Bridging the Digital Divide in Diabetes: Family Support and Implications for Health Literacy

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Abstract

Background: Patient web portals (PWPs) offer patients remote access to their medical record and communication with providers. Adults with health literacy limitations are less likely to access and use health information technology (HIT), including PWPs. In diabetes, PWP use has been associated with patient satisfaction, patient–provider communication, and glycemic control.

Methods: Using mixed methods, we explored the relationships between health literacy, numeracy, and computer literacy and the usage of a PWP and HIT. Participants ($N = 61$ adults with type 2 diabetes) attended focus groups and completed surveys, including measures of health literacy, numeracy, and computer anxiety (an indicator of computer literacy) and frequency of PWP and HIT use.

Results: Computer literacy was positively associated with health literacy ($r = 0.41$, $P < 0.001$) and numeracy ($r = 0.35$, $P < 0.001$), but health literacy was not associated with numeracy. Participants with limited health literacy (23%), numeracy (43%), or computer literacy (25%) were no less likely to access PWPs or HIT, but lower health literacy was associated with less frequent use of a computer to research diabetes medications or treatments. In focus groups, participants spontaneously commented on family support when accessing and using PWPs or HIT for diabetes management.

Conclusions: Participants reported family members facilitated access and usage of HIT, taught them usage skills, and acted as online delegates. Participant statements suggest family members may bridge the HIT "digital divide" in diabetes by helping adults access a PWP or HIT for diabetes management.

Introduction

PATIENT WEB PORTALS (PWPs) are web-based applications linked to an electronic health record. PWP functions often include the ability to view test results, message providers, and manage medical appointments and bills.[1,2] In a recent review evaluating the impact of PWPs on diabetes outcomes,[3] patient usage of a PWP was associated with patient–provider communication, patient satisfaction, diabetes self-care activities, glycemic control, and a reduction in emergency room visits and hospital admissions.

Although an estimated 79% of Americans used the Internet in 2010,[4] there continues to be a "digital divide" in using the internet for health-related reasons by age,[5–8] race/ethnicity,[5] education,[6–8] income,[6] and health literacy.[7–10] Among diabetes patients who have Internet access, those with health literacy limitations are less likely to use a PWP compared with those with adequate health literacy.[9] By definition, health literacy is the ability to understand and act on medical information,[11] numeracy is "the ability to understand and use numbers in daily life,"[12] and computer literacy is "fluency with information technology"[13] or the "ability to seek, find, understand, and appraise information from electronic sources and apply the knowledge gained."[14]

Only one study to our knowledge has explored the role of health literacy and usage of a PWP among individuals with diabetes.[9] Numeracy and computer literacy were not measured in that study, nor was qualitative information gathered to understand the details of patients' usage or non-usage of the PWP. Thus, we used a mixed methods approach to explore the role of patient health literacy, numeracy, and computer literacy on usage of a different PWP and other forms of health information technology (HIT) (e.g., health information and diabetes self-management websites, mobile health applications).

Subjects and Methods

Recruitment and study participants

Focus groups were conducted as part of a larger project studying PWP and HIT use for diabetes management. From

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June to December 2010, trained research assistants recruited adult, English-speaking patients prescribed antihyperglycemic medications for type 2 diabetes from a primary care clinic at an academic medical center. Research assistants approached patients in clinic waiting rooms and responded to patients inquiring about the study from fliers or medical center listerv announcements.

Data and procedures

Upon enrollment, participants gave researchers permission to obtain basic demographic information (age, gender, and race) from their medical record and were asked, "How often do you use Vanderbilt's patient web portal, MyHealthAtVanderbilt, when you need to manage your health?" Responses were in Likert format, ranging from 1 = not at all to 5 = very often, and were used to assign participants to a nonuser, low user, or high user focus group. Groups homogeneous with respect to the subject matter tend to generate more rich discussions and decrease the likelihood any one perspective is marginalized or silenced by another perspective.[15] Thus, grouping by usage of a PWP was intended to make participants more comfortable and facilitate more discussion rather than generate thematic saturation by user group.

Focus group participants attended a 90-min single session consisting of a semi-structured discussion and a survey. Authors L.S.M. and C.Y.O. led each focus group, while research assistants logged who said what and all nonverbal communications. Focus group discussions adhered to the question protocol of the parent study, which focused on usage of the medical center's PWP and HIT for diabetes management and suggestions for improving the PWP to support diabetes self-management. All 11 focus group discussions began with introductions and general questions about diabetes and self-management, such as "How long have you had diabetes?" and "What do you do when you have questions about your medications?," and then focused participants on their perspectives and experiences regarding technology use for diabetes management. We encouraged focus group discussion related to barriers and strategies for diabetes self-care, use of technology to manage diabetes or general health, and experiences or suggestions regarding the PWP.

Focus group methodologies allow for participants to serve as experts, and the diversity and similarities in their experiences and perspectives create richness of data.[15,16] As experts, focus group participants teach researchers about the phenomenon of interest, generate emergent comments, and thus shift the research in unanticipated areas.[15,16] To that end, the topic of family support for PWP and HIT use emerged without specific questions from the facilitators.

Survey questions pertained to demographics and usage of HIT. Focus group sessions were recorded and transcribed verbatim, supplemented with session notes, and linked to participant survey data. Research assistants later contacted participants by phone and e-mail to complete a brief follow-up survey that included measures of health literacy, numeracy, and computer literacy. Focus group participants were provided light refreshments and $40 for participation in the focus group discussion, and an additional $10 for completion of the follow-up survey. Enrolled participants who did not attend a focus group were invited to participate in the survey-only portion of the study via phone, mail, or e-mail. Survey-only participants were provided $20 for completion of the follow-up survey.

Measures

Demographic information collected from all enrolled who completed a consent form included age, gender, and race. Study participants provided additional demographic information, including educational attainment, annual family income, health insurance status, and marital status.

Health literacy. Health literacy was assessed with the three-item health literacy screening questionnaire,[17,18] which has been validated against widely used measures of health literacy.[19–21] Items ask respondents: (HL Q1) "How often do you have someone help you read hospital or clinic materials?"; (HL Q2) "How confident are you filling out medical forms by yourself?"; and (HL Q3) "How often do you have problems learning about your medical condition because of difficulty understanding written information?" We modified the responses from a 5-point to a 6-point Likert scale to be consistent with the other measures we administered. In keeping with prior studies, respondents scoring 1–5 (ever having problems) were categorized as having limited health literacy, and those scoring 6 (never having problems) were categorized as having adequate health literacy.[19] Each item was analyzed separately as the developers of these items recommend.[17,18]

Numeracy. Numeracy was assessed with items from the Subjective Numeracy Scale,[22] a valid and reliable measure of perceived ability to perform various mathematical tasks and a preference for numerical representations of information.[23] Responses are on a 6-point Likert scale and are averaged to produce a score ranging from 1 to 6, with higher scores indicating greater numeracy. We also performed a median split (median = 4.8) to categorize participants with low versus high numeracy scores.

Computer literacy. To assess computer literacy, we used a four-item subscale of the Computer Anxiety Rating Scale that measures comfort with computers and the ability to operate a computer.[24] Responses are on a 6-point Likert scale and are summed to produce a score ranging from 4 to 24, with higher scores indicating greater computer anxiety. For our purposes, items were reverse coded and then summed, such that higher scores indicated greater computer literacy. We also categorized participants as having low (scores 4–16), moderate (scores 16–22), or high (scores 22–24) computer literacy.

Usage of a PWP. Usage of a PWP was assessed at enrollment with a single question, "How often do you use Vanderbilt's patient web portal, MyHealthAtVanderbilt, when you need to manage your health?" Responses were in Likert format, ranging from 1 = not at all to 5 = very often.

Usage of HIT. Two items asked participants if they use a computer or cell phone to access health information. Responses were in yes or no format. We also asked, "How often do you use a computer to research diabetes medications or treatments?" This response was in Likert format, ranging from 1 = never to 6 = very often.

Data analysis

We used SPSS version 19.0 software (SPSS, Inc., Chicago, IL) for all analyses. First, we tested for differences between focus

group attendees ($n = 45$) and non-attendees ($n = 30$) on available demographic information (i.e., age, gender, and race) and usage of a PWP. We also tested for differences between focus group attendees ($n = 45$) and survey-only participants ($n = 16$) on all demographic information (i.e., age, gender, race, education, income, insurance status, and marital status), health literacy status, numeracy status, computer literacy status, and usage of a PWP and HIT. We specifically used χ^2 and Fisher's exact tests to examine group differences by race, gender, education, income, insurance status, marital status, health literacy status, numeracy status, computer literacy status, and use of a cell phone and of a computer to access health information. We then used independent-samples t tests and nonparametric Mann–Whitney U tests to examine group differences on continuous measures of age, health literacy, numeracy, and computer literacy, PWP use, and usage of a computer to research diabetes medications or treatments.

Next, we used Mann–Whitney U tests to examine the relationships between health literacy status, numeracy status, and computer literacy status and usage of a PWP and HIT (i.e., using a computer to research diabetes medications or treatments). We then used Fisher's exact test to examine the relationships between health literacy status, numeracy status, and computer literacy status and use of a cell phone and use of a computer to access health information. Finally, we used Spearman's ρ to examine relationships between continuous measures of health literacy, numeracy, and computer literacy and usage of a PWP and HIT. All focus group audio files were transcribed verbatim. We coded these transcripts with NVivo 9 software (QSR International Pty. Ltd., Doncaster, VIC, Australia), focusing on participants' comments about accessing technology to manage their health.

Results

Participant characteristics

Of the 75 enrolled participants, 45 (63%) attended a focus group, and 59 (79%; i.e., 43 focus group participants and 16 survey-only participants) completed a survey. Sample descriptions are provided in Table 1, presented for all enrolled participants, focus group attendees, focus group non-attendees, and (of non-attendees) survey-only participants. There were no significant differences between focus group attendees ($n = 45$) and non-attendees ($n = 30$) on age, gender, race, or usage of a PWP. There were no significant differences between focus group attendees ($n = 45$) and survey-only participants ($n = 16$) on age, gender, race, health literacy status (questions analyzed separately), numeracy status, computer literacy status, usage of a PWP, or usage of HIT (all variables tested for group differences are presented in Table 1).

All enrolled participants who did not attend a focus group were invited to an average of 2.9 (SD = 0.5) sessions. We conducted 11 focus groups: two non-user groups, five low-user groups, and four high-user groups. Of the 59 participants with survey data, 23% were identified as having limited health literacy on at least one of the health screening items. Numeracy scores ranged from 2.4 to 6.0 with an average score of 4.7 (SD = 0.9). Computer literacy scores ranged from 9 to 24 with an average score of 21.8 (SD = 4.1).

Seven participants reported never having used the medical center's PWP. Among PWP users, the average usage score was 3.6 (SD = 1.0), indicating that PWP users reported accessing the portal to manage their health "sometimes" to "often." Most participants (93%) reported using a computer to access health information, but only 10% reported using a cell phone to access this information. The majority (85%) also reported using a computer to research diabetes medications or treatments, with 44% doing so frequently (≥ 4 on a 6-point scale).

Group differences. Because of the small number of participants who reported using a cell phone ($n = 6$) or not using a computer ($n = 4$) to access health information, we were unable to detect group differences between health literacy status, numeracy status, and computer literacy status and using a computer or cell phone to access health information. Moreover, because of the limited number of participants who reported limited health literacy on individual screening questions, we dichotomized participants into two groups: those who reported no health literacy limitations on any screening questions (77%) and those who reported health literacy limitations on any screening questions (23%). Participants who reported any health literacy limitations reported less HIT use to research diabetes medications or treatments than participants who reported no health literacy limitations (Mann–Whitney U = 134.5, $P = 0.003$), but did not report less usage of a PWP. There were no statistically significant group differences in usage of a PWP or HIT based on numeracy (low vs. high) or computer literacy (low/moderate vs. high).

Correlations. Because of our small sample, we used Spearman's ρ to examine relationships between variables as continuous measures (Table 2). Computer literacy was positively associated with health literacy (HL Q2; $r = 0.41$, $P < 0.001$) and numeracy ($r = 0.35$, $P < 0.001$), but health literacy was not associated with numeracy. As shown in Table 2, health literacy was associated with usage of a computer to research diabetes medications or treatments, but not usage of a PWP. Furthermore, numeracy and computer literacy were not associated with usage of a PWP or HIT. However, usage of a PWP was marginally associated with usage of a computer to research diabetes medications or treatments ($r = 0.25$, $P = 0.06$).

Participant comments: family involvement in PWP/HIT use

Inconsistent with predictions, quantitative data did not support relationships between patient numeracy or computer literacy and usage of a PWP or HIT. Given these unexpected results, we reviewed the focus group transcripts to understand how participants accessed and used a PWP and HIT regardless of their health literacy status, numeracy status, or computer literacy status.

Despite the absence of family-specific questions from focus group facilitators, participants in all 11 focus groups mentioned family member support to access and use HIT, indicating the importance of family members in participant experiences with HIT. Focus group statements consistently illustrated three distinct ways in which family members support patients' usage of a PWP and HIT: (1) family members facilitate usage of a PWP and HIT, (2) family members teach patients usage skills, and (3) family members act as online delegates for patient's PWP accounts. High-, low-, and non-user focus group transcripts contained similar comments about family member support in accessing and using PWPs and HIT. One notable difference

Table 1. Sample Characteristics by Participation Group

Variable	All enrolled (n=75)	Focus group attendees (n=45)	Focus group non-attendees (n=30)	Survey-only participants (n=16)
Demographics				
Age (years)	56.9±8.8	57.6±8.9	55.8±8.8	55.7±7.9
Race				
White	47 (65)	30 (67)	17 (59)	11 (73)
Non-white	25 (35)	15 (33)	12 (41)	4 (27)
Female gender	51 (68)	30 (67)	21 (70)	12 (75)
Education				
< High school degree	—	0 (0)	—	0 (0)
High school degree	—	7 (16)	—	3 (20)
Some college	—	15 (35)	—	7 (47)
College degree or more	—	21 (49)	—	5 (33)
Annual family income				
<$10,000	—	4 (11)	—	1 (7)
$10,000–$29,000	—	3 (7)	—	1 (7)
$30,000–$59,000	—	19 (43)	—	4 (29)
>$60,000	—	17 (39)	—	8 (57)
Insurance status				
Private only	—	27 (60)	—	12 (75)
Public only	—	9 (20)	—	2 (12.5)
Both	—	7 (16)	—	2 (12.5)
None	—	2 (4)	—	0 (0)
Marital status				
Married/partnered	—	31 (69)	—	9 (56)
Single/widowed/divorced	—	14 (31)	—	7 (44)
Predictors				
Health literacy				
Q1: problems reading hospital/clinic materials	—	5.6±1.0	—	5.3±1.4
Limited	—	3 (7)	—	3 (19)
Adequate	—	40 (93)	—	13 (81)
Q2: problems filling out medical forms	—	5.8±0.8	—	5.7±0.6
Limited	—	1 (2)	—	1 (6)
Adequate	—	41 (98)	—	15 (94)
Q3: understanding written medical information	—	5.1±1.7	—	5.8±1.0
Limited	—	8 (19)	—	1 (6)
Adequate	—	35 (81)	—	15 (94)
Numeracy	—	4.7±0.9	—	4.9±0.9
Low	—	21 (49)	—	5 (31)
High	—	22 (51)	—	11 (69)
Computer literacy	—	21.8±4.6	—	21.3±3.9
Low	—	5 (12)	—	2 (12.5)
Moderate	—	4 (9)	—	4 (25)
High	—	34 (79)	—	10 (62.5)
Outcomes				
PWP use	3.2±1.3	3.3±1.3	3.0±1.4	3.5±1.2
HIT use				
Use computer for health information	—	41 (91)	—	16 (100)
Use cell phone for health information	—	4 (9)	—	2 (13)
How often use a computer to research diabetes medications/treatments	—	3.2±1.6	—	3.3±1.1

Data are mean±SD values or *n* (%).
HIT, health information technology; PWP, patient web portal.

between user focus groups is that participants in high-user groups commented on family member support with more advanced technologies, such as smartphone applications, whereas low- and non-users groups did not reference these advanced technologies as frequently. The ways in which family member support facilitates usage of HIT did not vary systematically by PWP user group. Table 3 maps study variables onto focus group statement summaries about family involvement in access and usage of a PWP and HIT. Relevant quotes are written verbatim below and denoted by letter in text and in Table 3.

Family members facilitate usage of a PWP and HIT. Family members increased participants' usage of a PWP and HIT by facilitating initial access and continued use. A common way participants learned about the medical center's PWP was through a knowledgeable family member:

TABLE 2. CORRELATIONS AMONG HEALTH LITERACY SCREENING QUESTIONS, NUMERACY, COMPUTER LITERACY, AND FREQUENCY OF PATIENT WEB PORTAL USE AND HEALTH INFORMATION TECHNOLOGY USE

	Health literacy			Numeracy	Computer literacy	PWP use	HIT use
	Q1	Q2	Q3				
Health literacy							
Q1: problems reading hospital/clinic materials	1.00					ns	ns
Q2: problems filling out medical forms	0.29*	1.00				ns	0.34*
Q3: problems understanding written medical information	0.25†	0.28*	1.00			ns	0.36**
Numeracy	ns	ns	ns	1.00		ns	ns
Computer literacy	ns	0.41**	ns	0.35**	1.00	ns	ns

†$P < 0.08$, *$P < 0.05$, **$P < 0.001$; ns = not significant.
Note that r between PWP use and HIT use is marginally significant ($r = 0.25$, $P = 0.06$).
HIT, health information technology; PWP, patient web portal.

My daughter showed [the PWP] to me in my doctor's office, on the computer in the waiting room. No one in the doctor's office ever approached me about it. If it wasn't for my daughter, I wouldn't be a [PWP] user.[a] (White male, 63 years old)

Participants also shared that a family member who was helping them manage their health or address a health problem would often facilitate their continued use of HIT. For instance, one participant indicated he used a cell phone application because his wife encouraged its use and used it with him:

I travel a lot, so a lot of what [my wife and I] do is on the Internet. We use Calorie King, on our cell phones, to do Weight Watchers together. My wife is very engaged in my health—more so than I am at times.[b] (Hispanic male, 46 years old)

Participants reported sitting at a computer to research a diabetes-related problem together with a family member. For instance, one participant recounted how he came to be diagnosed with diabetes:

My wife and son did some research online, and they showed me—they were like "I think you've got diabetes." And we presented it to the doctor…sure enough, I was diabetic.[c] (African American male, 46 years old)

Family members teach usage skills. Many participants described how a family member helped them learn how to use different PWP functions (e.g., viewing lab results) or other forms of HIT. For example, a participant recounted how her children had given her a smartphone and taught her how to use it for health-related lists:

And now I carry it with me and just add things as they come up. When I go to my doctor's appointments, I just pull up my list of medications and my list of questions.[d] (White female, 60 years old)

Some participants shared instances when they taught their family members with diabetes how to use a PWP:

I tried to get [my husband] involved on the [PWP] website. I showed him how to look up information about his diet, but it seems like he's just not interested in managing his diabetes like I am.[e] (White female, 61 years old)

Another participant described searching online for a video demonstrating how to perform blood glucose monitoring to share with his mother who had diabetes:

I was trying to show my mother that I take my blood [test] here instead of in the finger because it's painless. And, you know, I looked for some video clips that would show her… [We need] to have some videos online for that to make it more interactive as far as being educational.[f] (White male, 62 years old)

Family members act as delegates. Several participants discussed having a delegate access their PWP account. One couple shared that the wife often viewed her husband's account and used it to message his providers when his prescriptions needed to be refilled. Both partners had high levels of computer literacy, but the wife had considerably higher health literacy and numeracy than the husband. The PWP allowed her to have direct access to managing his medications.

Another participant explained how the delegate function would help him when he is traveling and needs care:

I think that with the amount of traveling I do, there are some advantages to using the PWP. If I ever end up in an Urgent Care or in an emergency, I now have access to something very quickly that my wife can pull up and [a provider] who doesn't know me can say "here's what's going on, here are all the medications and the history."[g] (Hispanic male, 46 years old)

Participants stressed the importance of having control over their PWP account and maintaining its security. One participant who did not use the PWP shared it was important for her to be able to choose who was allowed to access her health information through the portal:

My sister and I, we live together. I give her access [to my health information]. Anybody else in the family, no.[h] (African American female, 56 years old)

Later in the discussion, this participant shared that her sister handled all of her health information and was responsible for refilling her prescriptions and paying her medical bills, thereby emphasizing the utility of offering PWP delegates.

Discussion

We used a mixed methods approach to understand associations between patient health literacy, numeracy, and computer literacy and usage of a PWP and HIT. Health lit-

Table 3. Participant Statements About Family Member Roles in PWP/HIT Use Mapped onto Health Literacy Status, Numeracy Status, Computer Literacy Status, and PWP Use

Health Literacy	Numeracy	Computer Literacy	PWP Use	Family Member Role in PWP/HIT Use		
				Facilitate Usage	Teach Usage Skills	Act as a Delegate
Limited	Moderate	Low	Low	Daughter introduced pt to PWP[a]	Daughter taught pt how to use PWP features	
Limited	High	High	None	Wife engaged pt with HIT to manage diet; wife on program using the same HIT[b]		Pt wants wife to be able to access his PWP in an emergency [g]
Adequate	Low	High	High	Wife & son used internet research to help pt ask his provider about symptoms[c]		
Adequate	High	High	High	Children gave pt a portable electronic device	Children taught pt how to use device to make lists of medical information to share with providers[d]	
Adequate	Low	High	High		Pt engaged husband with PWP to help him to manage his diabetes[e]	
Adequate	High	High	Low		Pt shows his mother an online instructional video on blood sugar testing[f]	
Limited	Low	Low	None			Pt's sister manages prescriptions and billing[h]
Adequate	Moderate	High	High		Husband researches dietary information online to buy groceries that conform to pt's diabetic diet	Husband can access PWP and often attends doctor's appointments with pt
Limited	Low	High	Low			Pt looks at wife's PWP, keeps track of her appointments
Adequate	Moderate	High	Low			Pt looks at husband's PWP; manages prescription refills for him
Adequate	Low	Low	High	Husband shows pt how to research health information online	Husband searches online for information about pt's allergic reaction	
Adequate	Low	Moderate	Low	Wife tells pt about online weight loss programs		

Note: Participants who had limited health literacy on any of the three questions are characterized as having limited health literacy.
PWP, patient web portal; HIT, health information technology; EMR, electronic medical record; Pt (pt), participant.
[a-h]Verbatim comments are given in the text.

eracy was associated with usage of a computer to research diabetes medications or treatments, and health literacy and numeracy were associated with computer literacy in the predicted directions, but there was no association between health literacy and numeracy. This is consistent with studies reporting patients with high health literacy often have numeracy limitations.[12,25] Furthermore, we found no association between patient numeracy or computer literacy and

usage of a PWP and HIT, and no association between health literacy and usage of a PWP. A plausible reason for this was the processes through which participants come to access and use a PWP or HIT.

Based on qualitative data, we identified *family member support* as a reason for why patients of all health literacy, numeracy, or computer literacy levels might be accessing and using PWPs and HIT. We also found a relationship between

patient health literacy and the frequency of using computers to research diabetes-specific medications or treatments. Thus, health literacy appears to be associated with the *frequency* of using technology to manage one's health but, according to focus group statements, might not be a prerequisite to *accessing* a PWP or other HIT. Focus group participants indicated that family members facilitated both their access to and continued use of a PWP and HIT, taught PWP and HIT usage skills, and served as PWP delegates. Selwyn[26] also found that family members facilitated access to and usage of information and communication technologies among older adults, and several technology-based interventions for older adults have focused on the involvement of family members.[27–29]

Our findings follow those of Lee et al.[30] who propose an individual's social network serves to buffer the negative effects of low health literacy through resources and support. Osborn et al.[31] also found that diabetes patients with health literacy limitations require more social support to perform self-care behaviors and maintain glycemic control. Thus, adults with low health literacy may draw upon their social support networks and family members specifically when their limitations present barriers to accessing tools for diabetes management. In this way, social support may moderate the effects of low health literacy on use of a PWP and HIT among adults with diabetes.

In addition to health literacy, this is the first PWP study to our knowledge to include measures of numeracy and computer literacy. We found no relationship between these factors and usage of a PWP or HIT. Family members might be helping patients with numeracy and computer literacy limitations access these technologies, or patients might be utilizing HIT as a result of their engagement in their health rather than their efficacy and comfort with computers. Sarkar et al.[9] assessed PWP use through electronic records of PWP login information and characterized users as those who logged into a PWP successfully. In contrast, we assessed self-reported PWP use and the extent of use, allowing examination of usage on a continuum. Assessments of frequency provide a more granular understanding of the relationship between patient characteristics and usage and the ability to identify the extent to which patient characteristics are associated with incorporating these systems into one's own self-care.

There are study limitations to note. First, the relationships between health literacy, numeracy, and computer literacy described in this study might reflect unique characteristics of our sample. A small sample with largely adequate health literacy and computer literacy might have limited our ability to identify statistically meaningful relationships. For instance, participants with adequate health literacy reported variability on numeracy, therefore limiting the significance of correlations between the two variables. A post-hoc power analyses revealed that, on the basis of the mean, between-groups comparisons require $n \approx 34$ to obtain statistical power at the recommended 0.80 level. Nonetheless, on questions about HIT use the vast majority of participants reported using a computer (or not using a cell phone) to access health information, thereby limiting our ability to detect health literacy, numeracy, and computer literacy group differences with respect to these outcomes. We were, however, able to detect correlations stronger than 0.35 using continuous measures of health literacy and computer literacy with statistical power at the 0.80 level. Second, we did not have enough participants in each PWP user focus group to make quantitative or qualitative comparisons among non-, low, and high users. Although we did not set out to explore differences by user group, we did find that high-user groups were more likely to discuss advanced technologies (such as smartphone applications and medication refill websites) than other groups. Finally, we used subjective measures of health literacy, numeracy, and computer literacy. Thus, the major findings presented here provide a nuanced understanding of how patients of all levels of health literacy, numeracy, or computer literacy might come to access and use a PWP and HIT.

Future studies should examine the role of health literacy, numeracy, and computer literacy and the use of PWPs and HIT with larger, more diverse samples and different measures of these constructs. In particular, patients with health literacy, numeracy, and computer literacy limitations should be oversampled to understand their barriers and facilitators to using a PWP and HIT. We also recommend studies explore the role of family members in engaging with patient care through PWPs and HIT, with further exploration on the quantitative and qualitative differences between patients who are non-users, infrequent, and frequent users of PWPs and other HIT. Our findings indicate family member support may be facilitating HIT access for patients with limited health literacy, but more research is needed to understand how family members influence HIT use for patients who have incorporated technology into their health management.

Moreover, while quantitative data addressed using a computer or cell phone to access health information or research diabetes medications or treatments, qualitative data indicated participants are engaging with various HIT tools, including exercise and diet smartphone applications, websites for medication refills and medical information (such as WebMD and diabetes-specific sites), and personal health record websites such as Google Health. Adults with diabetes report interacting with various types of HIT, including PWPs, for different self-care and/or informational purposes. Future research should focus on the predictors and outcomes associated with usage of various HIT for different patient populations. Finally, the PWP online delegate function is a particularly intriguing area for future research, as these account holders have not been included in PWP research to date.

Conclusions

Involvement of family members in patient care might explain how patients with limitations in the areas of health literacy, numeracy, or computer literacy access and use PWPs and HIT to manage diabetes, suggesting that family members might help bridge the HIT "digital divide." By facilitating patient usage of HIT, family members express interest in a patient's care. Furthermore, by serving as a PWP delegate, family members might become more engaged in a patient's health, increase a patient's usage of a PWP, and receive pertinent medical information that allows them to provide diabetes-specific practical support.

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