. Across the study groups, at 6 months, there were decreases in perceived vulnerability ($b = -0.48$; $p < .001$; effect size = 0.45; 95% CI = −0.64 to −0.32); social isolation ($b = 0.79$; $p < .01$; effect size = 0.20; 95% CI = 0.24–1.35); loneliness ($b = -1.68$; $p < .01$; effect size = 0.17; 95% CI = −2.73 to −0.63); and quality of life ($b = -1.08$; $p < .01$; effect size = 0.19; 95% CI = −1.78 to −0.38). At 12 months, there were also decreases in perceived vulnerability ($b = -0.41$; $p < .001$; effect size = 0.38; 95% CI = −0.57 to −0.24); social isolation ($b = 0.84$; $p < .01$; effect size = 0.21; 95% CI = 0.27–1.41); and loneliness ($b = -2.50$; $p < .001$; effect size = 0.25; 95% CI = −3.59 to

−1.41). There were also decreases in the SF-36 ratings of physical functioning (b = −3.91; p < .05; effect size = 0.14; 95% CI = −6.99 to −0.83), and limitations in emotional functioning (b = −6.89; p < .05; effect size = 0.19; 95% CI = −13.68 to −0.11) and increases in social support (b = 1.33; p < .01; effect size = 0.19; 95% CI = 0.42–2.24) at 12 months but not 6 months.

To examine the differential effect of treatment over time, the interaction terms for the Group × Time effects at 6 and 12 months were examined employing the covariates listed above. At 6 months, in comparison to Binder participants, PRISM participants had a significantly greater decline in loneliness (b = 1.72; p < .04; effect size = 0.17; 95% CI = 0.16–3.28) and greater increase in perceived social support (b = −1.96; p < .004; effect size = 0.28; 95% CI = −3.26 to −0.66). There was also a trend indicating that they experienced a greater decline in social isolation (b = −0.66; p < .11; effect size = 0.17; 95% CI = −1.47 to 0.16) at 6 months.

Group differences were not maintained at 12 months; however, those in the PRISM condition maintained gains beyond baseline values on loneliness and social support outcomes (Figure 3). Those in the Binder condition also showed a decrease in loneliness and increase in perceived social support at 12 months. Those assigned to the PRISM condition also reported a greater increase in ratings on the SF-36 in Energy (b = −4.65; p < .05, effect size = 0.22; 95% CI = −9.22 to −0.08) and Well-Being (b = −4.86; p < .02, effect size = 0.27; 95% CI = −8.95 to −0.77).

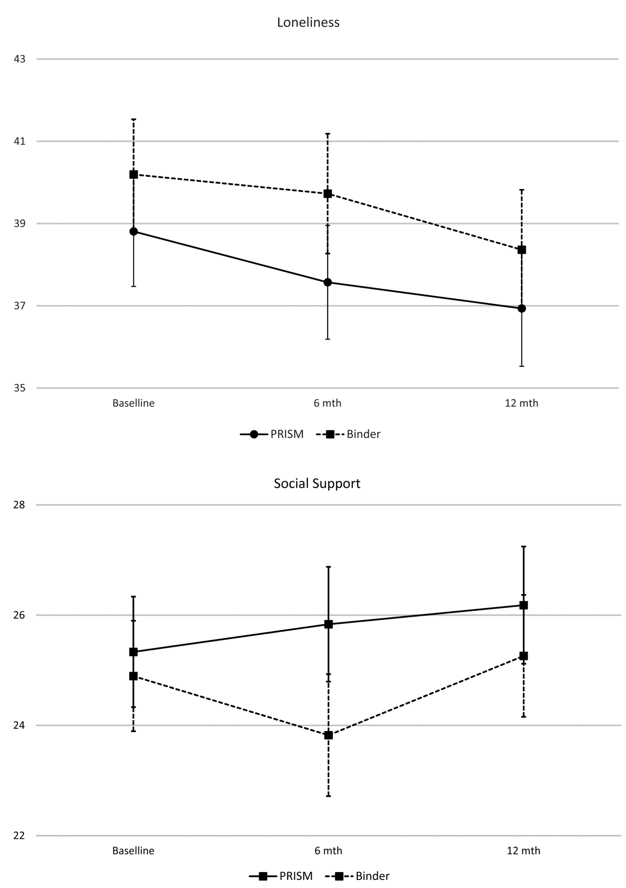

Figure 3. Changes in loneliness scale and social support by condition and predictive margins with 95% CI.

Secondary Outcomes Variables

Relative to those in the Binder condition, PRISM participants reported greater increases in computer comfort at 6 months (b = −1.68; p < .001; effect size = 0.39; 95% CI = −2.57 to −0.78) and 12 months (b = −2.32; p < .001; effect size = 0.53; 95% CI = −3.22 to −1.41); greater increases in computer interest at 6 months (b = −1.52; p < .001; effect size = 0.46; 95% CI = −2.26 to −0.79) and 12 months (b = −0.99, p < .01, effect size = 0.30; 95% CI = −1.74 to −0.25); and had greater increases in computer efficacy at 6 months (b = −1.29; p < .001; effect size = 0.41; 95% CI = −2.01 to −0.57) and 12 months (b = −0.94; p < .02; effect size = 0.30; 95% CI = −1.67 to −0.22). Those assigned to PRISM also demonstrated a greater increase in computer proficiency at 6 months (b = −6.37, p < .001; effect size = 1.11; 95% CI = −7.39 to −5.35) and 12 months (b = −7.06, p < .001; effect size = 1.23; 95% CI = −8.08 to −6.03).

Technology Acceptance Questionnaire and System Evaluation

Most PRISM participants found PRISM useful in their daily life (82%), indicated that PRISM made their life easier (80%), improved their daily life (84%), and enabled them to accomplish tasks more quickly (73%). They also found PRISM easy to use (88%) and easy to become skilled at using PRISM (80%). In fact, 60% indicated that they felt comfortable using PRISM within 1 week. Most found the E-mail feature valuable (85%), using the Internet valuable (82%), the Classroom feature valuable (80%), and the Games as valuable (77%). Only 57% found the Photo feature valuable and 51% found the Calendar valuable. Of those who received the Binder, 89% found the information and tips valuable and 87% found the community resource information valuable and about half (58%) found the Calendar valuable. In contrast to those who received PRISM, only 61% thought the games were valuable.

PRISM participants found it easier to communicate with family and friends relative to those who received the Binder (82% vs. 47%) and engage in hobbies and play games (82% vs. 52%). Participants in both conditions reported that it was easier to look up community information (78% vs. 73%) and health information (82% vs. 80%). Almost all of the PRISM participants (93%) found PRISM enjoyable to use and 88% of those receiving the Binder found it enjoyable to use. However, those in the Binder condition were more satisfied with the in-home training they received (90% vs. 82%).

System Usage

We examined overall use of PRISM and each feature in terms of number of days accessing PRISM or a feature over time. On average, participants used PRISM about 4 days a week (M = 3.85, SD = 2.07). The most used features were E-mail (M = 3.0, SD = 2.14), the Internet (M = 2.55, SD = 1.87), and Games (M = 2.55, 1.86). They used the other features—Classroom, Community, Photos, and the Calendar—less than once a day (Figure 4). Importantly, the help feature was used very infrequently. We examined correlations between days using PRISM and changes in our outcomes measures and did not find any significant associations. However, as noted we used a relatively gross measure of use that simply calculated overall use of PRISM and use of each feature and did not include assessment of subfeatures (e.g., use of the "buddy list" in E-mail).

Discussion

Social isolation and loneliness are problems confronting many older adults, which is consequential for their mental and physical well-being. This trial examined the value of a simple-to-use computer system, which provided access to a broad array of features, on outcomes related to isolation, perceived loneliness, and social support among a sample of older adults. Although other studies have examined the impact of ICT access on outcomes related to quality of life and well-being in older adults, and some have shown that going online can be beneficial in terms of social connectivity (e.g., Cotten, Anderson, & McCullough, 2013), our study is unique in several respects.

Our study represents the first large-scale randomized trial to examine the benefits of access to an ICT system with a large ethnically diverse older adult population from three cities in the United States who were at risk for social isolation, of lower socioeconomic status, and many of whom had relatively low education. Also, a large portion of our sample was 80 years and older and had minimal or no prior computer experience. These cohorts of older people are the least likely to adopt technology and use the Internet and remain on the other side of the digital divide. Although access to ICTs is increasing, recent data from the Pew Internet and American Life Report (Rainie, 2016; Smith, 2014) indicates that only 45% adults in the United States who have household incomes less than $30K (the majority of our sample) and only 47% of those aged 65 and older and 34% of those aged 75 and older have home broadband access. Similar trends exist for other newer forms of technology such as mobile devices. Thus, the findings from this study have implications with respect to fostering technology adoption in these populations. Not having access to current and emerging technologies puts the "have nots" at a great disadvantage given the increased reliance on these technologies for access to services, health applications, and the performance of everyday activities.

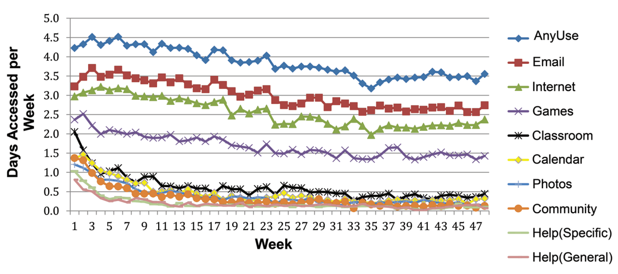

Figure 4. Average number of days per week participants used PRISM and PRISM features for participants who completed the trial. Note that we include only up to week 48; near the end of the trial some participants transitioned from PRISM to a Windows platform.

PRISM, unlike systems examined in previous studies, provided participants with access to a broad array of features beyond the Internet such as E-mail, games, and a dynamic classroom feature, which provided additional opportunities for social interaction and engagement. The content of PRISM features was chosen in terms of potential relevance to older adults, the features were easy to access (only requiring one "click" on the feature name on the homepage sidebar menu), and it was easy to shift among features. The system was also dynamic in the sense that participants had easy access to other information (e.g., through vetted links and videos) and the classroom was updated monthly. The system also provided opportunities to make new acquaintances with individuals who had similar interests. We also gathered feature usage data over a 12-month period. This data coupled with the subjective evaluation data can be used to guide the developments of future systems.

Overall, our results suggest that ICTs hold potential value with respect to reducing problems with social isolation, fostering connectivity and decreasing feelings of loneliness among older adults who live alone and have limited engagement in work and social activities. Our findings showed that at 6 months, participants who received PRISM reported greater perceived social support, decreased feelings of loneliness, and increased well-being.

Our data support the value of PRISM with respect to communication and engagement. The most used features of the system were E-mail, the Internet, and Games. PRISM participants also indicated that use of the system made it easier to communicate with family and friends; engage in hobbies and games; and find information. They also indicated the E-mail, Internet, and Game features were highly valuable. These findings indicate that features that facilitate communication and engagement should be incorporated in ICT technologies. Further, where possible these systems should provide opportunities for older adults to expand their social network.

Although improvements from baseline in loneliness, well-being, and social support were still evident for those receiving PRISM at 12 months, group differences were not maintained at 12 months. In fact those in the Binder condition showed some improvements on these measures but not to the same level as those receiving PRISM (Figure 3). It may be that over time the novelty of having access to E-mail and the Internet lessens and the immediate perceived benefits of access do not increase over time, especially because the features of PRISM were static and our participants did not have an opportunity to learn new applications. This suggests that for the benefits of systems like PRISM to be enhanced, these systems should provide users with opportunities engage in new learning and advance their skills. Findings from a recent study (Chan, Haber, Drew, & Park, 2016) indicated that training a sample of older adults to use an iPad resulted in improvements in aspects of cognition (processing speed and episodic memory). The training required sustained mental effort and productive engagement in new learning. The study participants not only acquired skills to improve their daily lives but also experienced cognitive benefits from the cognitive engagement stimulated by the training. Thus, in addition to providing opportunities for social interaction, ICT systems should also include dynamic features to promote continued opportunities for cognitive engagement.

The Binder condition provided a strong test of the benefits of PRISM as it provided participants with a large amount of valuable information. Participants who received the Binder appreciated the utility of the materials in the notebook, indicated that they enjoyed using it, found the information valuable, and that use of the notebook helped them find community and health care information. These findings suggest that for our participants simply having access to information in an easy to use form is helpful. Clearly though, PRISM offered several advantages over the notebook as it was a dynamic system that provided easy access to a broad array of features and information and a convenient way to communicate.

It may also be that simply being part of a study and having contact with our study personnel decreased loneliness and increased feelings of social support among participants receiving the Binder. All participants had the same amount of planned contract, which included four initial home sessions, telephone check-ins, and home and telephone follow-up assessments. Studies have shown that simply having telephone contact decreases feelings of loneliness among older adults (e.g., Fees, Martin, & Poon, 1999).

Participants who received PRISM also reported that it improved their daily life, made their life easier, allowed them to accomplish tasks more efficiently and enhanced their effectiveness in their day-to- day life. They also had a general increase in positive attitudes toward computers and demonstrated substantial gains in computer proficiency. These findings are important given the ubiquitous nature of technology in our society as comfort with computers and computer self-efficacy are important to general technology adoption (e.g., Czaja et al., 2006).

All of the PRISM participants were able to learn to use the system. The majority of users indicated that PRISM was easy to use, that it was easy to become skilled at using PRISM, and that they felt comfortable using PRISM within a short amount of time. These results are particularly striking given that many of our participants were aged 80 years and older and had no or very limited prior computer experience. These findings support the cognitive aging literature (e.g., Charness, Kelley, Bosman, & Mottram, 2001) which indicates that older adults are capable of learning new skills and dispel existing myths that older adults are technophobic. Our data also show that if users are provided with training and an easy to use system, they will be willing and able to use it. Difficulty learning to use new technologies is a common barrier to technology adoption and most older adults indicate that they need assistance learning new technologies (Smith, 2014).

Our findings also point to the value of a user-centered design approach. The design process for PRISM involved older adults, which is unique as it is not typical to involve older people in the design of ICTs. Even though future cohorts of older adults will have had greater exposure to technology, training and system design will continue to be important issues as technology is constantly evolving and thus future generations will confront the need to learn and interact with new systems. Recent data indicate (Pew Internet and American Life project, Rainie, 2016) that older adults perceive that they need assistance when using new devices and do not feel comfortable learning to use a new device on their own.

Limitations of the study should be noted. Although we pilot tested the training program and trained our participants gradually over 3 days, they might have benefited from additional booster training; 16% of those who received PRISM indicated they would have liked more training. Also, our sample was limited to those with no or very little computer experience. It would be important to evaluate PRISM with more experienced computer users to determine whether the benefits associated with PRISM are evident for this user group. It may also have been beneficial to have expanded the features of PRISM and include applications such as word processing or two-player games as well as to make the system more dynamic and include opportunities for continued new learning. It would also be interesting to examine if new forms of communication such as videoconferencing result in added benefits. Also, PRISM was only available in English, which restricted enrollment of older Hispanic adults.

Careful consideration also needs to be given to choice of outcome measures for these types of trials. For example, there was no impact on our measure of depression, but few participants in our trial manifested symptoms of depression. More thought also needs to be given to how to best capture system usage. As discussed, time on a system is problematic as time on a feature does not necessarily imply active use of a feature and as such would inflate system usage data. Developing a sampling plan for the measurement of usage also needs careful consideration as capturing continuous usage data may create challenges with respect to data reduction and analysis.

In summary, access to technology and the Internet may provide opportunities to reduce risks of social isolation and loneliness among older adults especially those who live in rural locations or have mobility restrictions. However, this is not to suggest that technology can replace human contact but rather that it can augment opportunities to remain connected. A cautionary note is that having access to technology is not sufficient. Systems must be useful and useable and training and technical support must be available. As we move to a more technologically oriented future, not having meaningful access to technology applications will likely contribute to enhanced disparities. This project illustrates how to successfully reduce such disparities through user-centered design and instructional support.

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References

Administration on Aging. (2012). *A profile of older Americans 2012*. Retrieved February 15, 2016, from http://www.aoa.acl.gov/Aging_Statistics/Profile/2012/docs/2012profile.pdf

Aylaz, R., Aktürk, Ü., Erci, B., Öztürk, H., & Aslan, H. (2012). Relationship between depression and loneliness in elderly and examination of influential factors. *Archives of Gerontology and Geriatrics*, **55**, 548–554. doi:10.1016/j.archger.2012.03.006

Baker, D. W., Williams, M. V., Parker, R. M., Gazmararian, J. A., & Nurss, J. (1999). Development of a brief test to measure functional health literacy. *Patient Education and Counseling*, **38**, 33–42.

Boot, W. R., Charness, N., Czaja, S. J., Sharit, J., Rogers, W. A., Fisk, A. D., … Nair, S. (2015). Computer proficiency questionnaire: Assessing low and high computer proficient seniors. *The Gerontologist*, **55**, 404–411. doi:10.1093/geront/gnt117

Cacioppo, J. T., & Cacioppo, S. (2014). Social relationships and health: The toxic effects of perceived social isolation. *Social and Personality Psychology Compass*, **8**, 58–72. doi:10.1111/spc3.12087

Chan, M. Y., Haber, S., Drew, L. M., & Park, D. C. (2016). Training older adults to use tablet computers: Does it enhance cognitive function? *The Gerontologist*, **56**, 475–484. doi:10.1093/geront/gnu057

Charness, N., Kelley, C. L., Bosman, E. A., & Mottram, M. (2001). Word-processing training and retraining: Effects of adult age, experience, and interface. *Psychology and Aging*, **16**, 110–127.

Choi, M., Kong, S., & Jung, D. (2012). Computer and internet interventions for loneliness and depression in older adults: A meta-analysis. *Healthcare Informatics Research*, **18**, 191–198. doi:10.4258/hir.2012.18.3.191

Cohen, J. (1992). A power primer. *Psychological Bulletin*, **112**, 155–159.

Cohen, S., Mermelstein, R., Kamarack, T., & Hoberman, H. (1985). Measuring the functional components of social support. In I. G. Sarason & B. R. Sarason (Eds.), *Social support: Theory, research, and application* (pp. 73–94). Hague, The Netherlands: Martinus Nijhoff.

Cotten, S. R., Anderson, W. A., & McCullough, B. M. (2013). Impact of internet use on loneliness and contact with others among older adults: Cross-sectional analysis. *Journal of Medical Internet Research*, **15**, e39. doi:10.2196/jmir.2306

Czaja, S. J., Boot, W. R., Charness, N., Rogers, W., Sharit, J., Fisk, A. D., … Nair, S. N. (2015). The personalized reminder information and social management system (PRISM) trial: Rationale, methods and baseline characteristics. *Contemporary Clinical Trials*, **40**, 35–46. doi:10.1016/j.cct.2014.11.004

Czaja, S. J., Charness, N., Fisk, A. D., Hertzog, C., Nair, S. N., Rogers, W. A., & Sharit, J. (2006). Factors predicting the use of technology: Findings from the Center for Research and Education on Aging and Technology Enhancement (CREATE). *Psychology and Aging*, **21**, 333–352. doi:10.1037/0882-7974.21.2.333

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, **13**, 319–340.

Dickinson, A., & Gregor, P. (2006). Computer use has no demonstrated impact on the well-being of older adults. *International Journal of Human Computer Studies*, **64**, 744–753.

Ellis, P., & Hickie, I. (2001). What causes mental illness? In S. Bloch & B. Singh B (Eds.), *Foundations of clinical psychiatry* (pp. 43–62). Melbourne, Australia: Melbourne University Press.

Fees, B. S., Martin, P., & Poon, L. W. (1999). A model of loneliness in older adults. *The Journals of Gerontology, Series B: Psychological Sciences and Social Sciences*, **54**, P231–P239.

Fisk, A. D., Rogers, W. A., Charness, N., Czaja, S. J., & Sharit, J. (2009). *Designing for older adults: Principles and creative human factors approach* (2nd ed.). Boca Raton, FL: CRC Press.

Folstein, M. F., Folstein, S. E., & McHugh, P. R. (1975). "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research*, **12**, 189–198.

Fratiglioni, L., Wang, H. X., Ericsson, K., Maytan, M., & Winblad, B. (2002). Influence of social network on occurrence of dementia: A community-based longitudinal study. *Lancet*, **355**, 1315–1319. doi:10.1016/S0140-6736(00)02113-9

Hawthorne, G. (2006). Measuring social isolation in older adults: Development and initial validation of the friendship scale. *Social Indicators Research*, **77**, 521–548.

Holt-Lunstad, J., Smith, T. B., & Layton, J. B. (2013). Social relationships and mortality risk: A meta-analytic review. *PLoS Medicine*, **7**, e1000316. doi:10.1371/journal.pmed.1000316.

Jay, G. M., & Willis, S. L. (1992). Influence of direct computer experience on older adults' attitudes toward computers. *Journal of Gerontology: Psychological Sciences*, **47**, P250–P257.

Kahana, E., & Kahana, B. (1996). Conceptual and empirical advances in understanding aging well through proactive adaptation. In V. Bengtson (Ed.), *Adulthood and aging: Research on continuities and discontinuities* (pp. 18–40). New York: Springer.

Kahana, E., & Kahana, B. (2001). Successful aging among people with HIV/AIDS. *Journal of Clinical Epidemiology*, **54**, S53–S56.

Logsdon, R. G., Gibbons, L. E., McCurry, S. M., & Teri, L. (2002). Assessing quality of life in older adults with cognitive impairment. *Psychosomatic Medicine*, **64**, 510–519.

Lubben, J. E. (1988). Assessing social networks among elderly populations. *Family Community Health*, **11**, 42–52.

Myall, B. R., Hine, D. W., Marks, A. D. G., & Thorsteinsson, E. B. (2009). Assessing individual differences in perceived vulnerability of in older adults. *Personality and Individual Differences*, **46**, 8–13.

Ortman, J. M., Velkoff, V. A., & Hogan, H. (2014). *An aging nation: The older population in the United States*. U.S. Census Bureau. Retrieved February 20, 2016, from https://www.census.gov/prod/2014pubs/p25-1140.pdf

Pruchno, R. A., Wilson-Genderson, M., Rose, M., & Cartwright, F. (2010). Successful aging: Early influences and contemporary characteristics. *The Gerontologist*, **50**, 821–833. doi:10.1093/geront/gnq041

Radloff, L. (1977). The CES-D scale: A self-report depression scale for research in the general population. *Applied Psychological Measures*, **1**, 385–401.

Rainie, L. (2016). *Digital divides 2016*. Retrieved from http://www.pewinternet.org/2016/07/14/digital-divides-2016/

Rowe, J. W., & Kahn, R. L. (1998). *Successful aging*. New York: Pantheon Random House.

Russell, D. W. (1996). UCLA Loneliness Scale (Version 3): Reliability, validity, and factor structure. *Journal of Personality Assessment*, **66**, 20–40. doi:10.1207/s15327752jpa6601_2

Seeman, T. E., Lusignolo, T. M., Albert, M., & Berkman, L. (2001). Social relationships, social support, and patterns of cognitive aging in healthy, high-functioning older adults: MacArthur studies of successful aging. *Health Psychology*, **20**, 243–255.

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

Smith, A. (2014). *Older adults and technology use: Adoption is increasing, but many seniors remain isolated from digital life*. Retrieved from http://www.pewinternet.org/files/2014/04/PIP_Seniors-and-Tech-Use_040314.pdf

Stalvey, B. T., Owsley, C., Sloane, M. E., & Ball, K. (1999). The life space questionnaire: A measure of the extent of the mobility of older adults. *Journal of Applied Gerontology*, **18**, 460–478.

Steptoe, A., Shankar, A., Demakakos, P., & Wardle, J. (2013). Social isolation, loneliness, and all-caused mortality in older men and women. *Proceedings of the National Academy of Sciences of the USA*, **110**, 5797–5801.

Wall, J. R., Deshpande, S. A., MacNeill, S. E., & Lichtenberg, P. A. (1998). The Fuld Object Memory Evaluation, a useful tool in the assessment of urban geriatric patients. *Clinical Gerontologist*, **19**, 39–79. doi:10.1300/J018v19n01_04

Ware, J. E., Jr., & Sherbourne, C. D. (1992). The MOS 36-item Short-Form Health Survey (SF-36). I. Conceptual framework and item selection. *Medical Care*, **30**, 473–483.

White, H., McConnell, E., Clipp, E., Branch, L. G., Sloane, R., Pieper, C., & Box, T. L. (2002). A randomized controlled trial of the psychosocial impact of providing internet training and access to older adults. *Aging & Mental Health*, **6**, 213–221. doi:10.1080/13607860220142422

Wilkinson, G. (1993). *Wide Range Achievement Test—third revision*. Wilmington, DE: Jastak Associates.