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Discontinued ICT Usage Among Older Adults in Continuing Care Retirement Communities in the United States

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Abstract

Background—Older adults are increasingly using information and communication technologies (ICTs). Recent studies show beneficial effects of using ICTs for older adults, particularly in terms of reducing loneliness and depression. However, little is known about the factors that may prevent discontinued ICT use in populations that may be at greater risk, such as those in continuing care retirement communities (CCRCs).

Objectives—The purpose of this study is to examine a range of factors that may influence discontinued: 1) ICT use, 2) searching for health information, and 3) searching for general information over time among CCRC residents.

Methods—We use longitudinal data from a randomized controlled trial conducted with residents of 19 CCRCs. We use flexible parametric models to estimate the hazard ratio or hazard rate over 5 waves of data to determine what factors significantly predict discontinued: 1) ICT use, 2) health information searching, and 3) general information searching.

Results—The analysis reveals that independent living residents who took part in an 8-week ICT training intervention were less likely to stop using ICTs. Age and the number of instrumental activities of daily living (IADL) impairments significantly predicted an increased likelihood of stopping ICT use. When examining specific ICT-related activities, the analysis reveals independent living residents who took part in the ICT training intervention were less likely to stop searching for health information and general information online. In addition, age and the number of IADLs were associated with increased likelihood of discontinued health information searches and discontinued general information searches.

Conflict of Interest:
The authors declare no conflicts of interest.

Conclusion—ICT training interventions may motivate residents of CCRCs to stay connected by increasing ICT skill level and promoting confidence, thus decreasing the probability that they will discontinue using ICTs and searching for general information. However, the effects of ICT training in motivating continued ICT usage may be more pronounced among independent living residents. Limitations in the number of IADL impairments is a key factor leading to discontinued use of ICTs among CCRC residents, suggesting that designers of ICTs should be cognizant of the cognitive and physical limitations among this group.

Keywords

information and communication technologies; continuing care retirement communities; older adults; online information seeking; online health information seeking; computers; Internet; instrumental activities of daily living; technology interventions

Introduction

Information and communication technologies (ICTs) such as Internet-connected computers and smartphones are a staple of contemporary living. Technological innovation in everyday life is increasingly difficult to avoid with the adoption of ICTs into work and leisure time [1]. The prevalence and adoption of ICTs is a positive development in the health domain [2–7]. Previous research reveals the potential benefits of ICT use to provide the tools and means of managing and treating a variety of physical and psychological ailments [5,7]. In general, older adults (i.e., aged 65 and older) in the United States may not experience the positive health effects of ICT use due to digital exclusion or the digital divide [8,9]. Older adults residing in continuing care retirement communities (CCRCs) may be the least likely to encounter the health benefits of ICT use due to decreased access or knowledge on how to successfully utilize ICTs for health-enhancing purposes [10,11]. Little research, however examines discontinued ICT use and specific types of ICT use (e.g. searching for information) among older adults living in CCRCs [12].

Our research expands upon previous work examining factors that predict discontinued ICT usage among older adults residing in CCRCs [12]. Specifically, our previous work revealed that participation in an ICT training intervention was not a significant predictor of discontinued ICT use among CCRC residents [12]. In the present research, we examine whether taking part in an ICT training intervention and residing in either assisted or independent living CCRC facility predicts the likelihood of discontinued: 1) ICT use, 2) searching for health information, and 3) searching for general information. Olphert and Damodaran [13] note that defining and measuring discontinued use is a significant challenge [13–15]. Direct questions related to ICT use, such as the length of time since last use, are not sensitive measures of discontinued use [13]. Our measure of discontinued ICT use is a combination of responses to two questions related to whether a respondent ever uses a computer at least occasionally and going online for any purpose.

We review research related to the benefits of ICT use, the digital divide, and ICT use among older adults living in CCRCs. We use longitudinal data collected from a randomized controlled trial of older adults living in CCRCs. The analyses employ flexible parametric estimation to determine the risk of discontinued ICT use. The results further the discussion

regarding the factors that applied researchers and CCRC staff must account for when promoting continued ICT use among CCRC residents.

Background

Older adults benefit from ICT use. Using ICTs provides an increasing opportunity to maintain and track physical health issues (e.g., diabetes, asthma, weight control, and smoking cessation) [5–7]. ICT use improves older adults' mental health and quality of life outcomes, such as reducing depression [3,4] and loneliness [2]. However, fewer older adults' use ICTs compared to other cohorts in the United States [1,8]. The percentage of older adults who go online increased between 2000 and 2016 from 14% to 67% in the United States. In comparison, however, 87% of the general population in the United States reports using the Internet [1,8].

Digital Divide

Digital inequality researchers identify several aspects of the digital divide to explain why older adults are less likely to use ICTs despite potential benefits of use [13,14,16–18]. Older adults who lack access to ICTs and the Internet experience a first-level or first order digital divide [19–21]. Additional work points to older adults' lack of skills related to ICT use as a second-level or second order digital divide [19,22]. Other explanations of digital inequality among older adults extend beyond the lack of access and skills to focus on attitudes towards technology [14,15,17,23]. For example, the reasons older adults do not use ICTs include: perceived lack of relevance, perceptions of being too old to learn, differences in cohort experience, characteristics and features of ICTs, lack of interest, availability and quality of ICT training and support, cognitive declines, and visual and manual dexterity [14,15,17,21,24–28].

Applied researchers employ intervention-based investigations to examine and potentially decrease the digital divide as well as enhance the well-being of older adults [13,16–18]. Previous research focuses on training older adults to use ICTs and then follows post-training ICT use trends [9,16–18,29]. The corpus of findings reveal that ICT interventions can help overcome aspects of the digital divide, such as negative attitudes towards computers [9,18,23,29,30].

In the general older adult population, previous research suggests a significant relationship between attitudes towards computers (e.g., interest, utility, and control) and discontinued ICT use [31]. Demographic characteristics, lower income, and racial/ethnic minority status are also found to significantly predict discontinued use [30]. However, *among older adults in CCRCs* there is limited research examining discontinued ICT use [12] and specific types of ICT use (e.g. searching for information).

ICT Use in CCRCs

Residents of CCRCs are a unique subgroup of the aging population as they are typically more physically and cognitively impaired than the general older adult population [11]. Given the higher likelihood of impairments, older adults might be more likely to use ICTs to search for health-related information to adjust to their impairments [10]. Conversely, increasing

impairments over time might lead older adults to discontinue use as they may no longer have the physical or cognitive ability to maintain use [10]. Older adults who reside in assisted living tend to have more physical and cognitive impairments compared to individuals in independent living [17]. Moreover, CCRC residents experience lower levels of social support as well as higher levels of loneliness and social isolation [32,33], which makes them an important population to focus on in terms of ICT use. Our attention on involvement in organized social activities as well as functional limitations due to an increase in physical and cognitive impairments are particularly salient to CCRC residents [11,32,33]

Our research is the first to examine discontinued use among residents in assisted and independent living CCRCs who also participate in a randomized control trial ICT training intervention. We anticipate a difference in discontinued use between assisted and independent living residents and study arm assignment. We acknowledge that there is little prior literature to guide or support a differential pattern of discontinued use. Yet, the greater level of physical and cognitive impairments assisted living residents experience may preclude ICT use.

Based on the extant literature, we hypothesize that assisted and independent living residents who participate in a technology-based training intervention will be less likely to discontinue ICT use over time, compared to residents who did not participate in the intervention. Moreover, we hypothesize that assisted and independent living residents who participate in a technology-based training intervention will be less likely to discontinue searching for health and general information over time, compared to residents who did not participate in the intervention. We also hypothesize that participants with greater functional limitations will be more likely to stop using ICTs over the period of interest.

Methods

Data for this research come from the ICTs and Quality of Life Study conducted between 2009–2013 [17]. The ICTs and Quality of Life Study was a randomized controlled trial designed to examine the effects of ICT use on various aspects of quality of life (e.g., life satisfaction, loneliness, isolation, mental health) among older adults residing in assisted and independent living communities. A total of 313 participants were recruited from nineteen CCRCs located in a medium-sized metropolitan city in the Deep South region of the United States. Participants were screened for cognitive impairment using a modified version of the Mini-Mental State Examination [34]. Participants were excluded from the study if they scored less than 18 out of a possible 24. The project was approved by the Institutional Review Board at the University of Alabama at Birmingham and all participants provided informed consent.

Intervention Design

A detailed description of the randomized controlled trial research design and ICT intervention are described elsewhere [17,35]. In brief, nineteen CCRCs were randomized into one of three study arms: an information and communication technologies (ICT) arm, an Activities Control (AC) arm, and a True Control (TC) arm. The 313 participants include: 101 in the ICT arm (from 5 CCRCs), 112 in the AC arm (from 7 CCRCs), and 93 in the TC

arm (from 7 CCRCs). Information sessions at each of the nineteen CCRCs provided the study details and encouraged residents to participate.

Participants in the ICT arm took part in an 8-week computer and Internet training intervention conducted in the CCRC using a mobile computer lab. Each week of the intervention featured two 90-minute instructional lessons on the basics of using a computer and the Internet, as well as the option of an additional 90-minute office hours session. The instructional lessons mimicked a traditional classroom format with a lead instructor giving lectures and demonstrating how to complete certain computer tasks and instructing the participants to complete tasks as practice.

The ICT classes were designed for individuals with little to no computer experience and began with the basics of using a computer and the Internet (e.g., turning a computer on/off, opening a program, and navigating to the Internet). Each lesson built upon the knowledge and skills learned in the previous lessons and then progressed to more complex computer activities such as searching for and evaluating information on the Internet, reading and sending email, social networking, and using entertainment websites (e.g., YouTube). In addition to the instructor, two to three graduate students assisted the participants as needed. Participants were also provided with custom-made training manuals. The optional office hours sessions provided participants the opportunity to practice skills, ask for help on topics, or attempt tasks that were not covered in the classes. Microsoft Windows© desktop computers were installed in CCRC common areas (e.g., resident library) for participants to use; one desktop computer was donated per every five residents who participated.

Participants in the AC arm engaged in 8-weeks of recreational and social activities that included trivia games, musical sing-alongs, and art and crafts, among others. The AC group served to partial out the effects of social interaction with graduate students doing the training and determine if changes in CCRC resident quality of life was a result of interaction or the ICT intervention [36]. AC participants interacted with the graduate students the same amount of time as those in the ICT arm despite not having an additional office hours session. The TC arm, unlike the other two arms, did not engage in any intervention.

Longitudinal Survey Data and Analytic Sample

Quantitative data was collected using surveys administered at baseline (Time 1), post-intervention or approximately 8 weeks after baseline (Time 2), and at 3-month (Time 3), 6-month (Time 4), and 12-month (Time 5) post-intervention. Surveys were scheduled by the study personnel at a time and private location convenient to the participants. Surveys were typically scheduled via phone call. Reminder calls and emails were sent to participants regarding follow-up surveys. All surveys were conducted in person with the participant. Participants who remained through the duration of the study completed five surveys over the course of 14 months. The survey included items related to demographic information, physical health and mental well-being, social capital and social support, life in the CCRC, and ICT usage. Of the 313 participants at baseline recruitment, the analytic sample includes participants who remained in the study across all time points and with complete data on the predictors of interest across the five waves of data collection (n = 186). The primary reasons for participant drop-out included lack of attendance for participants in the ICT and AC arms,

health, relocation, and death. The 186 participants contributed 534, 271, and 408 person-period observations in the analyses for discontinued: 1) ICT use, 2) searching for health information, and 3) searching for general information, respectively.

Dependent Variables

Discontinued ICT Use—Responses to two questions were used to create the event indicator (i.e., 1 = Discontinued, 0 = Continued) that a participant either discontinued or continued using an ICT device at each wave of data collection. First, participants were asked if they ever use a computer at least occasionally. The original response options (1 = Yes, 0 = No) were reverse coded to a dichotomous event indicator (i.e., 1 = Discontinued, 0 = Continued). Second, participants were asked how often they went online for any purpose and response options ranged from Several times a week to Never (i.e., 1= Several times a week, 2 = About once a week, 3 = Several times a month, 4 = About once a month, 5 = Once every few months, 6 = Never). The first five response options (i.e., Several times a week through Once every few months) were recoded to zero (0) indicating continued ICT use and the response option Never was recoded to one (1) indicating discontinued ICT use. At each time period, participants who used a computer at least occasionally (i.e., 0) and went online for any purpose at least once every few months or more often (i.e., 0) were classified as maintained ICT use (i.e., 0 = Continued using ICT devices). However, participants who did not use a computer at least occasionally (i.e., 1) and/or never went online for any purpose (i.e., 1) were classified as stopped using (i.e., 1 = Discontinued) ICT devices.

Discontinued Searching for Health Information—Responses to two questions were used to create the event indicator (i.e., 1 = Discontinued, 0 = Continued) that a participant either discontinued or continued searching for health information. The first question asked participants how often they went online for medical or health-related information for themselves. The second question asked participants how often they went online for medical or health-related information for others. The response options for both questions included Several times a week to Never (i.e., 1= Several times a week, 2 = About once a week, 3 = Several times a month, 4 = About once a month, 5 = Once every few months, 6 = Never). For each question, the first five response options (i.e., Several times a week through Once every few months) were recoded to zero (0) indicating continued searching for health information and the response option Never was recoded to one (1) indicating discontinued searching for health information.

The recoded event indicator at each wave means that a participant stopped (i.e., 1 = Discontinued) searching for medical or health-related information in the following three scenarios: 1) for both themselves (i.e., 1) and others (i.e., 1), 2) for themselves (i.e., 1) but continued searching for others (i.e., 0), and 3) continued for themselves (i.e., 0) but stopped searching for others (i.e., 1). However, a participant sustained (i.e., 0 = Continued) searching for health information if they were found to search for both themselves (i.e., 0) and others (i.e., 0). As many older adults provide care for partners, we asked about respondents searching for health information for themselves as well as their searching for health information for others. Asking separate questions accounts for any online health inquiries

motivated by the health of a partner, family member, friend, or another resident of the CCRC.

Discontinued Searching for General Information—Participants either discontinued or continued searching for general information based on their responses to how often they went online for: 1) information on hobbies, movies, restaurant reviews, or other leisure or entertainment related activities, and 2) news or weather. We use both questions to cover a range of topics that may be of interest to CCRC residents. The response options for both questions included Several times a week to Never (i.e., 1= Several times a week, 2 = About once a week, 3 = Several times a month, 4 = About once a month, 5 = Once every few months, 6 = Never). The first five response options (i.e., Several times a week through Once every few months) were recoded to zero (0) indicating continued searching for general information and the response option Never was recoded to one (1) indicating discontinued searching for general information.

The recoded event indicator at each wave means that a participant stopped (i.e., 1 = Discontinued) searching for searching for general information under the following three scenarios: 1) for both information on hobbies, movies, restaurant reviews, or other leisure or entertainment related activities (i.e., 1) and news or weather (i.e., 1), 2) stopped for hobbies, movies, restaurant reviews, or other leisure or entertainment related information (i.e., 1) but continued searching for news or weather (i.e., 0), and 3) continued for hobbies, movies, restaurant reviews, or other leisure information (i.e., 0) but stopped searching for news or weather (i.e., 1). However, a participant sustained (i.e., 0 = Continued) searching if they were found to search for both information on hobbies, movies, restaurant reviews, or other leisure or entertainment related activities (i.e., 0) as well as news or weather (i.e., 0).

Independent Variables

We created six categorical variables using the type of CCRC facility and study arm assignment to examine potential differences in discontinued: 1) ICT use, 2) searching for health information, and 3) searching for general information. The study arm (i.e., ICT, AC, TC) and type of CCRC facility (i.e., assisted and independent living communities) were recoded into six dichotomous (i.e., 1/0) categorical variables. In the analyses, participants in the assisted living TC group are the excluded or comparison category.

Respondents indicated the approximate number of hours per week, in a typical week, spent participating in organized activities. The participant's age was recorded at her/his last birthday. The approximate number of hours in activities and age are scalar variables in the analyses. We employed a modified Instrumental Activities of Daily Living (IADL) impairments assessment [37] that asked participants if they received eight types of assistance (medicine management, transportation, meal preparation, household chores, sitting services, financial assistance, shopping, or other not listed) at their living facility. Responses were recoded into a dichotomous indicator (i.e., 1 = Yes, 0 = No) and affirmative responses were summed so that higher values indicate a higher level of assistance needed.

Three predictors were considered but not included in the analyses. First, we did not include marital status as most respondents were widowed, divorced, or single (i.e., there was

decreased variation). Second, despite the potential importance of social support in ICT usage, we do not include social support in our analysis as the measure used in our study did not adequately capture support related to the technical or social aspects of ICT usage. Third, we do not include self-rated health while acknowledging that health is an important predictor of ICT use. In our initial models, we included both an objective measure (i.e., number of IADL impairments) and subjective measure (i.e., self-reported health status) of health. However, self-reported health status was not significant and reduced the Royston and Sauerbrei Adjusted R^2_D [38,39] in the full model. The reduction indicates model misspecification; therefore, we did not retain self-reported health status in our final analyses. In addition, we did not include sex and race as control variables given that the majority of participants were female and white.

Analytic Procedure

The three outcomes of interest in the analysis are dichotomous event indicators that a participant discontinued or continued (i.e., 1 = Discontinued, 0 = Continued) using ICTs, searching for health information, and searching for general information at five waves of data collection. We use flexible parametric models for the survival analysis as the technique is designed to incorporate multiple time points and evaluate the occurrence of an event or a discreet change from one state to another [40,41]. The advantages of the flexible parametric model estimation over the Cox model are the ease with which smooth predictions can be made, the modeling of complex time-dependent effects, investigation of absolute as well as relative effects, and the incorporation of the expected event for relative survival models [40].

Results

Descriptive Statistics at Each Time Period

Table 1 displays the descriptive statistics for the variables of interest at each of the five time periods. On average, at baseline (i.e., Time 1) 52% of participants reported not using ICTs. However, the percentage of respondents reporting discontinued ICT use decreases to 35% at Time 2 and slightly increases to 38%, 40%, and 39% at Times 3 through 5, respectively. In terms of discontinued health information searching, 85% of respondents did not search for health information at Time 1. The percentage of respondents who discontinued searching for health information decreases to 81% at Time 2 and slightly increases to 84% and 85% at Times 4 and 5, respectively. At Time 1, on average, 67% of respondents did not search for general information. The percentage of respondents who discontinued searching for general information decreases to 59% and 57% at Times 2 and 3, respectively. Approximately 61% and 64% of respondents discontinued searching for general information at Times 4 and 5, respectively. Respondents indicated an average of seven hours of organized activities per week at Time 1, nearly 8 hours at Time 2, and decreases to an average of 7 hours at Time 5. Participants indicated requiring assistance with approximately three IADL impairments at Times 1 through 5. At Time 1, the average age was 82 and increased to 84 at Time 5.

The percentage of respondents in each CCRC facility type and study arm group remains the same at each of the five-time periods. To avoid redundancy in Table 1, we present the percentages here. Approximately 15%, 16%, 21%, 14%, 25%, and 8% of participants

compose the independent living ICT, assisted living ICT, independent living AC, assisted living AC, independent living TC group, and assisted living TC groups, respectively.

Percentage at Baseline

Table 2 presents the percentage of respondents reporting ICT use as well as searching for health and general information by study arm, type of living facility, as well as study arm and type of facility groups at baseline (i.e., Time 1).

ICT Use—As shown in Table 2, 52.5%, 40.0%, and 51.6% of participants in the ICT, AC, and TC groups, respectively, reported using ICTs at Time 1. In terms of CCRC living facility, 59.3% and 28.2% of independent and assisted living residents, respectively, reported using ICTs at baseline. The study arm and type of facility groups reveal that 63%, 40%, 53.9%, 19.2%, 61.7% and 20% of independent living ICT, assisted living ICT, independent living AC, assisted living AC, independent living TC, and assisted living AC participants, respectively, reported using ICTs at Time 1. Comparing the study arm, type of living facility, and study arm and type of facility group percentages at baseline illustrate the diversity of ICT use within each group; thus, supporting the need for the fine grain analyses.

Searching for Health Information—In terms of searching for health information, approximately 15.3% of the participants in the ICT group reported searching for health information at Time 1. A fifth of residents in independent living (20.4%) indicated searching for health information at baseline. Roughly 22.2%, 6.7%, 15.4%, 3.9%, 23.4%, and 6.7% of independent living ICT, assisted living ICT, independent living AC, assisted living AC, independent living TC, and assisted living AC participants, respectively, reported health information seeking at Time 1. The percentages by study arm and type of facility groups at baseline reveal the range that participants searched for health information.

Searching for General Information—Approximately 33.9% of the participants in the ICT group reported searching for general information. A higher percentage of independent living residents (43.4%) indicated searching for general information compared to assisted living (16.9%). At Time 1, 44%, 23.3%, 38.5%, 11.5%, 46.8%, and 13.3% of independent living ICT, assisted living ICT, independent living AC, assisted living AC, independent living TC, and assisted living AC participants, respectively, reported searching for general information at baseline. Searching for general information varies across the combination of study arm and type of facility groupings at Time 1 compared to examining only study arm or facility type.

Descriptive Statistics Over the Five Time Periods

Discontinued ICT Use—Table 3 displays the descriptive statistics for the variables of interest for each outcome over the five time periods. On average, participants were most at risk for discontinued ICT use between the second and third waves of data collection. Roughly 33%, 31%, and 36% of participants assigned to the ICT, AC, and TC arms, respectively, discontinued ICT use over the14 months of the study. Approximately 72% and 28% of residents in independent living and assisted living CCRC facilities discontinued ICT use. Moreover, approximately 18% and 15% of participants in the independent living ICT

and assisted living ICT groups, respectively, discontinued using ICTs. Respondents participating in an average of seven hours of organized activities per week were at risk for discontinued ICT use. The average age of discontinued use was 82. In addition, participants requiring assistance with an average of three IADL impairments were at risk for discontinued ICT use. The most frequent types of assistance at each time point included transportation, meal preparation, and household chores.

Discontinued Searching for Health Information—Returning to Table 3, 36% of participants assigned to the TC arm and 69% of residents in independent living stopped searching for health information over the 14 months of the study. On average, participants were at risk to stop searching for health information at Time 2 (i.e., approximately 8 weeks after baseline). Participants in the independent living AC (21%), TC (29%), and ICT (18%) groups stopped searching for health information over the period of the study. Respondents involved in an average of nearly seven hours of organized activities per week were at risk to discontinue health information searching. Participants needing assistance with approximately three IADL impairments and an average age of 82 were at risk to stop searching for health information.

Discontinued Searching for General Information—Over the 14-month study period, 37% of participants assigned to the TC arm and 71% of residents in independent living stopped searching for general information. Participants were at risk to abandon searching for general information after the second wave of data collection (see Table 3). Approximately 17% and 14% of participants in the independent living ICT and assisted living ICT groups, respectively, discontinued searching for general information over the five waves. Respondents who participated in an average of nearly seven hours of organized activities per week, required assistance with three IADL impairments, and an average age of 82 were at increased risk to stop searching for general information.

Flexible Parametric Analyses

The results of the flexible parametric regression models are presented in Tables 4–6. The coefficient for each predictor variable can be interpreted as the hazard ratio or hazard rate that a participant discontinued: 1) ICT use, 2) searching for health information, and 3) searching for general information over 14 months. A significant positive coefficient above 1 indicates an increase in the hazard rate; conversely, a significant coefficient below 1 indicates a decrease in the hazard rate and translates into an increase in the expected duration that a participant will continue to report device use or information searching. Predictor variables are entered in the analysis as follows: Model 1 introduces the study arm assignment with TC participants as the reference group. Model 2 adds the independent living facility indicator and assisted living is the reference group. The study arm assignment and type of living facility are included in Model 3, with assisted living TC participants as the reference group. Model 4 adds the average number of hours per week participants engaged in organized activities and participants' age. The full model (Model 5) adds the number of reported IADL impairments.

Discontinued ICT Use—In Model 1 (Table 4), the hazard ratio for the ICT group was not significantly different from the TC group. However, the AC group was significantly different from the TC group. The hazard ratio indicates that participants assigned to the AC group were 41.6% more likely to discontinue ICT use compared to the TC group. The Royston and Sauerbrei [38] adjusted R^2_D indicates that the baseline model accounts for 0.7% of the variation in discontinued ICT use. Model 2 includes the independent living facility indicator with residence in assisted living as the reference group. CCRC residents in independent living were 53.9% less likely to stop using ICTs over the 14 months of the study compared to the reference group. In addition, participants in the ICT group, compared to the TC group, were 14% less likely to discontinue using ICTs. The adjusted R^2_D indicates that the model accounts for 7.9% of the variation in discontinued ICT use.

We remove the study arm assignment and type of living facility in Model 3 (Table 4) and include the study arm assignment and type of CCRC facility groups. The hazard ratio for the independent living ICT, independent living AC, and the independent living TC groups were significantly different from the assisted living TC group (the reference group). For all three groups, the hazard ratios are below 1 indicating that these groups discontinued ICT usage at a lower rate and were more likely to continue using ICTs over the course of the study. The independent living ICT group was 63% less likely to stop using ICTs over the 14 months of the study compared to the reference group. The independent living AC and TC groups were 46% and 65% less likely to stop using ICTs, respectively. Model 3 accounts for 12.5% of the variation in discontinued ICT use [39].

Model 4 added the average number of hours spent in activities per week and participants' age. The average number of hours in activities per week did not significantly predict discontinued ICT use. While the study duration was 14 months, each additional year of age from baseline increased the risk of discontinued ICT use by 3.7%. The hazard ratios for the independent living ICT and TC groups indicated that participants were less likely to stop using ICTs over the course of the study compared to the assisted living TC group. The model accounts for 14.7% of the variation in discontinued ICT use.

Model 5 includes the number of IADL impairments that require assistance. Participants in the independent living ICT and TC groups were respectively 58% and 56% less likely to stop using ICTs, compared to the assisted living TC participants. As participants aged they were 3.7% more likely to discontinue using ICTs. Participants with increased number of IADL impairments that require assistance were more likely to stop using ICTs over the course of the study, such that a 1-point increase in the number of IADL impairments needing assistance was associated with approximately a 28.9% increase in the likelihood that the participant would stop using ICTs. The final model accounts for 17.1% of the variation in discontinued ICT use over the five times periods.

Discontinued Searching for Health Information—In Model 1 (Table 5), the ICT and AC groups were not significantly different compared to the TC group. CCRC residents in independent living were 49.5% less likely to discontinue searching for health information

compared to assisted living residents over the 14 months of the study (Model 2). Model 2 accounts for 4.9% of the variation in discontinued ICT use over the five times periods.

Compared to participants in the assisted living TC group, participants in the independent living ICT group were 52% less likely to discontinue searching for health information over the course of the study (Model 3, Table 5). The model accounts for 6.9% of the variation in discontinued searching for health information. Model 4 (Table 5) adds the average number of hours spent in activities per week and participants' age. Each additional year of age from baseline increased the risk to stop searching for health information by 3.2%. Compared to participants in the assisted living TC, independent living ICT group participants were 51.8% less likely to discontinue searching for health information. Model 4 accounts for 7.8% of the variation in discontinued health information searching.

A 1-point increase in the number of IADL impairments needing assistance (Model 5) was associated with approximately a 17.4% increase in health information searching desistance. Increasing age increased the risk of discontinued health information searching by 2.9%. The independent living ICT group was 48.7% less likely to stop searching for health information. The full model accounts for 8.4% of the variation in discontinued health information searching. Moreover, we point out that in Model 5 the independent living AC and TC as well as the assisted living ICT and AC group participants were not significantly different to stop searching for health information compared to the assisted living TC group.

Discontinued Searching for General Information—Participants in the AC group were 41.6% more likely to stop searching for general information compared to the TC group (Model 1 Table 6). Model 1 accounts for 0.7% of the variation in discontinued general information searching over the study duration. Independent living participants were 53.9% less likely to discontinue searching for general information compared to assisted living residents in Model 2. The predictors account for 7.9% of the variation in discontinued general information (Model 2).

In Model 3 (Table 6), the independent living ICT group was approximately 50% less likely while the TC group was 49% less likely to discontinue searching for general information over 14 months compared to the reference group. Model 3 accounts for 6.5% of the variation in discontinued general information searching.

In Model 4, increasing age increased the risk of discontinued general information searching by 3.3%. The independent living ICT and TC groups were 47% and 53% less likely to stop general information searching. Model 4 accounts for 7.3% of the variation in discontinued general information searching. In Model 5 a 1-point increase in the number of IADL impairments requiring assistance was associated with a 27.7% increase in the likelihood that a participant would stop searching for general information. Increasing age increased the risk of discontinued general information searching by 3.4%. The independent living ICT group was 46.1% less likely to discontinue general information searching. Model 5 accounts for 10.4% of the variation in discontinued general information searching.

Discussion

Older adults are at risk for discontinued ICT use. We examined risk of discontinued: 1) ICT usage, 2) searching for health information, and 3) searching for general information among older adults in CCRCs and determined what factors may serve as predictors. The potential for discontinued use was greatest between the end of intervention activities and the 3-month follow-up (see Table 4), suggesting that CCRC residents may need periodic assistance related to ICT use even after structured classes/trainings end. Previous work examining ICT use among older adults [42] indicates that older adults, including those who experience cognitive decline as they age, can be at risk of lower self-efficacy and lower levels of confidence in technology use in the absence of continued ICT training. Our experience from this randomized trial indicates that a lack of continued training and support motivated some individuals to stop usage, especially when the technologies change or update.

Our findings reveal that 63% of participants in the independent living ICT groups and 40% of participants in the assisted living ICT group, respectively, reported using ICTs at baseline. As expected, the percentage of users increased post-intervention since the participants routinely used ICTs over the 8-week intervention. More importantly, we find that participants in the ICT arm, regardless of type of CCRC facility, had lower risk of discontinued ICT use and searching for general information compared to assisted living residents in the TC arm (although the results were significant only for those in independent living). Studies examining the effects of ICT interventions [17,23] suggest that ICT training programs not only increase ICT skill level but also increase positive attitudes towards technology and decrease perceived limitations to use. However, prior studies do not account for difference in types of communities (independent living vs. assisted living). Our prior work [12] also found that social support, marital status, and self-reported health status did not predict discontinued ICT use. The current study adds to the body of literature, suggesting that ICT training can reduce the digital divide and prevent discontinued ICT use among older adults in CCRCs, particularly those in independent living.

Independent living residents in the ICT arm were more likely to continue ICT use as well as continue searching for health information compared to the reference category. The findings are important for two reasons. First, consistent with previous research [5–7], ICT use benefits older adults by providing the opportunity to manage and maintain their health. Specifically, our findings clearly indicate that independent living residents in the ICT arm continued using ICTs to search for health information. Second, our results provide evidence that older adults search for health information for themselves as well as for others (e.g., partner, family member, friend, or another CCRC resident). Independent living residents in the ICT arm were also more likely to continue searching for general information.

Engaging in a discretionary recreational activities intervention (i.e., the AC arm) was not associated with continued or discontinued ICT use, suggesting that more recreational and leisurely activities conducted in the CCRC have no impact on ICT use. One may assume that older adults participating in fun activities with friends and CCRC residents may have less time to use an ICT or have less energy to do so; however, our results do not support this assumption. The average number of activities participated in per week did not significantly

predict discontinued ICT use. However, participants' age and increases in IADL impairments were associated with a higher risk of discontinued ICT use. These finding are not unexpected, as physical declines associated with the aging process and higher IADL impairment scores suggest physical limitations that may make it difficult for older adults to use and manipulate certain devices without considerable strain; indeed, older adults themselves often cite physical limitations as a potential barrier to successful ICT use [25]. Our findings suggest that those who seek to increase ICT use, which may ultimately positively affect well-being, among older adults in CCRCs can do so through specially-designed ICT interventions conducted in CCRCs. Interventionists, however, need to be cognizant of the physical limitations of the residents and how these limitations may change over time as this poses a significant risk to discontinued ICT use.

As with all studies, there are limitations to the present research. While the demographic composition is similar to national trends in CCRC resident makeup (e.g., our sample was a majority female and white) [43], our sample lacks diversity in areas such as sex, race, and income. In the United States, approximately 70.2% of CCRC residents are women, 84.3% are white (non-Hispanic), and 52.6% are 85 and over [43]. In comparison, 82.2% of residents in our analytic sample are women, 96.2% are white (non-Hispanic), and 41.4% are 85 and older. Thus, despite collecting data from one metropolitan area our sample slightly underestimates non-whites and those aged 85 and older. The findings may not be generalizable to all CCRC residents. As the study was conducted exclusively in CCRCs in a metropolitan area in the Deep South, there may be geographical and cultural bias that prevents these results from being generalizable on the national level. Our research considers assisted and independent living residents only and does not account for other levels of care that can be present in a CCRC (e.g., skilled nursing care). Finally, we acknowledge that the event indicator for each of the three dependent variables does not take into account CCRC residents' intentions to resume use and searches at a point in the future [13].

Despite these limitations, our research indicates that ICT training can help older adults in CCRCs continue using ICTs and searching for general information. However, IADL impairments present a major hurdle that often trumps the benefits of ICT training for residents in these communities. Future researchers should further investigate which types of IADL impairments have the strongest effects on ICT use over time. Most importantly, technology developers/designers should strive to design new ICTs that require less cognitive and physical demands from older adults in general and those with IADL impairments in particular.

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Table 1

Descriptive Statistics for Discontinued: ICT Use, Searching for Health Information, Searching for General Information, Average Number of Organized Activities Per Week, Number of Instrumental Activities of Daily Living (IADL) Impairments, and Age at Baseline and Post-Intervention Follow-Ups

	Time 1 (Baseline)				Time 2 (8 Weeks)				Time 3 (3 Months)				Time 4 (6 Months)				Time 5 (12 Months)			
	Mean	**SD**	**Min**	**Max**	**Mean**	**SD**	**Min**	**Max**	**Mean**	**SD**	**Min**	**Max**	**Mean**	**SD**	**Min**	**Max**	**Mean**	**SD**	**Min**	**Max**
Discontinued:																				
ICT Use	52%				35%				38%				40%				39%			
Searching for Health Information	85%				81%				84%				83%				85%			
Searching for General Information	67%				59%				57%				61%				64%			
Avg. Num. Hours Organized Activities/Week	7.09	6.71	0.00	40.00	7.77	6.15	0.00	30.00	7.24	6.25	0.00	35.00	6.80	5.96	0.00	30.00	6.71	5.60	0.00	30.00
Number of IADL Impairments	3.27	1.29	0.00	8.00	3.19	1.37	0.00	6.00	3.20	1.16	0.00	8.00	3.00	1.35	0.00	7.00	3.20	1.25	0.00	7.00
Age	82.75	6.56	66.00	100.00	83.06	6.58	67.00	102.00	83.29	6.62	67.00	101.00	83.57	6.57	67.00	102.00	84.03	6.60	67.00	103.00

Source: ICTs and Quality of Life Study. n = 186.

Table 2

Percent of Respondents at Baseline (Time 1) Reporting ICT Use, Searching for Health Information, and Searching for General Information by Study Arm, Type of CCRC Facility, and Type of CCRC Facility and Study Arm Groups

	ICT Use	Searching for Health Information	Searching for General Information
ICT Group	52.5	15.3	33.9
AC Group	40.0	10.8	27.7
TC Group	51.6	19.4	38.7
Independent Living	59.3	20.4	43.4
Assisted Living	28.2	5.6	16.9
Independent Living ICT Group	63.0	22.2	44.4
Assisted Living ICT Group	40.0	6.7	23.3
Independent Living AC Group	53.9	15.4	38.5
Assisted Living AC Group	19.2	3.9	11.5
Independent Living TC Group	61.7	23.4	46.8
Assisted Living TC Group	20.0	6.7	13.3

Source: ICTs and Quality of Life Study. n = 186.

Table 3

Descriptive Statistics for Discontinued: ICT Use, Searching for Health Information, and Searching for General Information Over the 14 Month Study Period

	Discontinued ICT Use [a]				Discontinued Searching for Discontinued Searching for Health Information [b]				General Information [c]			
	Mean	**S.D.**	**Min**	**Max**	**Mean**	**S.D.**	**Min**	**Max**	**Mean**	**S.D.**	**Min**	**Max**
Discontinued Event Indicator	2.62	1.49	1.00	5.00	1.71	1.23	1.00	5.00	2.31	1.46	1.00	5.00
ICT Group	0.33	0.47	0.00	1.00	0.31	0.46	0.00	1.00	0.31	0.46	0.00	1.00
AC Group	0.31	0.46	0.00	1.00	0.33	0.47	0.00	1.00	0.31	0.46	0.00	1.00
TC Group	0.36	0.48	0.00	1.00	0.36	0.48	0.00	1.00	0.37	0.48	0.00	1.00
Independent Living	0.72	0.45	0.00	1.00	0.69	0.46	0.00	1.00	0.71	0.45	0.00	1.00
Assisted Living	0.28	0.45	0.00	1.00	0.31	0.46	0.00	1.00	0.29	0.45	0.00	1.00
Independent Living ICT Group	0.18	0.38	0.00	1.00	0.18	0.39	0.00	1.00	0.17	0.38	0.00	1.00
Independent Living AC Group	0.22	0.42	0.00	1.00	0.21	0.41	0.00	1.00	0.22	0.42	0.00	1.00
Independent Living TC Group	0.31	0.46	0.00	1.00	0.29	0.45	0.00	1.00	0.31	0.46	0.00	1.00
Assisted Living ICT Group	0.15	0.35	0.00	1.00	0.12	0.33	0.00	1.00	0.14	0.35	0.00	1.00
Assisted Living AC Group	0.08	0.27	0.00	1.00	0.07	0.26	0.00	1.00	0.09	0.28	0.00	1.00
Assisted Living TC Group	0.05	0.22	0.00	1.00	0.21	0.41	0.00	1.00	0.06	0.23	0.00	1.00
Avg. Num. Hours Organized Activities/Week	7.12	6.12	0.00	40.00	6.80	5.97	0.00	40.00	6.68	5.69	0.00	40.00
Age	82.06	6.71	66.00	100.00	81.96	6.68	66.00	100.00	81.70	7.00	66.00	100.00
Number of IADL Impairments	3.00	1.32	0.00	8.00	3.03	1.39	0.00	8.00	2.96	1.34	0.00	8.00

Source: ICTs and Quality of Life Study.

[a] Note: 534 person period observations representing n = 186 over 5 waves.

[b] Note: 271 person period observations representing n = 186 over 5 waves.

[c] Note: 480 person period observations representing n = 186 over 5 waves.

Table 4

Flexible Parametric Survival Analysis. Study Arm Groups, Type of CCRC Facility, Type of CCRC Facility and Study Arm Groups, Average Number of Organized Activities Per Week, Number of Instrumental Activities of Daily Living(IADL) Impairments, and Age Predicting the Hazard Ratios for Discontinued ICT Use

	Model 1	Model 2	Model 3	Model 4	Model 5
ICT Group	1.087	0.860 *			
AC Group	1.416 +	1.280			
Independent Living		0.461 ***			
Independent Living ICT Group			0.371 *	0.352 *	0.420 *
Assisted Living ICT Group			0.723	0.649	0.621
Independent Living AC Group			0.536 +	0.583	0.676
Assisted Living AC Group			1.529	1.553	1.317
Independent Living TC Group			0.353 **	0.376 **	0.443
Avg. Num. Hours Organized Activities/Week				0.978	0.971
Age				1.037 *	1.037 *
Number of IADL Impairments					1.289 **
Constant	0.545 ***	0.974	0.726	0.0421 *	0.0171 **
Log-Likelihood	−270.7	−259.0	−249.6	−246.5	−241.9
Royston and Sauerbrei Adjusted R^2_D	0.007	0.079	0.125	0.147	0.171
Akaike's Information Criterion (AIC)	549.484	528.098	513.233	511.037	503.789
Bayesian Information Criterion (BIC)	565.529	548.080	543.196	549.560	546.593

Source: ICTs and Quality of Life Study. 534 person period observations representing n = 186 over 5 waves.

+ p < 0.10

* p < 0.05

** p < 0.01

*** p < 0.001.

Assisted Living TC Group is the reference category.

Table 5

Flexible Parametric Survival Analysis. Study Arm Groups, Type of CCRC Facility, Type of CCRC Facility and Study Arm Groups, Average Number of Organized Activities Per Week, Number of Instrumental Activities of Daily Living (IADL) Impairments, and Age Predicting the Hazard Ratios for Discontinued Searching for Health Information

	Model 1	Model 2	Model 3	Model 4	Model 5
ICT Group	1.144	1.027			
AC Group	1.309	1.197			
Independent Living		0.505 ***			
Independent Living ICT Group			0.479 *	0.482 *	0.513 *
Assisted Living ICT Group			1.483	1.558	1.497
Independent Living AC Group			0.771	0.874	0.974
Assisted Living AC Group			1.244	1.305	1.155
Independent Living TC Group			0.618	0.705	0.791
Avg. Num. Hours Organized Activities/Week				1.018	1.015
Age				1.032 *	1.029 *
Number of IADL Impairments					1.174 **
Constant	0.688 **	1.119	0.949	0.0590 **	0.0425 **
Log-Likelihood	−223.3	−213.5	−213.3	−208.9	−205.1
Royston and Sauerbrei Adjusted R^2_D	0.002	0.049	0.069	0.078	0.084
Akaike's Information Criterion (AIC)	454.649	437.029	440.542	435.745	430.176
Bayesian Information Criterion (BIC)	469.057	454.984	465.757	468.164	466.197

Source: ICTs and Quality of Life Study. 271 person period observations representing n = 186 over 5 waves.

$^{+}$ $p < 0.10$

* $p < 0.05$

** $p < 0.01$

*** $p < 0.001$.

Assisted Living TC Group is the reference category.

Table 6

Flexible Parametric Survival Analysis. Study Arm Groups, Type of CCRC Facility, Type of CCRC Facility and Study Arm Groups, Average Number of Organized Activities Per Week, Number of Instrumental Activities of Daily Living (IADL) Impairments, and Age Predicting the Hazard Ratios for Discontinued Searching for General Information

	Model 1	Model 2	Model 3	Model 4	Model 5
ICT Group	1.087	0.860			
AC Group	1.416 $^{+}$	1.280			
Independent Living		0.461 ***			
Independent Living ICT Group			0.495 $^{+}$	0.467 *	0.539 $^{+}$
Assisted Living ICT Group			0.864	0.799	0.768
Independent Living AC Group			0.622	0.666	0.760
Assisted Living AC Group			1.461	1.431	1.203
Independent Living TC Group			0.489 *	0.526 *	0.625
Avg. Num. Hours Organized Activities/Week				1.006	1.003
Age				1.033 *	1.034 *
Number of IADL Impairments					1.277 ***
Constant	0.545 ***	0.974	0.895	0.0586 *	0.0235 **
Log-Likelihood	−270.7	−259.0	−262.6	−259.4	−253.3
Royston and Sauerbrei Adjusted R^2_D	0.007	0.079	0.065	0.073	0.104
Akaike's Information Criterion (AIC)	549.484	528.098	539.279	536.823	526.548
Bayesian Information Criterion (BIC)	565.529	548.080	567.358	572.924	566.66

Source: ICTs and Quality of Life Study. 408 person period observations representing n = 186 over 5 waves.

$^{+}$ p < 0.10

* p < 0.05

** p < 0.01

*** p < 0.001.

Assisted Living TC Group is the reference category.