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Facilitators and barriers to blood pressure telemonitoring: A mixed-methods study

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Abstract

Background: Telemonitoring of blood pressure (BP) may improve BP control. However, many patients are not using BP telemonitoring due to personal, technological, and health system barriers. Individuals are required to have electronic health literacy (e-HL), defined as knowledge and skills to use technology services effectively, such as BP telemonitoring.

Objective: The objective was to determine the facilitators and barriers experienced by patients with hypertension in telemonitoring of BP using the e-HL framework (e-HLF).

Methods: This study was a prospective mixed-methods study using a convergent design. We recruited a convenience sample of 21 patients with hypertension. The qualitative section was online or phone individual in-depth interviews based on the e-HLF, which has seven domains. The quantitative section was an online survey consisting of demographics, an e-HL questionnaire, and patient–provider communication preferences. A joint display was used in the mixed-methods analysis.

Results: Five themes including knowledge, motivation, skills, systems, and behaviors along with 28 subthemes comprising facilitators or barriers of BP telemonitoring were identified. The mixed-methods results showed concordance between the participants' e-HL status and their experiences in the ability to actively engage with BP monitoring and managing digital services (domain 3) of the e-HLF. Other e-HL domains showed discordance.

Conclusion: Patients may engage with BP telemonitoring when they feel the usefulness of concurrent access to telemonitoring services that suit their needs.

Keywords

Telemonitoring, blood pressure, hypertension, remote patient monitoring, electronic health literacy, patients, technology

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Introduction

About half of adult Americans have hypertension, and less than 25% have it under control.[1] Multifaceted approaches are required to control blood pressure (BP) including consolidated use of health technology, empowering and equipping patients to use self-measured BP monitoring, medication adherence strategies, and maintenance of patient–healthcare provider communications.[2] Advancements in technology such as electronic communication tools and monitoring devices as well as experiences with the global COVID-19 pandemic have made telehealth a viable option in the management of various diseases including hypertension.[3–5] The four major forms of technologies used in telehealth include mobile health apps, store-and-forward electronic transmission of data, video conferencing, and remote patient monitoring (RPM).[6]

RPM, also known as telemonitoring, is simply monitoring of patients from a distance.[7,8] It comprises the use of

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electronic communication devices, such as mobile monitoring devices, wearables, smartphone apps, and computers, usually from a patient's home to collect and transmit the patient's health data to a healthcare provider for evaluation and appropriate intervention.[6,9] Health data transmission can be automated or manually entered by the patient. Telemonitoring can be accompanied by structured telephone support (human or machine-delivered phone calls)[10] or text messages[11,12] that provide reminders and self-care health education to the patient. According to the Telehealth.HHS.gov website, conditions such as diabetes, heart conditions, chronic obstructive pulmonary disease, sleep apnea, and asthma and symptoms like high BP and weight loss or gain can be telemonitored.[13]

Telemonitoring has evolved in both the components and processes of administration. Several systematic reviews published from 2003 to 2022 about telemonitoring in varying diseases exist, and the results are mixed. A systematic review of 272 publications on telemonitoring from 2000 to 2018 showed that it is effective in improving patient outcomes in 209 (76.8%) of the papers.[8] Most of the papers reviewed were on telemonitoring of cardiovascular (47.8%) and endocrinologic (18.0%) diseases. A meta-analysis of 7138 patients with hypertension found that BP self-monitoring led to an overall reduction in clinic systolic BP (−3.2 mmHg, 95% CI −4.9, −1.6) compared with usual care at 12 months. However, self-monitoring combined with telemonitoring including medication titration or lifestyle counseling led to a greater reduction in systolic BP (−6.1 mmHg, 95% CI −9.0, −3.2).[14] Finally, another meta-analysis of 32 randomized controlled studies done in patients with hypertension living in urban areas demonstrated higher BP control rates among the remote BP monitoring (RBPM) group (relative ratio 1.226, $p < 0.001$) compared to the usual care group.[15]

Despite mixed evidence of effectiveness in improving patient outcomes, support for telemonitoring is still growing.[16] The focus is now on how to overcome the challenges of telemonitoring, especially related to patient experiences. Some of the challenges limiting the widespread adoption of telemonitoring include the lack of skills required to operate the technology, acceptability, beliefs, long-term adherence, and cost of the technology.[17,18] Among patients with various chronic diseases, remote monitoring was facilitated by the disease-specific knowledge gained, early identification of disease decline triggers, improved self-management skills, and shared decision-making with providers.[19] Nonetheless, there is still fear of losing in-person contact and apathy toward technology caused by a lack of trust and skills.[19] These studies provide a good insight into barriers and facilitators of remote monitoring adoption; however, they are non-specific to patients with hypertension.

A scoping review of 36 studies on digital health technology adoption for hypertension management reported technology usability and support, better patient–provider communication, improved self-management, and fewer clinic visits as patient-related facilitators.[20] The barriers to digital health technology adoption for patients were cost, data privacy and security concerns, anxiety, loss of the patient–provider relationship, and lack of technology trust, skills, and support.[20] A weighted analysis of the Health Information National Trends Survey showed that among adults with hypertension, previous electronic communication with healthcare providers through email or the Internet and access to health apps were important predictors of interacting with healthcare providers through short message service (SMS) text messages.[21] A randomized controlled study of patients with hypertension in telemonitoring and non-telemonitoring groups showed that BP telemonitoring was facilitated by the acceptability of the intervention, data safety, and timely communication with the healthcare provider. The barriers were concerns about data safety, lack of motivation, and technology skills.[22] Another systematic review of the adoption of telemedicine for the management of hypertension reported similar facilitators and barriers, in addition to the availability of access to care, improved patient knowledge, and involvement.[23] Though these studies are specific to patients with hypertension, they do not explore the role of electronic health literacy (e-HL) among patients, which is necessary for the adoption of RPM.

Fundamental to technology adoption is the understanding of the skills, knowledge, and resources needed to apply them, a concept known as e-HL.[24] Several models of e-HL have been proposed[24–28] along with different e-HL assessment scales,[29] with variations in sample populations and concepts. The e-HL framework (e-HLF)[24] developed by systematic inductive methods involving inputs from patients and e-health professionals provides a comprehensive view of all the elements that impact a patient's decision to use a particular technology for their health management. The objective of our study was to determine the facilitators and barriers experienced by patients with hypertension in telemonitoring of BP using the e-HLF. Our research question was, "what are the facilitators and barriers that affect the use of technology in remote monitoring of BP?" To fully capture all the intricacies regarding patients' experiences in telemonitoring of BP, our study employed a mixed-methods framework to assess the relationship between the participants' qualitative responses and quantitative e-HL mean scores.

Methods

Design

The study was a prospective mixed-methods study using a convergent parallel design. The quantitative section was an online survey, while the qualitative section was phone or

online in-depth semi-structured interviews. The consolidated criteria for reporting qualitative research (COREQ) were followed.[30] The study was approved by the institutional review board (HUM00179130).

Study setting and participants

This was a single-center study at a large academic health institution. Study participants were selected using purposive and convenience sampling. The participants were adults with hypertension who were seen at one of the institution's primary care clinics at least twice in the past 1 year, had a prescription for at least one hypertension medication, understood the English language, and had phone numbers. Participants were excluded if they had active cancer, had a diagnosis of cognitive impairment, or had been admitted to the intensive care unit in the past 6 months.

Several sources of recruitment were used. An invitation to participate in the study was sent through text messages to prospective participants' phone numbers. Non-respondents received two more messages on two different days, after which we did not contact them again. Those who responded to the text message invitation were called, screened for eligibility, and provided with further study details. Consenting participants were sent the survey, and the interview date was scheduled. We first contacted a list of patients who participated in the interactive voice response (IVR) and MiChart Patient Outreach Text Application (MPOTA) systems within the institution, which utilized automated voice calls and text messages, respectively. The IVR and MPOTA are RBPM intervention systems set up by health providers at Michigan Medicine. Only five of the potential 61 patients chose to participate in the study. We then sought more participants using the institution's online platform for research volunteers. We received 72 interested participants, and 16 were eligible to participate. A total of 21 individuals signed the consent form and participated (Figure 1).

Data collection and analysis

The approach of the convergent mixed-methods design used was a parallel collection of the quantitative and qualitative data.[31] Quantitative data were collected using an online survey with questions on patients' demographics, patient–provider communication channel preferences, and e-HL. Demographics included age, sex, race, marital status, educational level, employment status, income, comorbidity, self-rated general health status, and length of time diagnosed with hypertension. Patient–provider communication channel preferences included in-person clinic visits, electronic health records, phone calls, emails, video visits, and SMS text messages. Participation in RBPM was defined as self-measurement of BP and any form of electronic transmission of the measurement to health providers through electronic means such as automatic transfer, text messaging, phone call, electronic health portal, email, or smartphone apps.

e-HL was assessed using a validated e-HL questionnaire (e-HLQ), which is a 35-item questionnaire with seven domains[32,33] developed from the e-HLF. The seven domains of the e-HLF have been categorized into three parts representing the individual, the system, and the interaction between the individual and the system. The first two domains provide information on the patient's capability (individual part), the next three domains show the interaction between the patient and digital services (interaction part), and the last two are about the patient's experiences with digital services (system part). The 35 items in the e-HLQ are mapped under the seven domains of the e-HLF. Each item was rated on a 4-point Likert scale (strongly disagree, disagree, agree, and strongly agree). The e-HLQ was validated using both classical test theory and item response theory psychometrics, and the domain items were found to have strong composite scale reliability (CSR). The seven e-HL domain variables include (1) using technology to process health information (5 items, CSR: 0.84); (2) understanding health concepts and language (5 items, CSR: 0.75); (3) ability to actively engage with digital services (5 items, CSR: 0.86); (4) feel safe and in control (5 items, CSR: 0.87); (5) motivated to engage with digital services (5 items, CSR: 0.84); (6) access to digital services that work (6 items, CSR: 0.77); and (7) digital services that suit individual needs (4 items, CSR: 0.85). Each domain score is the average of the individual item scores in the domain. The e-HLQ license was obtained from Swinburne University of Technology, Denmark. The online survey was administered using the Qualtrics® platform, and it took about 10 min to complete.

Descriptive statistics were used to describe patients' demographics and e-HL domains. Categorical variables were reported as frequencies and percentages, while continuous variables were reported as means and standard deviations (SD). The Mann–Whitney U test and Kruskal–Wallis test were used to assess the association between e-HL domains, demographics, and users and non-users of RBPM. All analyses were performed using RStudio version 3.6.1.

Qualitative data were collected through an in-depth interview using a phone call or Zoom®. The semi-structured interview guide (Supplemental Appendix 1) was developed from the e-HLF and literature, piloted and expert-reviewed to establish face validity. Participants were asked questions about hypertension and their experiences with technology in BP telemonitoring. The patients' interviews were transcribed verbatim using Microsoft® transcription software and verified manually. The transcripts were analyzed by thematic analysis.[34] They were first coded using Microsoft® Excel followed by NVivo (Release 1.6) software to ensure validity. CEE and KBF coded the transcripts independently and then met to

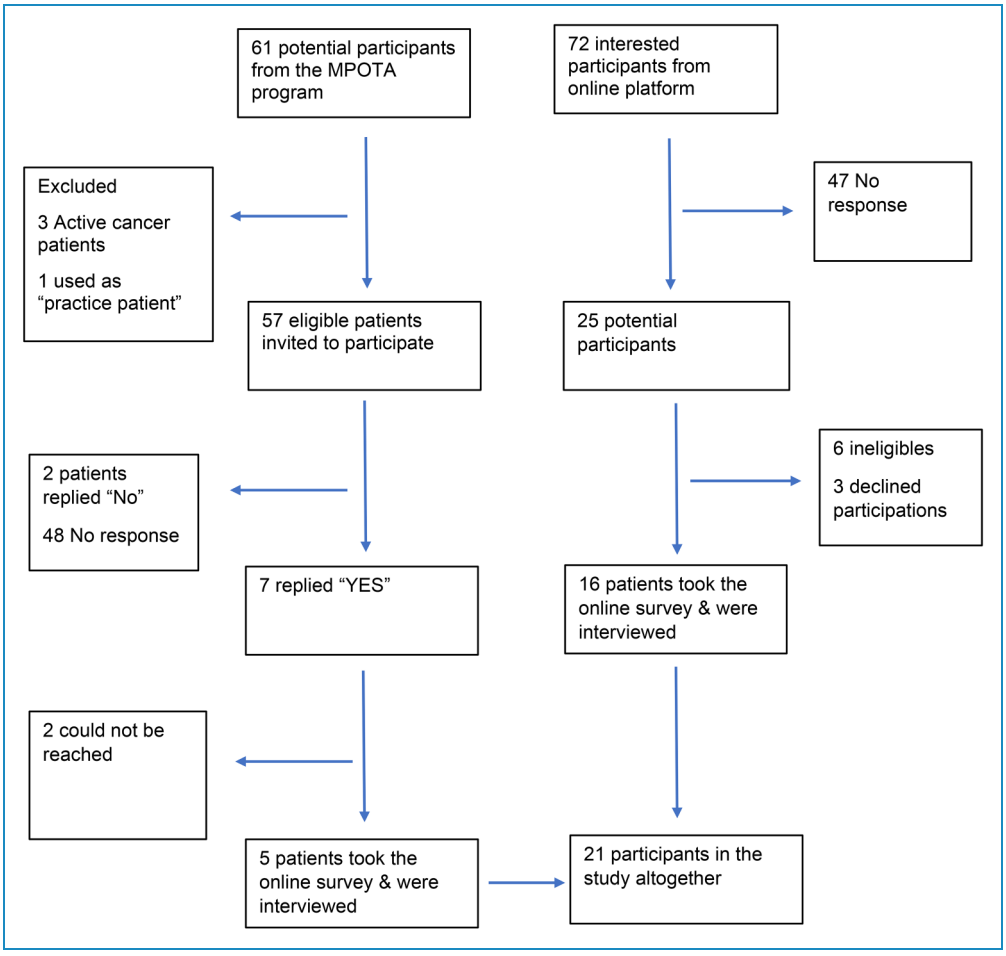

Figure 1. Flow chart of recruitment.

discuss and agree on the codes. Themes and subthemes were generated from the codes. The themes were grouped accordingly as facilitators or barriers to BP telemonitoring and mapped to the seven domains of the e-HLF where possible.

Mixed-methods data integration and analysis

The seven domains of the e-HLF were adapted to RBPM and used to integrate the quantitative and qualitative results. Integration of the quantitative and qualitative results occurred at the analysis level by connecting the mean e-HL scores with the qualitative responses, merging, and presenting the results in a joint display with meta-inferences. A joint display is a tabular or graphical representation showing how quantitative and qualitative results are integrated to provide a better understanding of the mixed-methods results.[35] The individual mean e-HL score ranges for e-HL domains were matched with the corresponding qualitative responses for a side-by-side comparison to assess for concordance or discordance between results and draw meta-inferences. The mean e-HL score ranges were used because the domain mean scores cannot be tied to any participant's response, but the range allows for the examination of interview responses of the lowest- and highest-scoring participants and provides a better understanding and reasonable comparison of the qualitative and quantitative data. Concordance happens when the qualitative and quantitative findings support each other leading to the same interpretation, while discordance occurs when the two findings contradict or conflict with each other.[36] We examined everyone's transcript and their e-HL scores to be able to draw a comparison between what they experienced and what they answered in the survey. We used the range of e-HL scores such as the highest score and lowest score for ease of presentation and understanding. Concordance occurred when the comments from the lower- and higher-scoring participants matched the theme being considered. Discordance occurred when there was a disagreement between the participants' scores and their comments regarding the theme in question.

Results

Thirteen (61.9%) of the 21 participants were aged between 50 and 74 years, and seven (33.3%) were less than 50 years old (Table 1). There were similar numbers of males (52.4%) and females (47.6%). Most participants were non-Hispanic (95.2%) and White (76.2%). All participants had attempted either some college or higher education. About two-thirds of the participants were married and had an annual household income of US$75,001 or more. The mean number of years of hypertension diagnosis was 8.33 (SD 1.28). Two-thirds of participants (66.7%) had participated in RBPM.

In-person clinic visits (89%) were the most preferred mode of interaction between participants and their healthcare providers. Electronic health records (87%), phone calls (77%), emails (74%), and video calls (62%) were also included. Convenience and accessibility were the most common reasons for the most preferred interaction method. The least preferred mode of interaction was SMS text messaging (52%), which the participants considered the least satisfying.

The mean scores for the seven domains of the e-HLQ for all participants ranged from 3.29 to 3.53. The individual scores ranged from average (2.00) to the highest point possible (4.00). The Mann–Whitney test comparison of the mean (SD) e-HL scores among those who participated in RBPM and those who did not showed statistically significant differences in domains 5 (motivated to engage with digital services) and 7 (digital services that suit individual needs) (Table 2). No statistically significant differences were found in mean e-HL domain scores compared by demographics (age, gender, ethnicity, race, educational level, marital status, patient-rated general health status, income, and comorbidity).

The thematic analysis of the qualitative data identified five main themes including knowledge, motivation, skills, systems, and behaviors along with 28 subthemes comprising facilitators or barriers of BP telemonitoring (Table 3). The themes were also grouped into factors that are intrinsic to the individual (knowledge, motivation, skills, and behaviors) and those that are external to the individual (systems). Exemplary quotes for the themes are provided. Some themes are outright facilitators of BP telemonitoring, for example, a clinical decision-making tool, where a participant said, *"I think it's a great value because it gives the doctor a lot of data. Um, from those three days a week over multiple weeks. That she can make an accurate descriptor recommendation for my health."* Some themes are barriers, for example, challenge with message timing because of work, with the participant's statements such as *"It seemed easy, except that I would forget, say, the message came in and maybe I was at work, I would forget to do it when I get home."* However, some themes can fit into both facilitators and barriers depending on their presence or absence, for example, awareness of BP telemonitoring, where a participant said, "*Well, I would do it anyway, like if I knew about it. I didn't know about that, so"* (barrier) while another participant said, *"It's just like you know, like I knew I needed to track my blood pressure and I didn't do a good job of it. So it took the technology to get me to track it"* (facilitator). The seven domains of the e-HLF were adapted to RBPM. For example, domain 1 became ability to process BP measurements and information. Domains 1 and 2 align with the knowledge theme, domain 3 aligns with skills, domains 4 and 5 align with motivation, and domains 6 and 7 align with systems. The behavior theme did not fall into any of the domains.

The mixed-methods results were based on the seven domains of the e-HLF adapted to RBPM themes (Table 4). The mean e-HL score ranges were aligned with the corresponding individual qualitative responses. The meta-inference showed concordance in the qualitative and quantitative data for domain 3 and discordance for other domains. For example, in the first domain (ability to process BP measurements and information) and second domain (understanding hypertension as it relates to own health), both the lowest- and highest-scoring participants' comments suggest a higher ability to process information and understand hypertension, showing a discordance. In domain 4 (feel that they have ownership of their BP measurements and other health data in the systems and the data are safe and only accessible to relevant persons), the participant with the highest mean e-HL score of 4 with a conflicting corresponding response, *"Just, Well, it's just discomforting to know with the concern that the data they take may or may not be safe from hackers,"* shows discordance. Participants were asked to rate their proficiency in technology use on a scale of 1–10, with 10 being the highest proficiency. In domain 3 (ability to actively engage with BP monitoring and managing digital services), the comment of the highest-scoring participant, *"Extremely comfortable Ten. I've written programs for these. I have been a software developer at one time, so I feel very comfortable with the technology,"* and that of the lowest-scoring participant, *"Mmmm, So you know, like not too fancy, but not too horrible, you know, proficiency of 5,"* match their mean e-HL scores of 4 and 2.4, respectively, showing a concordance.

Discussion

In this study, participants involved in RBPM had significantly higher motivation to engage with digital services and had digital services that suited their individual needs compared to non-participants. We identified five main themes (knowledge, motivation, skills, systems, and behaviors), which included facilitators and barriers to RBPM. The most referenced facilitators of RBPM were e-health

Table 1. Participants' demographics.

Variable and category	Total, $N = 21$, (%)	RBPM, $n = 14$, (%)	Not RBPM, $n = 7$, (%)	p-value
Age in years				0.19
<50	7 (33.3)	6 (42.9)	1 (14.3)	
50–74	13 (61.9)	8 (57.1)	5 (71.4)	
75+	1 (4.8)	0 (0.0)	1 (14.3)	
Gender				0.88
Male	11 (52.4)	8 (57.1)	3 (42.9)	
Female	10 (47.6)	6 (42.9)	4 (57.1)	
Ethnicity				1.00
Hispanic	1 (4.8)	1 (7.1)	0 (0.0)	
Non-Hispanic	20 (95.2)	13 (92.9)	7 (100.0)	
Race				0.47
White	16 (76.2)	11 (78.6)	5 (71.4)	
Black or African American	1 (4.8)	1 (7.1)	0 (0.0)	
Asian	1 (4.8)	0 (0.0)	1 (14.3)	
Other	3 (14.3)	2 (14.3)	1 (14.3)	
Educational level				0.19
Some college	6 (28.6)	4 (28.6)	2 (28.6)	
Bachelor's degree	8 (38.1)	7 (50.0)	1 (14.3)	
Post-baccalaureate	7 (33.3)	3 (21.4)	4 (57.1)	
Marital status				0.16
Married	13 (61.9)	10 (71.4)	3 (42.9)	
Single	1 (4.8)	0 (0.0)	1 (14.3)	
Divorced	5 (23.8)	2 (14.3)	3 (42.9)	
Living as married	2 (9.5)	2 (14.3)	0 (0.0)	
General health status				0.33
Very good	6 (28.6)	3 (21.4)	3 (42.9)	
Good	12 (57.1)	8 (57.1)	4 (57.1)	

(continued)

Table 1. Continued.

Variable and category	Total, $N = 21$, (%)	RBPM, $n = 14$, (%)	Not RBPM, $n = 7$, (%)	p-value
Fair	3 (14.3)	3 (21.4)	0 (0.0)	
Annual household income				0.54
Less than US$20,000	2 (9.5)	1 (7.1)	1 (14.3)	
US$20,000–US$35,000	2 (9.5)	1 (7.1)	1 (14.3)	
US$35,001–US$50,000	1 (4.8)	0 (0.0)	1 (14.3)	
US$50,001–US$75,000	3 (14.3)	2 (14.3)	1 (14.3)	
US$75,001 or more	13 (61.9)	10 (71.4)	3 (42.9)	
Comorbidity				0.55
Heart disease and diabetes	1 (4.8)	0 (0.0)	1 (14.3)	
Diabetes	1 (4.8)	1 (7.1)	0 (0.0)	
Diabetes and depression or anxiety	1 (4.8)	1 (7.1)	0 (0.0)	
Depression or anxiety	3 (14.3)	1 (7.1)	2 (28.6)	
Depression or anxiety and other	3 (14.3)	2 (14.3)	1 (14.3)	
Other	5 (23.8)	4 (28.6)	1 (14.3)	
None	7 (33.3)	5 (35.7)	2 (28.6)	
Hypertension history in years (mean (SD))	8.33 (1.28)	8.14 (1.46)	8.71 (0.76)	0.35
Hypertension medications (mean (SD))	1.48 (0.75)	1.57 (0.85)	1.29 (0.49)	0.42
Other medications (mean (SD))	2.43 (2.16)	2.64 (2.41)	2.00 (1.63)	0.53

BP: blood pressure; *N*: total number of study participants; *n*: number of participants in subgroups; RBPM: remote blood pressure monitoring; SD: standard deviation.

system experience, self-efficacy with technology, access to a home BP monitor, BP self-monitoring (checking BP by self at home), and convenience and ease of use of the RBPM process. We included BP self-monitoring as one of the parameters because not everyone who monitors their BP by themselves engages in remote monitoring. Notable barriers to RBPM included lack of awareness of BP telemonitoring, challenges with message timing due to work schedule, lack of access to a home BP monitor, and trust in the technology. Participants recommended the provision of an accurate wearable BP monitor, automatic transmission of home-measured BP, and peer support as some of the measures to improve engagement with RBPM.

Within the knowledge theme, our exploratory study found that the understanding of participants' disease condition such as knowing the benefits of management and complications that could arise from uncontrolled hypertension, knowing medications, being aware of body cues, and knowing their BP goals facilitated involvement in RBPM. Knowledge gain was reported as a facilitator of engagement in remote monitoring in patients with chronic diseases[19] and hypertension.[23] This implies that educating patients on their hypertension condition and what is expected to control it[37] is an important basis for participation in RBPM. Motivation is also an essential factor in getting patients engaged in their health management.[38,39] We found that the motivation to engage with RBPM digital services is facilitated by awareness of BP telemonitoring, convenience and ease of use of the digital services, the value gained by engagement such as improved

Table 2. e-HL mean score dichotomized by those who use RBPM versus not.

e-HLQ domains	Total participants' mean (SD) scores, $N = 21$	RBPM participants' mean (SD) scores, $n = 14$	Non-RBPM participants' mean (SD) scores, $n = 7$	p-value
1. Using technology to process health information	3.38 (0.53)	3.50 (0.53)	3.14 (0.49)	0.15
2. Understanding health concepts and language	3.33 (0.46)	3.43 (0.44)	3.14 (0.49)	0.23
3. Ability to actively engage with digital services	3.53 (0.53)	3.64 (0.45)	3.31 (0.63)	0.30
4. Feel safe and in control	3.30 (0.53)	3.41 (0.45)	3.09 (0.65)	0.16
5. Motivated to engage with digital services	3.44 (0.49)	3.63 (0.32)	3.06 (0.56)	0.02
6. Access to digital services that work	3.38 (0.54)	3.55 (0.40)	3.05 (0.65)	0.08
7. Digital services that suit individual needs	3.29 (0.61)	3.50 (0.49)	2.86 (0.63)	0.03
Average		3.52 (0.09)	3.09 (0.13)	0.04

e-HLQ: electronic health literacy questionnaire; RBPM: remote blood pressure monitoring; *N*: total number of study participants; *n*: number of participants in subgroups; SD: standard deviation.

communication with a healthcare provider, and clinical decision-making. Similar facilitators such as improved motivation, ease of use monitoring devices, better patient–provider communication, reduction in office visits, shared decision-making, and timely and accessible care have been reported to increase patient involvement in remote disease monitoring.[19,20,22] Having the appropriate skills to use any remote monitoring services facilitates engagement with the service.[24,40] There should be adequate training of patients and provision of readily available technical support to boost their comfort with the remote monitoring service. In addition to knowledge, motivation, and skills, external factors may also impact RBPM.

Engagement in RBPM services is not solely dependent on the patient's knowledge and skills. The health system has an important role to play by increasing access to digital resources, improving trust in technology, and ensuring the e-health system that suits individual patient needs. Access to digital services can be increased by reducing the cost of technology devices and providing insurance coverage for technology used by patients in BP telemonitoring. RBPM could be integrated into health providers' routine workflow and reimbursement offered for monitoring services. RBPM interventions should be designed with patient inputs and tailored toward individual patient requirements. Studies have shown that selecting the right patient for remote monitoring interventions is essential for adherence and positive health outcomes.[41] Patients' behaviors such as BP self-monitoring, medication adherence, and healthy lifestyle adherence play a significant role in BP control and overall health.[42–44] A study of participants with hypertension showed that those already engaged in a behavior such as electronic communication with their healthcare provider were more likely to engage in another level of behavior like sending or receiving SMS text messages from their healthcare provider.[21] In essence, the exhibition of positive behaviors toward BP control may facilitate engagement in RBPM and can be used by providers to identify potential participants.

The barriers to engagement in BP telemonitoring are essentially the opposite of the facilitators mentioned above. Some patients also expressed trust in their clinic visits with their healthcare provider, such that they do not feel they need to engage in an extra activity like RBPM. The challenges with technology usage such as security, accessibility, and operational issues in this study aligned with patients' highest preference for direct in-person contact as a means of interaction with their healthcare providers. Direct contact physician care preferences have been reported in other studies.[45,46] Technology is here to augment in-person services and should be made easy, accessible, and secure in a way that spurs an increase in usage to free up clinic time for necessary in-person services. Patients are more willing to use digital services if they understand the benefits they add to their health.[47,48]

Patients with hypertension in this study collectively had high e-HL in all domains of the e-HLF, and this high e-HL may explain why two-thirds of them were engaged in RBPM. Higher e-HL has been linked to greater engagement in digital services.[49,50] e-HL was not significantly associated with the participants' demographics such as age, gender, race, marital status, income, or educational level.

Table 3. Facilitators and barriers of technology use in RBPM.

Themes	e-HLF adapted domains	Subthemes	Facilitator	Barrier
Internal factors				
1. Knowledge				
	Ability to process BP measurements and information	Knowledge of BP goals *"They gave me a target. They said that anything below that is good and anything above that is bad. So I've been keeping track of it" (RBPM participant)*	√	√
		Self-health information seeking with technology *"you have to go searching for it, so that's exactly what I did in the Example that I gave. In taking a look at particularly white coat hypertension" (Non-RBPM participant)*	√	√
	Understanding hypertension as it relates to own health	Knowledge of benefits of hypertension management *"To keep my blood pressure down Um? Just so I don't have further complications as time goes along" (RBPM participant)*	√	√
		Knowledge of complications of uncontrolled hypertension *"my family background, Uhm, my parents and siblings have hypertension and I know It's made other organs, It's affected other organs like my dad had kidney disease from that and when he was older, Uhm, he had a stroke and they were unable to control his hypertension and I know the stroke resulted from his having high blood pressure that was hard to control" (RBPM participant)*	√	√
		Hypertension medication knowledge *"it's important that you keep track of you know your medication, how much you take, how often you take" (Non-RBPM participant)*	√	
		Body change awareness/cues *"I can typically tell when it's not because I will either get lightheaded or I can feel my heart racing and uhm, I don't have either of those symptoms. Those are the symptoms that kind of Clue me in on whether or not my blood pressure is either way rarely low, but if it's high you know, I'll get the fluttering failure and then" (Non-RBPM participant)*	√	
2. Motivation				

(continued)

Table 3. Continued.

Themes	e-HLF adapted domains	Subthemes	Facilitator	Barrier
	Motivated to engage with remote BP digital services	Awareness of BP telemonitoring *"No, I was not aware of that (remote BP monitoring)" (Non-RBPM participant)*	√	√
		Convenience and ease of use *"I think this is convenient and easy" (RBPM participant)*	√	√
		Better communication with healthcare providers *"It allows me to Communicate better with my Health care providers" (RBPM participant)*	√	√
		Challenge with message timing because of work schedule *"It seemed easy, except that I would forget, say, the message came in and maybe I was at work, I would forget to do it when I get home" (RBPM participant)*		√
		Clinical decision-making tool *"I think it's a I think it's a great value because it gives the doctor a lot of data. Um, from those three days a week over multiple weeks. That she can make an accurate descriptor recommendation for my health" (RBPM participant)*	√	
	Feel that they have ownership of their BP measurements and other health data in the systems and the data are safe and only accessible to relevant persons	Healthcare provider trust *"I could do a better job of Getting on the online portal at U of M and signing up for that so that I have access to my all my overall health more readily I I, but I trust my doctors there" (RBPM participant)*		√
		Concern for data security and integrity *"Just, Well, it's just discomforting to know with the concern that the data they take may or may not be safe from hackers Knowing a lot about that" (RBPM participant)*		√
3. Skills				
	Ability to actively engage with BP monitoring and managing digital services	Excellent home BP self-monitoring technique *"Oh OK, so I have one that's electronic. I would get the monitor and sit. Where my legs weren't crossed. And where I was calm and comfortable, but with my arms resting, put some monitor on my arm and let it you*	√	√

(continued)

Table 3. Continued.

Themes	e-HLF adapted domains	Subthemes	Facilitator	Barrier
		know, hit the button. So it started. It would pump up and take the pressure" (RBPM participant)		
		Self-efficacy with technology *"Extremely comfortable Ten. I've written programs for these. I have been a software developer at one time, so I feel very comfortable with the technology" (RBPM participant)*	√	√
		Training *"I'm very comfortable (with technology) as long as you train me" (RBPM participant)*	√	√
External factors				
4. Systems				
	Access to RBPM digital services that work	Access to a home BP monitor *"Uh, well, you know before I never had a machine at home, so I really, I mean, originally I didn't have a blood pressure machine at home, so I would have to go to the doctor or I would have to go to like a pharmacy that had the uhm, They used to have Machines at the pharmacy you could use, but, Then you don't really know. You have to get something consistent. If I can use the one at home, I know how it is, uhm, consistently" (RBPM participant)*	√	√
		Technology trust *"I don't think that they gave accurate readings, so I never really knew if my blood pressure was too high or not because I could take two readings 10 minutes apart or 20 minutes apart and one would be kind of low and the other will be high. You know, I never trusted it. So I felt that I I really wasn't learning anything about my actual blood pressure" (Non-RBPM participant)*	√	√
		Access to smartphone *"I have an Android phone which is a smartphone and that allows me to use the portal" (RBPM participant)*	√	√

(continued)

Table 3. Continued.

Themes	e-HLF adapted domains	Subthemes	Facilitator	Barrier
		Access to tablet *"I have a tablet" (Non-RBPM participant)*	√	√
		Access to computer *"OK, I have a computer" (RBPM participant)*	√	√
	RBPM digital services that suit individual needs	Adapting services to patients' needs *"It started out, I had to do it every week and then it reduced down to every I think like once every three weeks. And then now it just went down to once in a Quarter" (RBPM participant)*	√	
		The e-health system experience *"It's gotten better and better the patient portal. Um, it, you know, I've been a patient at U of M for about 20 years I think, and maybe longer. Yeah, early 90s. Um? It's gotten so much better" (RBPM participant)*	√	√
5. Behaviors				
		BP self-monitoring *"I have a blood pressure cuff here at home. I monitor it myself once a week" (RBPM participant)*	√	
		Action/action plan to aid BP monitoring *"I went and looked for anything technology wise that could help me with that. And I found A blood pressure device" (RBPM participant)*	√	
		Medication adherence *"I have a pill box with Monday through Sunday and I take them every morning when I go to work" (RBPM participant)*	√	
		Diet, exercise, and related behaviors *"We have mainly a plant-based diet and we cook almost all of our own food, so we're able to greatly limit the salt intake as compared to buying Prepared foods or eating out. The other is I exercise daily" (RBPM participant)*	√	
		Advocacy *"So I mean, if people had the proper equipment. You know, and some more knowledge to go with that. I mean, you know we probably could knock the numbers down a little bit" (Non-RBPM participant)*	√	

RBPM: remote blood pressure monitoring; e-HLF: electronic health literacy framework.

Table 4. Joint display of the relationship between e-HL mean scores and RBPM themes.

RBPM themes	Average e-HL mean (SD) scores (Mean (SD) score range)	Example quotes from the interview	Meta-inference
Ability to process BP measurements and information	3.38 (0.53) (2.40 (0.55)–4.00 (0.00))	*"They gave me a target. They said that anything below that is good and anything above that is bad. So I've been keeping track of it" (RBPM participant)* **"It (BP) is under control now…I check my blood pressure Monday, Wednesday and Friday" (RBPM participant)**	Discordance The participants' comments suggest a higher ability to process information that does not match the lower score range.
Understanding hypertension as it relates to own health	3.33 (0.46) (2.40 (0.55)–4.00 (0.00))	*"I know that with the hypertension there can be a lot of really bad effects further down the line up heart can heart problems. It can also interact with diabetes. You can have strokes. Uhm, so there are number of side effects to just hypertension that can be really bad if you don't take care of it and keep it under control" (Non-RBPM participant)* **"Because if you are monitoring yourself and your blood pressure is high, You're gonna do something probably try to take that down. That would have made you probably get up and go** **Because you know, nobody wanna die" (Non-RBPM participant)**	Discordance The participants' comments suggest a higher understanding of hypertension that does not match the lower score range.
Ability to actively engage with BP monitoring and managing digital services	3.53 (0.53) (2.40 (0.55)–4.00 (0.00))	*"Extremely comfortable Ten. I've written programs for these. I have been a software developer at one time, so I feel very comfortable with the technology" (RBPM participant)* **"Mmmm, So you know, like not too fancy, but not too horrible, you know, proficiency of 5" (Non-RBPM participant)**	Concordance The comments of the lower- and higher-scoring participants match their level of engagement with technology.
Feel that they have ownership of their BP measurements and other health data in the systems and the data are safe and only accessible to relevant persons	3.30 (0.53) (2.40 (0.55)–4.00 (0.00))	*"Just, Well, it's just discomforting to know with the concern that the data they take may or may not be safe from hackers Knowing a lot about that" (RBPM participant)* **"No comment" (Non-RBPM participant)**	Discordance The higher-scoring participants' comments express concerns for data safety, while there was no record of such concerns expressed by those in the lower score range.

(continued)

Table 4. Continued.

RBPM themes	Average e-HL mean (SD) scores (Mean (SD) score range)	Example quotes from the interview	Meta-inference
Motivated to engage with remote BP digital services	3.44 (0.49) (2.20 (0.45)–4.00 (0.00))	*"Well, I would do it (remote BP monitoring) anyway, like if I knew about it. I didn't know about that, so. Because I tend to get, I think that is common thing for a lot of people, when your blood pressure is controlled for a long time and you're doing great, you kind of push it to the side. And as soon as you do that, that's when you fall off the wagon so the text messaging would definitely help me" (RBPM participant)* **"To I mean, to a certain degree, yeah, I mean they do help. I mean by supplying you with knowledge, you know** **But I think ultimately It's up to the individual, you know to. I believe in that lifestyle change. You know, I think ultimately it's up to the individual to do some soul searching, make some changes in their life. You know technology can definitely help assist you in that you know that you know the journey. But ultimately, yeah, it does. So it does answer the question. Yeah, it helps, so it is a valuable tool" (Non-RBPM participant)**	Discordance The participants' comments suggest higher motivation to engage with digital services, which does not match the lower score range.
Access to RBPM digital services that work	3.38 (0.54) (2.00 (0.63)–4.00 (0.00))	*"So I use the blood pressure monitor that is like on my wrist. And turn it's Bluetooth enabled so I can connect to my phone" (RBPM participant)* **"I have computer, smartphone, Sphyg and stethoscope" (Non-RBPM participant)**	Discordance The participants' comments suggest they have digital services that work, which does not match the lower score range.
RBPM digital services that suit individual needs	3.29 (0.61) (2.25 (0.50)–4.00 (0.00))	*"I would record it at home and then I would input all of my weekly blood pressure measurements* *in and then send it so it would be like every week" (RBPM participant)* **"No comment" (Non-RBPM participant)**	Discordance The higher-scoring participants' comments suggest they have services that suit their needs, while there was no record of comments to support the lower score range.

Note: The italics texts are participants' quotes corresponding to the highest e-HL score range, while the bold texts correspond to the lowest e-HL score range. "No comment" means there was no statement by the lower-scoring participants against the RBPM theme under consideration to match the lower scores.
e-HL: electronic health literacy; RBPM: remote blood pressure monitoring; SD: standard deviation.

Our findings differ from a study of 110 older Thai adults ≥60 years with hypertension and mostly (76%) with income below US$30,000,[51] where higher e-HL was associated with being male and having higher income but not with age, educational level, or marital status. Studies on 247 patients with hypertension or diabetes, ≥50 years, and mostly White Hispanic[40] and Asian patients with hypertension, diabetes, and coronary heart disease, mean age 47 years (SD 12.51), and mostly female (56.5%)[52] reported low e-HL to be associated with older age and lower educational levels. A similar association was also found among 453 Australian people with cardiovascular disease diagnosis or risk including systolic BP ≥ 180 mmHg, diastolic BP ≥ 110 mmHg, heart disease, stroke or transient ischemic attack, and peripheral vascular disease.[53] All these studies used the eHealth literacy scale (eHEALS) to measure e-HL. A study on 246 Danish adult patients with diabetes and/or gastrointestinal diseases and a mean age of 56.5 years (range 18–89) that utilized the e-HLQ found that lower age was associated with a higher ability to engage with digital services, while lower educational status was weakly associated with an increase in feeling safe, in control, and access to digital services that work.[54] The differences between our study findings and these studies could be due to differences in study population characteristics, sample size, or disease conditions accounted for. Our study is the first to our knowledge to use the e-HLQ to assess e-HL among people with hypertension. We found, however, that those who telemonitor their BP were significantly more motivated to use RBPM services (domain 5) and tended to have RBPM services that suit their needs (domain 7) than those who do not telemonitor BP. Though we could not find a comparable study on RBPM, Holt et al.[54] who used the e-HLQ in their study found that adult patients with diabetes and/or gastrointestinal diseases who are users of the national health portal have significantly higher e-HL in all domains except domain 4 (feel safe and in control of health data) when compared with non-users. This underscores the importance of willingness on the part of patients to take charge of their health and the health system providing the necessary resources to boost that motivation.

In our mixed-methods joint display (Table 4), the lack of alignment of the participants' e-HLQ scores to their qualitative responses could be because the questionnaire was not specific to RBPM. It could also be due to participants' perception of their knowledge and skills at the different times of answering the survey and the interview questions. Based on our findings, we recommend more studies on patients with hypertension using the e-HLF to fully understand the relationship between patients' e-HL and their RBPM experiences. Future studies could adapt the e-HLQ to RBPM to ensure participants have the same context in the qualitative and quantitative study.

Our study has some limitations. We used a convenience sample of 21 participants with hypertension who were mostly White, have some college or higher education, and have an annual household income in the middle or upper class. The participants may have responded from experiences unique to them. Sampling participants digitally and using an electronic survey may have biased our sample in favor of those with higher e-HL. It is possible we may not have captured all the factors affecting e-HL, such as the social or cultural context with the instrument we used. The findings may not be generalizable to all the hypertension population, but it provides a good insight into what may be obtainable. Our mixed-methods approach makes the study more robust.

Future studies should explore RBPM practices and their relationship with e-HL in a larger and more diverse hypertension population. With the availability of several e-HL assessment scales, testing two or more on the same hypertension sample may be worthwhile to provide a better inference on e-HL status.

Conclusion

Patients with higher e-HL are more likely to use BP telemonitoring. Patients may engage with BP telemonitoring when they feel the usefulness of concurrent access to telemonitoring services that suit their needs.

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