Journal of Aging and Health

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J Aging Health 2010 22: 804 originally published online 21 May 2010
DOI: 10.1177/0898264310366161

The online version of this article can be found at:
http://jah.sagepub.com/content/22/6/804

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SAGE
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Journal of Aging and Health
22(6) 804–826

DOI: 10.1177/0898264310366161
http://jah.sagepub.com
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Utilization of Internet Technology by Low-Income Adults: The Role of Health Literacy, Health Numeracy, and Computer Assistance

Jakob D. Jensen, PhD[1], Andy J. King, MA[1], LaShara A. Davis, MA[1], and Lisa M. Guntzviller, MA[1]

Abstract

Objectives: To examine whether low-income adults' utilization of Internet technology is predicted or mediated by health literacy, health numeracy, and computer assistance. **Method:** Low-income adults (N = 131) from the midwestern United States were surveyed about their technology access and use. **Results:** Individuals with low health literacy skills were less likely to use Internet technology (e.g., email, search engines, and online health information seeking), and those with low health numeracy skills were less likely to have access to Internet technology (e.g., computers and cell phones). Consistent with past research, males, older participants, and those with less education were less likely to search for health information online. The relationship between age and online health information seeking was mediated by participant literacy. **Discussion:** The present study suggests

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that significant advances in technology access and use could be sparked by developing technology interfaces that are accessible to individuals with limited literacy skills.

Keywords

underserved populations, health literacy, numeracy, computer assistance, mediation

Recent data suggest that nearly 8 in 10 Americans own a computer and have Internet access (Kennedy, Smith, Wells, & Wellman, 2008). Not only is access widespread, but it is also growing at a fast rate. For example, Internet access rose from 15% of U.S. households in 1995 to 77% in 2008 (Kennedy et al., 2008; Madden, 2006). Rapid diffusion of the Internet provides Americans with access to information on a variety of topics. One topic that seems to be especially interesting to Internet users is health, as 66% of Americans report searching online for health information at least once (Fox, 2008) and 70% have used online information as the basis for a health care decision (Fox & Raine, 2000). People prefer to talk with physicians about health issues, but physician–patient encounters are infrequent and Americans are much more likely to search for health information online (Hesse et al., 2005). The Internet seems to be used both as a primary information source (e.g., diagnosing illness, checking symptoms) and as a means for further investigation following physician consultation (Fox & Fallows, 2003). It is also increasingly the case that basic health and social services (Medicaid, Medicare) are accessible online (Schmeida & McNeal, 2007).

Widespread Internet access has created new opportunities for health care, but it has also magnified enduring problems. Service and access gaps have long existed in the U.S. health care system and similar gaps appear to undermine use and access of the Internet (Eng et al., 1998; Gibbons, 2005; Kaiser Family Foundation, 2005). Online capability is unequally distributed in the population, as many traditionally underserved groups (i.e., low income, low education) are less likely to own or utilize computer technology (Kreps, 2002; Kutner, Greenberg, Jin, & Paulsen, 2006; Schmeida & McNeal, 2007). For this reason, computer technology has the potential to amplify inequalities if researchers fail to address the digital divide (Viswanath & Kreuter, 2007).

The long-term potential of computer technology for public health rests in part on the ability of researchers to dissect and eliminate inequalities. Past research has identified several demographic factors that predict technology access and use in low-income populations (e.g., gender, age, education, and race; Fox, 2006, 2008). Only one study to date, however, has examined if and how basic skills (e.g., literacy and numeracy) are related to utilization. The 2003 National Assessment of Adult Literacy (NAAL) found that, compared with their more skilled counterparts, individuals with lower literacy and numeracy skills were less likely to search for health information online (Kutner, Greenberg, Jin, & Paulsen, 2006). However, the NAAL assessed literacy and numeracy in general, rather than health literacy and numeracy specifically.

Health literacy is "the degree to which individuals can obtain, process, and understand basic health information and services they need to make appropriate health decisions" (Institute of Medicine, 2004, p. 1). Health numeracy is considered to be part of the health literacy construct, referring to one's mathematical abilities regarding health and medical information. Even though health literacy is a somewhat ambiguous concept, researchers have routinely measured it as basic literacy and/or mathematical ability (i.e., basic numeracy). As a result, it has been argued that it would be more helpful to refer to specific parts of health literacy (e.g., literacy and numeracy independently) rather than health literacy as a whole (DeWalt & Pignone, 2005). Not only does this clarify the object of study but also highlights cognitive aspects of health literacy that have been virtually ignored (e.g., communication anxiety, health motivation). Furthermore, literacy and numeracy, as general constructs, do not account for medical terminology and health-related or medicine-based numerical skills.

Literature Review

Demographics and Technology Access and Use

In August 2006, the Pew Center surveyed 1,990 U.S. adults about their online health information seeking behaviors (Fox, 2008). They reported that certain groups were more likely to search for health information online: women, those under 65 years of age, college graduates, users with more online experience, and individuals with broadband access. Previous surveys ran by the Pew Center in 2002 and 2004 had obtained similar results (Fox, 2008).

Education, experience, and broadband access were all positively related to online health information seeking; however, the relationship between age and health seeking appeared to be quadratic (i.e., an upside down U-shape). Users aged 30 to 49 were more likely to have searched for health information online compared to their younger and older counterparts. There also appeared to be a linear component to this relationship (i.e., the left side of the upside down U-shape was higher than the right side), as there was a severe decline in online health information seeking for users above 64 years. In fact, only 6% of individuals aged above 64 had sought out health information of any kind online. Subsequent research further muddled the relationship, as it found age to be positively related to seeking out certain types of health information online (e.g., Medicare and Medicaid; Schmeida & McNeal, 2007). Thus, the link between age and online health information seeking appears to be multifaceted and complex.

In addition to those mentioned above, two other demographic factors have been linked to online health information seeking: race and income. Previous Pew Center studies have found that race is related to technology access and utilization (Fox, 2006). Notably, African Americans lagged behind other racial groups in access (dial up and broadband) as well as utilization of various technologies. Those studies also found that low-income adults were less likely to have access to, or utilize, technology for actions like online health information seeking (Schmeida & McNeal, 2007), presumably because of access and skill barriers.

Basic Skills and Technology Access and Use

It is useful to know that demographic factors are related to technology access and utilization, but these can be challenging targets for health communication scholars to address in message design for campaigns or interventions. Interventions have been effective at tailoring or customizing messages to specific groups based on demographic characteristics (Noar, Benac, & Harris, 2007), yet there is a growing recognition that communicators need additional targets for hard to reach groups. In other words, health literacy is an individual's ability to find and use health information. As such, health literacy could include basic skills (e.g., reading, writing, mathematics, speaking), cognitions (e.g., self efficacy, health motivation), and environmental factors (e.g., access). Put another way, what constitutes health literacy may be situationally dependent. It is whatever an individual needs to successfully navigate their health care environment.

At least two parts of health literacy—literacy and numeracy—could be meaningfully related to technology access/use. Although some have become icon and touch based, most digital interfaces still require an understanding of text for successful navigation. Individuals with limited literacy skills may struggle to navigate and comprehend these interfaces, a barrier that could also limit desire to access such technology. The digital world utilizes numbers and mathematics as well, from number pads on cell phones to numbers in email addresses, passwords, and Web sites. Individuals with low or limited numerical abilities may lack the desire or ability to use cell phones, computers, and the Internet. This has the potential to be problematic as it is increasingly the case that health information and services are online (Schmeida & McNeal, 2007) and accessible only to those with sufficient skills to navigate the sites (West & Miller, 2006).

To date, one study has examined the relationship between literacy, numeracy, and technology utilization for health purposes. The 2003 NAAL surveyed a sample of over 19,000 U.S. adults (Kutner et al., 2006). Literacy and numeracy were assessed using three scales (prose literacy, document literacy, and quantitative literacy) that were combined to categorize all participants as belonging to one of four skill levels (from highest to lowest): proficient, intermediate, basic, and below basic. They found that only 12% of adults had the skills necessary to perform complex literacy tasks, although they used general literacy, rather than health literacy, measures. As discussed, the NAAL's operationalization may not account for the medical component of health literacy.

Several groups in the NAAL had higher literacy skills, including women, Whites and Asian Pacific Islanders, individuals 64 years and younger, those with more education, and those living above the poverty line. Of particular interest to the present study, literacy was positively related to looking for health information online (Kutner et al., 2006). In fact, across four sources of information (newspapers, magazines, books or brochures, and the Internet), the strongest relationship was between literacy and Internet use. Individuals with lower literacy skills were dramatically less likely to seek out information online; 80% of adults with below basic literacy received no health information from the Internet.

If basic skills are related to technology access and use, then knowing someone who can offer computer assistance may also be important. A computer assistant could be a person with extensive knowledge of technology or just someone at the next skill level of computer use. Regardless of their ability, computer assistants could serve as a catalyst to technology access (by encouraging and facilitating ownership/access) and use (by helping people overcome skill barriers). The potential value of computer assistants suggests that it would be useful to know more about these individuals. If computer assistants are meaningfully connected to access and use, then researchers may want to identify or even target these individuals. This is especially important as individuals with higher literacy skills also seem to have stronger information networks. That is, skilled individuals receive more health information from family members, friends, coworkers, and health care professionals than their lower skilled counterparts (Kutner et al., 2006), suggesting a disconnectedness that could magnify existing disparities.

The present study sought to examine the relationships among low-income adults' basic skills, computer assistance, and technology access and use. Concerning the latter, technology use was broadened to include both computers and cell phones. Computers may be essential for complete Internet access, but society is increasingly moving toward a single-interface world (Fried, 2008). Americans are becoming accustomed to the notion that every screen should have the same capability: Internet access, movie downloads, email, document storage, voice transmission, and so on. That dream is yet to be realized; however, many Americans have come to expect computer-like service from at least one other screen: their cell phone. A growing number of cell phones have Internet access of some kind or at least allow users to engage in quasi-Internet activity (i.e., Internet searches over the phone and short message service capability).

Low-income adults were targeted because past research has suggested that they have greater skill deficiencies (Kutner et al., 2006), lower access and utilization of technology (Kutner et al., 2006; Schmeida & McNeal, 2007), and a pressing need to become proficient with technology to obtain health services (Viswanath & Kreuter, 2007; West & Miller, 2006). As such, this study looks to answer the following research questions:

Research Question 1 (RQ1): Whom do low-income adults rely on the most for computer assistance?
Research Question 2 (RQ2): Are health literacy, health numeracy, and computer assistance related to technology access?
Research Question 3 (RQ3): Are health literacy, health numeracy, and computer assistance related to technology use?

Mediation

Health literacy and numeracy are often studied as predictor variables. For instance, researchers have examined the relationship between literacy and adherence to asthma self-care (Williams, Baker, Honig, Lee, & Nowlan, 1998). Less often, studies view literacy and numeracy as potential mediators. This is somewhat unexpected as health literacy and numeracy seem to be ideal explanatory mechanisms. For example, past research suggests that the relationship between education and online health information seeking is a reflection of underlying skill disparities (Fox, 2006).

Prior research offers preliminary support for this idea. Past research has found that literacy mediated the relationship between education and glycemic control for 395 diabetes patients (Schillinger, Barton, Karter, Wang, & Adler, 2006).

That is, when literacy was positioned as a mediator, the statistically significant relationship between education and glycemic control became nonsignficant. The authors argued that their results suggest "education operates in part by improving literacy" (Schillinger et al., 2006, p. 252).

Health literacy and numeracy are not the only variables well suited to act as mediators. Computer assistance also has the potential to be a mediator, as individuals with help may be more inclined to engage in an activity. Considering possible mediators and several demographic variables identified as predictors of online health information seeking, including gender, age, education, and race (Fox, 2006, 2008), the following hypotheses are proposed: Health literacy, health numeracy, and computer assistance will mediate the relationship between gender (Hypothesis 1 [H1]), age (Hypothesis 2 [H2]), education (Hypothesis 3 [H3]), race (Hypothesis 4 [H4]), and online health information seeking.

Method

Participants

Low-income adults (*N* = 131) participated in the study. Residents were recruited from seven counties in Indiana (Lake, Madison, Marion, Howard, Tipton, Grant, and Delaware) through University extension programs servicing low-income populations. To qualify as low-income, participants had to be at or below 200% of the poverty line. This threshold was selected as it is routinely used by Indiana agencies to identify individuals in need. Based on this criterion, 97 females (74%) and 34 males (26%) participated in the study. Very few participants had a college degree (15.3%) or a junior college/vocational tech degree (10.7%). Fifty-five percent of the participants had only a high school education. Roughly 1 in 5 (19.1%) had not completed high school education. Participants' mean age was 42.9 years (*SD* = 17.5). The sample was diverse: 59.5% White, 26% African American, 9.2% Hispanic, 3.8% mixed heritage, and 1.8% described themselves as "other."

Procedure

University extension employees helped researchers identify eligible participants in seven poverty-stricken counties in the state of Indiana. Participants were recruited (and participated) in their homes/apartments or in shelters, food pantries, rehab centers, or transitional living spaces. Participants were offered US$30 in grocery certificates to complete the study.

In the study, participants were read a consent form describing their rights as well as the study itself. If they consented, then participants were offered a three-page survey (Flesch-Kincaid grade level = 4.9) in either normal-sized font (12-point, Times New Roman) or large-sized font (18-point, Times New Roman). Participants also had the option to have the survey read by the researcher (to accommodate participants with vision impairments or very low literacy). Eleven people (8%) asked to have the survey read aloud. After the survey, an oral measure of health literacy was administered. Per Institutional Review Board instructions, the study concluded with a debriefing session where participants were encouraged to ask questions.

Independent Variables/Mediators

Demographics. Participants' gender (female, male), race/ethnicity (White, Black, Hispanic, or Mixed/Other), education (less than high school, high school degree, Junior college or vocational tech degree, college degree), and age were measured.

Health literacy. Literacy was measured using the full 66-item Rapid Estimate of Adult Literacy in Medicine (REALM; Davis et al., 1993). The REALM is a word recognition test where participants are given a list of 66 medical terms and asked to read them aloud. Words that are mispronounced or skipped are counted as incorrect. Literacy level is based on the number of correct answers: 0 to 18 correct (≤third grade), 19 to 44 correct (fourth to sixth grade), 45 to 60 (seventh to eighth grade), and 61 to 66 (≥ninth grade). Individuals who score below a 61 on the REALM will struggle with most health materials (Davis et al., 1993). Participants in the current study had a raw mean score of 54.38 (SD = 14.55). By literacy level, participants were distributed as follows: ≤third grade (5.3%), fourth to sixth grade (11.5%), seventh to eighth grade (35.1%), and ≥ninth grade (48.1%).

Health numeracy. Numeracy was measured using an abbreviated version of the Test of Functional Health Literacy in Adults (TOFHLA; Parker, Baker, Williams, & Nurss, 1995). The TOFHLA uses patient materials with written information to assess numeracy. Based on recommendations of past research using the TOFHLA (Baker, Williams, Parker, Gazmarian, & Nurss, 1999), four items assessed numeracy. Participants in the current study had a mean numeracy score of 2.79 (SD = 1.05). By number correct, participants distributed as follows: zero correct (2.3%), one correct (10.7%), two correct (22.1%), three correct (35.1%), and four correct (29.8%). Individuals scoring a four out of four would be considered to have sufficient numerical ability to navigate most health situations.

Computer assistance. Participants were asked, “Is there someone in your life who helps you with computers?” Participants could respond yes or no; if they responded yes, then they were asked to indicate the nature of their relationship with the helper: close relative, distant relative, close friend, friend of a friend, librarian, a computer person I pay to help me, or other.

Dependent Variables

Technology access. Participants were asked if they owned or had access to (a) a computer and (b) a cell phone. Response options were as follows: own, have access to, or neither.

Technology use. Four questions with four-point scales (*never*, *a little*, *a lot*, or *always*) were used to assess technology use. Participants were asked about email use, surfing the Internet, search engine use, and whether they had looked online for health information.

Data Analysis

To answer RQ1, a crosstabs analysis was performed in PASW Statistics 17. RQ2 and RQ3 were addressed using hierarchical regression analysis. A combination of linear regression and multiple mediation analysis (Preacher & Hayes, 2008) tested H1 to H4. Multiple mediation analysis is a two-step process. First, a relationship between two variables must be verified (e.g., via linear regression). Second, multiple mediation analysis is carried out to test whether other variables mediate the relationship identified in the first step.

Results

To better understand the data, a correlation matrix was constructed and examined (see Table 1). The matrix revealed that many of the variables in this study were significantly correlated. Education was positively correlated with literacy and numeracy, and negatively correlated with gender (females were more educated). Health literacy was positively correlated with health numeracy and negatively correlated with race (White participants had higher literacy scores) and age (younger participants had higher literacy scores). Numeracy was also negatively correlated with race and age.

RQ1 asked about the identity of individuals providing computer assistance. Just under half of all participants (43.8%) acknowledged that they have someone in their life who helps them with computers. Of those who received assistance, participants were most likely to be assisted by close relatives

Table 1. Correlation Matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Gender	1.00												
2. Race	−0.29***	1.00											
3. Age	−0.16*	0.23***	1.00										
4. Education	−0.16*	−0.06	−0.03	1.00									
5. Literacy	−0.03	−0.32***	−0.19**	0.40***	1.00								
6. Numeracy	0.06	−0.25***	−0.25***	0.28***	0.42***	1.00							
7. Computer assist	−0.05	0.02	0.09	0.13	−0.02	0.01	1.00						
8. Computer access	−0.16*	−0.12	−0.06	0.33***	0.15*	0.22**	0.29***	1.00					
9. Cell access	−0.05	−0.24***	−0.38***	0.22**	0.14*	0.34***	0.09	0.37***	1.00				
10. Email	−0.06	−0.17	−0.38***	0.25***	0.33***	0.29***	0.09	0.41***	0.25***	1.00			
11. Surf	0.00	−0.18**	−0.41***	0.28***	0.35***	0.27***	0.10	0.38***	0.25***	0.79***	1.00		
12. Search engine	−0.05	−0.06	−0.29***	0.30***	0.34***	0.18**	0.20**	0.38***	0.24***	0.74***	0.79***	1.00	
13. Health seeking	−0.19**	−0.06	−0.16*	0.35***	0.24***	0.16*	0.18**	0.34***	0.12	0.61***	0.71***	0.72***	1.00

*$p < .10$. **$p < .05$. ***$p < .01$.

Table 2. Technology Access

	Own (%)	Have access to (%)	Neither (%)	χ^2
Computer	39.7	34.4	26.0	3.77
Cell phone	70.8	12.3	16.9	82.40***

Note: N = 131. Percentage of participants who owned or had access to a computer or cell phone. If a participant marked both owned and have access to, then they were coded as owned. Chi-squares are reported for each item.
***$p < .01$.

(56.4%), close friends (23.6%), and librarians (7.3%), $\chi^2(5, N = 55) = 72.96$, $p < .001$.

RQ2 asked whether health literacy, health numeracy, and computer assistance were related to technology access. Two types of technology were considered: computers and cell phones (for distribution of technology access variables, see Table 2). To answer this question, hierarchical regression analyses were conducted with predictor variables entered in the following order: health literacy, health numeracy, and computer assistance. For computer access, the model was significant at the third block (computer assistance), $R = .374$, $R^2 = .140$, $F(3, 126) = 6.815$, $p = .001$ (see Table 3). Two predictors were significant at the third block, health numeracy and computer assistance. Individuals with higher numerical skills and those with computer assistance were more likely to own or have access to a computer. For cell phone access, the model was significant at the second block (numeracy), $R = .344$, $R^2 = .118$, $F(2, 126) = 8.457$, $p < .001$. Individuals with higher health-related numerical skills were more likely to own or have access to a cell phone.

RQ3 asked whether health literacy, health numeracy, and computer assistance were related to technology use. Several technology behaviors were examined, including email use, Internet surfing, using search engines, and going online to find health information (for distribution of technology use variables, see Table 4). To answer this question, hierarchical regression analyses were conducted with predictor variables entered in the following order: computer access, health literacy, health numeracy, and computer assistance. Computer access was entered in the first block because technology access and use were highly correlated (see Table 1). In all cases, the model was significant at the second block (health literacy): email use, $R = .507$, $R^2 = .257$, $F(2, 119) = 20.558$, $p < .001$; Internet surfing, $R = .513$, $R^2 = .263$, $F(2, 117) = 20.920$, $p < .001$; search engine use, $R = .484$, $R^2 = .234$, $F(2, 118) = 18.062$, $p = .001$; and online health information seeking, $R = .409$, $R^2 = .168$,

Table 3. Hierarchical Regression Predicating Technology Access and Use with Literacy, Numeracy, and Computer Assistance

	Computer access		Cell access		Email		Surfing		Search engine		Health seeking	
	B (*SE*)	R^2	*B* (*SE*)	R^2	*B* (*SE*)	R^2	*B* (*SE*)	R^2	*B* (*SE*)	R^2	*B* (*SE*)	R^2
Computer access	—	—	—	—	.53 (.12)**	.17	.44 (.12)**	.14**	.45 (.12)**	.15**	.37 (.11)**	.12**
Literacy	.00 (.00)	.02*	.00 (.00)	.02	.02 (.00)**	.25**	.02 (.00)**	.26**	.02 (.00)**	.23**	.01 (.00)**	.16**
Numeracy	.13 (.07)*	.05**	.25 (.06)**	.11**	.10 (.10)	.26	.05 (.09)	.26	–.04 (.10)	.23	.00 (.09)	.16
Assistance	.47 (.13)**	.14**	.13 (.13)	.12	–.04 (.20)	.26	.02 (.18)	.26	.26 (.19)	.24	.21 (.18)	.17
Constant	.29 (.27)		.80 (.26)		.37 (.39)		.31 (.36)		.38 (.38)		.66 (.37)	
n	129		128		121		119		120		122	

Note: Coefficients (*B*) and standard errors (*SE*) are for the final model in which all variables are entered. The R^2 column represents the amount of variance explained by all of the blocks included up to that point. Subtracting R^2 from the previous block will yield R^2 change (i.e., the amount of variance explained by that block alone).
*$p < .10$. **$p < .05$.

Table 4. Technology Use

	Never (%)	A little (%)	A lot (%)	Always (%)	*M* (*SD*)	χ^2
Email use	29.3	26.8	14.6	29.3	2.44 (1.19)	7.24*
Surfing the Internet	29.8	25.6	25.6	19.0	2.34 (1.10)	2.86
Search engine use	35.2	22.1	22.1	20.5	2.28 (1.15)	6.91*
Online health information seeking	37.1	31.5	16.9	14.5	2.09 (1.05)	18.00***

Note: $N = 131$. Percentage of participants who engage in a type of technology use. Means, standard deviations, and chi-squares for each item are also provided.
*$p < .10$. **$p < .05$. ***$p < .01$.

$F(2, 120) = 12.076$, $p = .011$ (see Table 3). Individuals with higher health literacy skills were more likely to use email, surf the Internet, use search engines, and seek out health information online.

H1 posited that health literacy, health numeracy, and computer assistance would mediate the relationship between gender and online health information seeking. Linear regression analysis was used to test whether gender was significantly related to online health information seeking. The model was significant, $R = .191$, $R^2 = .036$, $F(1, 122) = 4.615$, $p = .034$. Consistent with past research (Fox, 2008), women were more likely than men to seek out health information online.

To test whether the relationship between gender and online health information seeking was mediated by health literacy, health numeracy, and computer assistance (controlling for computer access), a series of regressions were carried out (Preacher & Hayes, 2008). The analyses revealed that gender was not significantly related to any of the mediators (a paths), that only one of the mediators (health literacy) was significantly related to online health information seeking (b paths), and that the direct relationship between gender and online health information seeking was still significant even after mediators were taken into account (c' path; see Table 5). In other words, multiple mediation analysis did not support the hypothesis that health literacy, numeracy, and computer assistance mediated the relationship between gender and online health information seeking.

H2 posited that health literacy, numeracy, and computer assistance would mediate the relationship between age and online health information seeking. Past survey research has suggested that the relationship between age and online health information seeking is quadratic (upside down U-shape; Fox, 2008). To test this idea, a curve analysis was carried out; it revealed a significant

Table 5. Mediation Analyses

	Coefficient	*SE*	*t*	*p*
Gender mediation analysis (H1)				
Independent variables to mediators (a paths)				
Literacy	–0.681	3.15	–0.216	.829
Numeracy	0.406	0.218	1.857	.065*
Assistance	–0.007	0.103	–0.074	.940
Direct effects of mediators on dependent variables (b paths)				
Literacy	0.015	0.006	2.25	.026**
Numeracy	0.031	0.096	0.321	.748
Assistance	0.205	0.185	1.112	.268
Direct effect of independent variables on dependent variables (c' path)				
Gender	–0.426	0.213	–2.001	.047**
Age mediation analysis (H2)				
Independent variables to mediators (a paths)				
Literacy	–0.15	0.074	–2.088	.038**
Numeracy	–0.015	0.005	–2.967	.003***
Assistance	0.002	0.002	0.869	.386
Direct effects of mediators on dependent variables (b paths)				
Literacy	0.014	0.006	2.201	.029**
Numeracy	–0.014	0.098	–0.145	.884
Assistance	0.190	0.189	1.008	.315**
Direct effect of independent variables on dependent variables (c' path)				
Age	–0.007	0.005	–1.394	.165
Education mediation analysis (H3)				
Independent variables to mediators (a paths)				
Literacy	6.176	1.058	5.836	.000***
Numeracy	0.256	0.081	3.159	.002***
Assistance	0.040	0.039	1.022	.308
Direct effects of mediators on dependent variables (b paths)				
Literacy	0.009	0.007	1.267	.207
Numeracy	–0.028	0.094	–0.303	.762
Assistance	0.148	0.185	0.796	.427
Direct effect of independent variables on dependent variables (c' path)				
Education	0.216	0.090	2.387	.018**

Note: Mediation analyses for H1, H2, and H3. All analysis controlled for computer access.
*$p < .10$. **$p < .05$. ***$p < .01$.

quadratic relationship between age and online health information seeking, $F(2, 120) = 8.121$, $R^2 = .119$, $p < .001$, as well as a marginally significant linear relationship, $F(1, 121) = 3.388$, $R^2 = .027$, $p = .068$ (i.e., the left side of

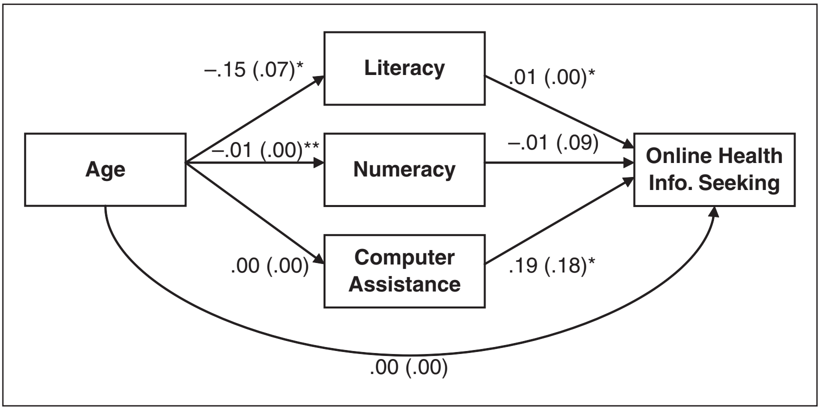

Figure 1. Relationship between age and health seeking
Note: Numbers in the figure are coefficients.
*$p < .05$.

the upside down U-shape is higher than the right side). Participants aged 29 to 52 were more likely than their younger and older peers to search for health information online (quadratic relationship). In addition, the older the participants were the less likely they were to go online for health information (linear relationship).

Multiple mediation analysis was used to test whether the relationship between age and online health information seeking was mediated by health literacy, numeracy, and computer assistance. The analysis revealed that age was significantly related to literacy and numeracy (a paths), that one of the mediators (health literacy) was significantly related to online health information seeking (b paths), and that the direct relationship between age and online health information seeking was no longer significant after mediators were taken into account (c' paths). In other words, multiple mediation analysis supported the hypothesis that health literacy mediated the relationship between age and online health information seeking (see Figure 1). As multiple mediation analysis can only account for the linear component of the relationship between age and online health information seeking, this result means that older individuals are less likely to search for health information online primarily as a result of diminishing health literacy skills.

H3 posited that health literacy, numeracy, and computer assistance would mediate the relationship between education and online health information seeking. Consistent with past research (Fox, 2008), linear regression analysis revealed a significant relationship between education and online health information seeking, $R = .380$, $R^2 = .145$, $F(1, 122) = 19.981$, $p < .001$. Higher educated individuals were more likely to go online for health information. Multiple mediation analysis revealed that education was significantly related to health literacy and numeracy (a paths), that none of the mediators were significantly related to online health information seeking (b paths), and that the direct relationship between education and online health information seeking was still significant even after mediators were taken into account (c' paths). H3 was not supported.

H4 posited that health literacy, numeracy, and computer assistance would mediate the relationship between race and online health information seeking. However, inconsistent with past research (Fox, 2006), the relationship between race and online health information seeking was not significant, $R = .061$, $R^2 = .004$, $F(1, 121) = 0.450$, $p = .504$. Thus, H4 was not supported.

Discussion

The present study sought to address inequalities in online health information seeking by examining the nature of technology access and utilization among low-income adults. Several findings emerged that warrant consideration. Health literacy was unrelated to technology access, suggesting that individuals with limited skills are just as likely to own or have access to computers and cell phones. Thus, possibly due to the widespread diffusion of computers and cell phones, low-income individuals with limited literacy appear to have opportunities to use technology. Unfortunately, the present study suggests they do not currently use this access. Researchers will want to consider what it is about technology use that proves daunting to low-literacy populations.

The need to understand and manipulate text is one obstacle; however, it is also possible that user control and/or interactivity could overwhelm users with limited literacy capabilities. For instance, high-literacy individuals might weave through exhausting Internet searches, jumping from item to item in pursuit of desired information, whereas individuals with low literacy may struggle to manage the seemingly infinite tide of dense (and often jargon heavy) text. The growing body of literature on aging adults and technology (see Burdick & Kwon, 2004), however, might suggest another possible explanation. Unfamiliarity, rather than diminishing health-literacy skills, might stand between aging and low-literacy adults and online health information seeking. It might be useful to train low-literacy and adult populations to find trustworthy sites that use plain language as a way to increase utilization of this population's technology access. Experimental and observational methods could be used to test the validity of these explanations. Special attention should be paid to whether decreased cognition, compared to self-efficacy related to the technology, are most related to utilization.

Some outlets exist, like the National Institutes of Health's Senior Health Web site (www.NIHSeniorHealth.gov; see Morrell, Dailey, & Rousseau, 2003), that provide less dense, easy-to-use interfaces. Researchers still need to investigate how variations in Web site elements and amount of user interactivity relate to knowledge growth and behavior change in aging, low-literacy populations. Future research needs to account for the usability of Web sites for aging adults (e.g., Nahm, Preece, Resnick, & Mills, 2004) as well as the potential utility of online communities for this population (see Preece & Maloney-Krichmar, 2005). Proven interfaces exist (e.g., Zajicek, 2004) that could be useful in planning comparative studies that scientifically test multiple interfaces against each other on a variety of dimensions such as usability, interactivity, enjoyment, and other related constructs.

Unlike literacy, numeracy was positively related to technology access but unrelated to technology utilization. One explanation for numeracy's role in predicting technology access is that computers and cell phones are uniquely numerical information systems. Email addresses, keypads, phone numbers, and interfaces routinely require a basic ability to handle numerical information. This may highlight the importance of interface features for low-literacy populations. To a person with sufficient numerical ability, computers and cell phones may seem more textual than numerical. But to individuals with low numeracy, these devices could be thought of as complex calculators or number-driven machines that are so challenging as to be completely avoided (i.e., reduced access).

Taken together, literacy and numeracy findings from this study suggest that health communicators and technology developers should (a) minimize the numerical component of computer technology and (b) increase the interactive capability of new information systems. Touch- or icon-based systems may be more appealing to low-skilled groups, especially if they can be easily adapted to those with declining skills. For example, with an aging population, it will be increasingly important to cultivate computer technology that is sensitive to declining visual and physical skills. Developers should explore the possibility of redesigning Web pages so that they can be viewed in sections (rather than as long, horizontal intact pages). This would allow for more focused (and perhaps less intimidating) consumption of computerized information. An alternative approach is to cultivate a more human persona for computer technology. Traditional information sources are often very personal (e.g., a doctor, a news anchor, a librarian), a concept that could be built into new media portals.

The present study explored one personal factor in computer technology: computer assistants. Computer assistance was only significantly related to computer access, a finding that could reflect the fact that those who own computers are more likely to need assistance. More interesting is the information garnered about the identity of computer assistants. Much has been written on the strength of weak ties (Granovetter, 1973)—in other words, the tendency for distally related individuals to serve as key information/skill resources. But with widespread penetration and utilization of cell phones, computers, and the Internet, it is possible that the remaining nonusers are unique in their lack of skilled weak ties. That is, underserved groups may be fairly isolated and therefore cut off from the larger social networks that bind and move the general population. Within this sample, individuals received assistance primarily from close relatives, close friends, or librarians. Participants lacking a close contact with the desire or ability to help seemed to have no assistance at all, although our questionnaire could not account for whether those reporting they had no assistance *needed* any assistance. Our finding related to close contacts is, however, consistent with past research that found that low-literacy populations have fewer personal information sources (and perhaps contacts) than their more skilled counterparts (Kutner et al., 2006). It could be that those who lag behind have been disconnected from the larger social system.

Finally, consistent with past research, gender, age, and education were once again identified as key predictors of technology use and access (Fox, 2008; Kaiser Family Foundation, 2005). In some ways, these three variables are a cornerstone of research on technology disparities, as progress will likely stem from successful attempts to explain why these demographic factors are so important. What our study does not explain is why women, even when they have low health literacy and low income, still search for health information more than men. Researchers need to focus efforts on determining how to get men with lower skills more involved with their own health. Perhaps men look for health information less because some close female relative seeks information on their behalf, but this sort of traditional, patriarchal explanation seems unlikely, as it is overly simplistic. The present study took another step in that direction by examining the interrelations between gender, age, and education and three other variables: literacy, numeracy, and computer assistance.

Only one mediator emerged in the present study: literacy. Literacy was a significant mediator of the relationship between age and online health information seeking. This finding does not imply any type of causal relationship, but it is in line with past research (Fox, 2008); the relationship between age and online health information seeking was found to be both quadratic and marginally linear (i.e., the left side of the upside down U-shape is higher than the right side). Literacy mediated the linear aspect of this relationship; that is, the linearity is primarily a byproduct of diminishing skill associated with advancing age (e.g., Clay et al., 2009). Not only does this support the notion that literacy can be an effective mediator, but it also has strong face validity. The quadratic relationship between age and online health information seeking is likely a result of two different forces: (a) Young people are less likely to search for health information because they do not perceive themselves to be at risk and (b) older individuals, who are at risk, are less likely to search because of declining literacy skills. Other explanations for this quadratic relationship also exist. Perhaps younger individuals have a lower need to search for online health information, and as discussed, older individuals' lack of use might be attributed to limited familiarity with certain technology rather than declining skills. Further explaining the quadratic relationship should be answered by future research.

Mounting evidence suggests that skill deficiencies may explain a multitude of service gaps (Baker et al., 2004; Jensen, King, Guntzviller, & Davis, 2010; Williams, Davis, Parker, & Weiss, 2002). Moreover, unlike demographic factors, inequalities related to skill can be addressed directly by either enhancing certain skills of underserved groups or reducing the necessary skills required to perform certain tasks. Of the two options to address those inequalities, interventions to enhance skills are a complex endeavor, so it may be more efficacious and cost effective to focus on making more user-friendly technological interfaces for individuals engaging in online health information seeking.

The alternative explanation to skills deficiencies is that older individuals may be less likely to use computer technology for health information because they prefer more traditional information sources. For example, older individuals may value sources like medical professionals, family, newspapers, or television news more than information sources accessed through new technologies. In other words, there could be a general disinterest or discomfort with computer technology among older populations generally, a situation that undermines utilization of this communication channel for health purposes.

Results related to H4 presented seemingly anomalous findings. There was no relationship between race and online health information seeking, contrary to previous findings (e.g., Fox, 2006). Explanations for this finding are difficult as our data came from a very low-income sample from one geographical area. One interpretation could be that there is a weakening racial disparity in Internet access and utilization in Indiana, but the data only allow for speculation. Future large-scale survey studies should allow for further exploration into the increasing or decreasing nature of Internet-related disparities.

Limitations

The current study had several limitations. The sample was recruited from seven counties in Indiana and therefore may not be representative of the low-income population of the rest of the United States. Low-literacy populations were targeted in this study, so the survey instrument was designed to be as short and simple as possible. As a result, single-item measures were used for some constructs where indexes would be preferred (e.g., online health information seeking). On a related note, an obstacle to studying literacy in low-income populations is that many of the least-skilled individuals actively avoid research. Recruitment of participants attempted to counter this by working with extension employees who knew/worked with low-income members of the community, visiting participants in their homes or current housing (e.g., shelters) and by providing nonliteracy participation options (i.e., reading the survey).

Finally, cell phone use is examined here because some users may access cell phones for Internet services; however, it is true that not all cell phone users access the Internet with their phones. Future research could investigate the extent low-income populations use cell phones to traverse the Internet.

Conclusion

Individuals currently have access to more information about their health than at any point in recorded history. Unfortunately, both technology and health care are undermined by access/utilization inequalities. As a result, certain members of the populations are less likely to have access to, use, and benefit from technology advances. Researchers should continue to study inequalities with the goal of reducing or at least minimizing such disparities. The present study suggests that significant advances in technology access and use could be sparked by increasing literacy and numeracy skills in underserved groups through educational programming and developing technology interfaces that are accessible to individuals with limited literacy and numeracy skills.

Declaration of Conflicting Interests

The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding

The authors disclosed that they received the following support for their research and/or authorship of this article: work supported by Regenstrief Center for

Healthcare Engineering and the National Institutes of Health, Grant No. 1R25CA128770-25.

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