


Effects of an eHealth Intervention on Patient-Provider Interaction and Functional Health Literacy in Adults With Hypertension

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Abstract

Introduction: Hypertension is a life-limiting, chronic condition affecting millions of Americans. Modifiable factors, quality of the patient-provider interaction and functional health literacy, have been linked to effective hypertension self-management. However, there has been limited interventional research targeting these modifiable factors. Electronic hypertension self-management interventions, in particular those incorporating virtual simulation, may positively influence the quality of the patient-provider interaction and functional health literacy status of adults with hypertension. Yet there is a dearth of evidence examining the efficacy of eHealth interventions targeting these modifiable factors of hypertension self-management.

Objective: Evaluate the effects of two electronic hypertension self-management interventions on the quality of the patient-provider interaction and functional health literacy in adults with hypertension.

Methods: A convenience sample of community-dwelling adults (>18 years) with hypertension were recruited and randomized to an avatar-based simulation (eSMART-HTN) or a video presentation on hypertension self-management (attention control). Participants were administered questionnaires to capture demographic characteristics, the quality of the patient-provider interaction, and functional health literacy. Questionnaire data were collected at baseline, and then monthly across three months. Two separate repeated measures analysis of covariance models were conducted to assess the effects of the interventions across the time points.

Results: The sample included 109 participants who were predominately middle-aged and older, nonwhite, and female. Scores for the quality of the patient-provider interaction demonstrated significant within-group changes across time. However, there were no significant differences in the quality of the patient-provider interaction or functional health literacy scores between experimental conditions while adjusting for covariates.

Conclusion: An avatar-based simulation (eSMART-HTN) intervention proved to have a positive effect on patient-provider interaction compared to an attention control condition. Although the results are promising, future research is needed to optimize the effectiveness of eSMART-HTN and enhance its efficacy and scalability in a larger cohort of adults with hypertension.

Keywords

hypertension self-management, adults, avatars, eHealth, randomized controlled trial

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Introduction

Hypertension (HTN) is a prevalent and modifiable life-limiting condition in the United States and worldwide (Benjamin et al., 2017; Mozaffarian et al., 2015). Despite advancements in drug therapy, individuals diagnosed with this chronic condition often do not achieve sufficient blood pressure control. With new emphasis on

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lower blood pressure parameters and earlier treatment, the 2017 Guideline for the Prevention, Detection, Evaluation, and Management of High Blood Pressure in Adults put forth by the American College of Cardiology (ACC) and American Heart Association (AHA) reclassified more than 30 million Americans as newly hypertensive and recommends lifestyle modifications or pharmacologic therapy for over 130 million Americans (Ritchey et al., 2018; Whelton et al., 2018). However, less than one-quarter of Americans with a diagnosis of HTN are likely to have their blood pressure under control (<140/90 mm Hg). Poor adherence to medication regimens, lifestyle modifications, and other HTN self-management behaviors contribute to the adverse systemic effects of hypertension and nearly 1,300 deaths per day among people living with HTN. The 2017 ACC/AHA Hypertension Guideline expands the number of Americans who require management of their HTN, increasing the importance of proactive and sustained HTN self-management behaviors for millions of Americans (Ritchey et al., 2018).

Review of the Literature

HTN self-management can play a pivotal role in attenuating the morbidity and mortality associated with living with HTN. The self-management of HTN consists of a set of health promotion behaviors and decisions that individuals perform to achieve sufficient blood pressure control. For individuals who are living with HTN, most often such self-management includes symptom monitoring, lifestyle modifications (e.g., diet, physical activity, smoking cessation, stress reduction), adherence to anti-hypertension medication regimens, blood pressure self-monitoring, and effective communication of their needs or symptoms to their healthcare providers (Benjamin et al., 2017; Muntner et al., 2018). There are numerous HTN self-management interventions that have shown efficacy, and many of these interventions have primarily focused on promoting lifestyle modifications, medication adherence, and self-monitoring of blood pressure (Alessa et al., 2019; Bosworth et al., 2009; Still et al., 2018). Given the ubiquitous nature of technology, there is an emergence of electronic health (eHealth) interventions (e.g., telephone-delivered interventions, smartphone applications, videos, and text-messaging) that have been evaluated to enhance the varied effectiveness of self-management in improving HTN outcomes (Ma et al., 2019). To date, there is a paucity of eHealth interventions that have focused on improving the quality of patient-provider interaction and functional health literacy status of persons with HTN. These two behavioral components of HTN self-management, quality of patient-provider interaction and functional health literacy, are seldom the targets of self-management

interventions, but are associated with self-management behavior and health outcomes of persons living with HTN.

The quality of the patient-provider interaction (PPI) is a proxy for the quality of health care, a contributor to self-management behavior, and a driver of health outcomes in adults with HTN. Quality of the interactions between patients and providers influences components in the initiation and maintenance of self-management behaviors. Individuals living with chronic conditions who are from racial minorities, and individuals who are socially marginalized, often report a lower quality of interactions with healthcare providers. Patient characteristics such as age, gender, race, education, and communication style have been linked to the quality of the PPI (Cramm & Nieboer, 2015; Hickman et al., 2016; Institute of Medicine (US) Committee on Understanding and Eliminating Racial and Ethnic Disparities in Health Care et al., 2003; R. L. Johnson, Roter, et al., 2004; R. L. Johnson, Saha, et al., 2004; Street et al., 2005). In addition, the interplay of social position (e.g., professional authority), socioeconomic and racial-ethnic disparities, inequities in education and employment, and health literacy influence patients' perceptions of the quality of interactions with their healthcare providers (Cramm & Nieboer, 2015; Hickman et al., 2016, 2017; Institute of Medicine (US) Committee on Understanding and Eliminating Racial and Ethnic Disparities in Health Care et al., 2003; R. L. Johnson, Roter, et al., 2004; Wolf-Maier et al., 2003).

A second influential factor, functional health literacy, is also associated with low-quality interactions with healthcare providers and ineffective HTN self-management (Bauer et al., 2014; Macek et al., 2013; Nouri & Rudd, 2015; Schillinger et al., 2004). According to Nutbeam (2008), functional health literacy is characterized as an individual's capacity to gain access to, understand, and use information to promote or maintain health. Low functional health literacy has been associated with lower educational level, racial minority status, and advanced age (Kutner et al., 2006). Individuals with these characteristics may be unable to understand and use health-related information to modify their health behaviors, resulting in poor health outcomes (Berkman et al., 2011). Thus, eHealth self-management interventions with an emphasis on the quality of PPI and functional health literacy hold the potential to improve blood pressure control by enhancing self-management behaviors among adults with HTN.

A promising approach to support eHealth HTN self-management is the use of immersive, serious game technology to provide experiential learning to enhance the quality of the patient-provider interactions and functional health literacy of adults living with HTN. The immersive learning environments offered through the use of

“serious game technology” is a recent innovation that is enabling behavioral scientists to create virtual experiences or simulations accessible across computer and mobile platforms to prepare individuals for *real-world* experiences, such as interactions with their healthcare providers or skills needed to effectively self-manage a chronic condition and become more health literate. Virtual simulations have been effectively used to promote training in clinical scenarios and to promote self-management of chronic disease among individuals across the lifespan, and is commonly used to train healthcare providers to manage various emergent situations (Keys et al., 2020; Rajeswaran et al., 2018; Stuart et al., 2020). Outside of health care, immersive virtual experiences have been shown to effectively train our military forces (Liu et al., 2018; Manojlovich et al., 2003; Pallavicini et al., 2016), first responders to natural disasters (Sermet & Demir, 2019), and flight crews (Sun et al., 2020) who are expected practice their skills in virtual environments and apply them to real-world scenarios. The application of virtual healthcare encounters to promote experiential learning to increase higher-quality interactions between patients and their healthcare providers and improve functional health literacy is innovative and offers a new medium to support HTN self-management behavior.

In an effort to contribute to the expanding evidence base of eHealth self-management interventions using serious game technology, we present in this study evidence from a pilot randomized controlled trial of an electronic HTN self-management intervention (eSMART-HTN) that exposed adults with HTN to simulations with virtual healthcare providers compared to those exposed to an attention control condition.

Objectives

Therefore, our study’s purpose is two-fold: (1) to examine the effects of the electronic HTN self-management intervention (eSMART-HTN) and an attention control condition on the quality of the patient-provider interaction across time, and (2) to evaluate the effects of the two experimental conditions on functional health literacy over time in community-dwelling adults living with HTN.

Methods

Design

This study is a two-arm, single-blinded randomized controlled trial with a repeated measures design. A 2:1 randomization schema was used to assess the effects of the interventions (eSMART-HTN vs. attention control) on the primary outcomes, quality of patient-provider interaction and functional health literacy. Institutional

review board approval was obtained prior to the initiation of recruitment and data collection procedures. Data collection was conducted across four time points: at baseline (T1) and then monthly across three months (T2-T4). A three-month observational period was selected to maintain consistency with clinical guidelines for HTN management. Prior to participant recruitment and data collection, the study procedures were reviewed and approved by the institutional review board affiliated with the primary author.

Sample and Setting

A nonprobability sample of community-dwelling adults 18 years or older diagnosed with hypertension, as evidenced by prescription for an antihypertensive medication or known to have arterial blood pressures that exceeded 140/90 mm Hg, were included in the study. Additionally, participants were able to understand English and did not have profound vision and/or hearing impairments that may affect their comprehension of the information contained within the electronic health interventions. Participants were recruited through a variety of community-based recruitment methods: print advertisements in a variety of community businesses, local newspapers, and in the interiors of a fleet of buses and railcars of the local transit system of the metropolitan area in Northeast Ohio. Interested individuals responded to advertisements by calling the research staff for screening. Those who were eligible to participate in this clinical trial were scheduled for a baseline interview within a few weeks of their initial contact with the research staff.

Description of the Experimental Conditions

Participants were randomly assigned to one of two experimental conditions: eSMART-HTN or the attention control arm. For participants randomly assigned to eSMART-HTN, a monthly dose of this condition consisted of the following: introduction and reinforcement of a structured communication strategy to facilitate the conveyance of the participants’ needs and preferences to healthcare providers, educational content on effective HTN self-management behavior, and an opportunity for behavioral practice of the structured communication strategy through interactions with avatar-based healthcare providers and a coach. Additionally, participants assigned to eSMART-HTN received for behavioral reinforcement a pocket-sized tri-fold reference guide that contained an explanation of the structured communication strategy and space for home blood pressure and symptom recording, medication tracking, and note-taking during an actual visit with their healthcare providers. eSMART-HTN was

administered to participants on 22-inch touchscreen computers. Each dose of eSMART-HTN simulated a virtual office visit in which the participants were expected to communicate their needs to an avatar healthcare provider, and this simulation was estimated to last no longer than 20 minutes.

The second experimental condition was conceptualized to serve as an attention control condition to address a potential novelty effect. For participants randomized to the attention control condition, they were exposed to investigator-developed videos that included a presentation on general information about HTN, stress and symptom management, and dietary practices based on ACC/AHA guidelines for HTN self-management. Participants assigned to the attention control condition viewed the videos on the same 22-inch touchscreen computers and used a standard pair of headphones to hear the audio. The video was administered to participants at each study visit and the length of the video was approximately 15 minutes.

Instruments

Two instruments were used to measure the primary dependent variables: quality of patient-provider interaction and functional health literacy. Additionally, an investigator-developed demographic form was administered to capture participants' demographic data, such as age, gender, racial identity, body mass index, and blood pressure in millimeters of mercury (mm Hg), as well as other explanatory variables.

Questionnaire on the Quality of the Physician-Patient Interaction (QQPPI). This questionnaire was developed by Bieber et al. (2010) and was administered to assess patients' perceptions of the quality of their interaction with a healthcare provider. The QQPPI is a 14-item patient self-report questionnaire constructed using a 5-point Likert scale ranging from 1 ("I do not agree") to 5 ("I fully agree"). A total score is calculated by summing the scale items, with higher scores indicating higher-quality interactions with a healthcare provider (Bieber et al., 2010). The QQPPI demonstrated sufficient internal consistency (Cronbach's $\alpha = .95$) and evidence of convergent validity was established; the QQPPI was highly correlated with patients' perceived involvement in care ($r = .64$), satisfaction with decision ($r = .59$) and quality of health care ($r = .54$; Bieber et al., 2010). In the present study, the Cronbach's alpha coefficients ranged from .95 to .97 and demonstrated sufficient test-retest reliability ($r = .39-.60$) across the four monthly time points.

Functional Health Literacy. Health literacy was measured using a single-item screening measure (How often do you have someone help you read hospital materials?) developed by Chew et al. (2004). Chew et al. (2004) evaluated the performance of three items that could be used

as a brief screening measure of functional health literacy. Their results indicated that the most valid item was the aforementioned question. Participants rate their health literacy using a 5-point Likert scale (always, often, sometimes, occasionally, or never). Higher scores on the single item indicates lower states of perceived functional health literacy.

Data Collection

Data for this randomized controlled trial were collected on a monthly basis across four time points using structured, face-to-face interviews. At baseline (T1), a research assistant read aloud the demographic form, the QQPPI, and single-item indicator of functional health status. Consistent with ACC/AHA recommendations for blood pressure measurement, participants had three serial blood pressure measurements using an automatic oscillometric sphygmomanometer, with one-minute intervals between each blood pressure measurement on the same arm and taken while the participant was in a sitting position (Whelton et al., 2018). During the baseline interview, self-report and blood pressure data were collected and participants were randomized and exposed to an experimental condition. Participants were able to complete the baseline interviews in approximately 60 minutes, which included the collection of self-report and blood pressure data, as well as their initial exposure to an experimental condition.

Subsequent interviews were also conducted on a monthly basis for three months following their baseline interviews. At the beginning of every monthly, structured, vis-à-vis interview (T2-T4), participants completed the QQPPI and the single-item indicator of functional health literacy, and had their blood pressure measured as previously described. Once these data were collected, participants were exposed to another dose of an experimental condition. On average, the follow-up interviews lasted approximately 45-60 minutes. After the completion of each study interview, including the baseline interview, participants received a \$20 gift card of their choice to local retailers, grocery stores, and restaurants to enhance participant retention.

Statistical Analysis

All data collected in this study were directly entered into the Research Electronic Data Capture system, REDCap, and imported into IBM SPSS Statistics, version 26, for data analysis. Descriptive statistics were used to describe sample characteristics and specify the mean scores for the outcome variables, QQPPI and functional health literacy scores.

Two separate repeated measures analysis of covariance (RM-ANCOVA) models were conducted to assess

the effects of the interventions across the four time points. The selection of the RM-ANCOVA permits an evaluation of changes in dependent variable scores across the four time points (main effect for time), if participant assignment to an experimental condition influenced changes in the dependent variable scores across time (main effect for group), and if changes in the dependent variable scores across time differed by group (interaction effect). The selection of covariates for each RM-ANCOVA was determined a priori and guided by the extant literature on variables that showed an effect on the dependent variables, the quality of the patient-provider interaction or functional health literacy among adults living with a chronic condition. The level of significance for each statistical test was $P < .05$.

Results

Sample Characteristics

A total of 109 participants with HTN were recruited into this study. The mean age of this sample was 52 years ($SD = 11$) and mean baseline blood pressure was $144/88 \pm 24/16$ mm Hg. This sample consisted of mostly (76%) individuals who identified themselves as African-American, Hispanic, or multiracial; 59% were female; 61% were not employed; and 38% had a high school education or less. More than one-third (41%) of participants rated their health as fair and 32% reported their health as good. In addition to managing their high blood pressure, 76% of participants were managing at least 2 additional chronic conditions. As shown in Table 1, there were no significant differences in the demographic or

clinical characteristics of the sample when compared by assignment to an experimental condition.

Intervention Effects on the Quality of the Patient-Provider Interaction

To evaluate differences in the perceptions of quality of patient-provider interaction by experimental condition across time, RM-ANCOVA was conducted. In this general linear model, the covariates of health literacy, age (in years), and systolic blood pressure control (mm Hg) were used to assess changes in the quality of the patient-provider interaction within and between the experimental conditions across time. Mauchly's sphericity test indicated that the assumption of sphericity was not violated (Mauchly's $W = .91$ and $\chi^2(5) = 8.0$, $P = .15$).

There was a significant within-subjects change in the quality of patient-provider interaction across time ($F(3) = 5.27$, $P = .001$, partial $\eta^2 = .055$, observed power = .93) and a within-subject effect between study condition and time ($F(3) = 2.91$, $P = .035$, partial $\eta^2 = .031$, observed power = .69) is noted in Table 2. For participants assigned to eSMART-HTN, there was a mean difference of +7 in their QQPPI scores whereas participants assigned to the attention control condition had relatively no change in their QQPPI scores across the observation period. Of the covariates entered in the model, none had a statistically significant interaction with time. Additionally, in this sample, there was no difference in the quality of the patient-provider interaction between the experimental conditions across time ($F(1) = .343$, $P = .56$) while accounting for covariates.

Table 1. Summary of Sample Characteristics by Experimental Condition.

Variables	Attention control			Intervention			<i>t</i>	<i>P</i>
	<i>n</i>	<i>M</i>	<i>SD</i>	<i>n</i>	<i>M</i>	<i>SD</i>		
Age (in years)	34	50.00	11.70	75	52.60	10.75	1.13	.260
Systolic blood pressure (mmHg)	34	141.29	24.90	75	144.6	24.39	-.66	.510
Diastolic blood pressure (mmHg)	34	87.41	16.42	75	88.58	15.74	-.36	.722
Functional health literacy	32	4.63	.751	70	4.21	1.01	2.29	.025
Quality of patient-provider interaction	34	51.76	14.36	75	50.48	15.38	.412	.681
	<i>n</i>	%		<i>n</i>	%		χ^2	<i>P</i>
Racial identity: nonwhite	28	82		55	73		1.05	.306
Gender: female	21	62		43	57		.190	.663
Education:							3.43	.330
Less than high school	6	18		5	7			
High school graduate	8	23		23	30			
Technical training/some college	10	29			28			
College graduate		29		21	35			
	10			26				
General health status:								
Very good – excellent health	6	18		23	31		2.03	.154
Fair – good health	28	82		52	69			

Table 2. Summary of the Repeated Measure Analysis of Covariance for Quality of Patient-Provider Interaction.

Source of variance	SS	df	MS	F	P
Within-subject effects					
Time	1464.91	3	488.30	5.25	.001
Time × Age	1394.15	3	464.71	5.02	.002
Time × Functional Health Literacy	676.87	3	225.62	2.44	.065
Time × Systolic Blood Pressure	1130.50	3	376.83	4.07	.069
Time × Experimental Condition	806.95	3	269.00	2.91	.035
Error	25273.62	273			
Between-subject effects					
Age	1674.64	1	1674.64	2.91	.031
Functional health literacy	129.60	1	129.60	.225	.636
Systolic blood pressure	35.40	1	35.40	.061	.805
Experimental condition	197.50	1	197.50	.343	.559
Error	52355.33	91			

Table 3. Summary of the Repeated Measure Analysis of Covariance for Functional Health Literacy.

Source of variance	SS	df	MS	F	P
Within-subject effects					
Time	8.90	3	2.97	6.92	<.001
Time × Age	8.80	3	2.93	6.84	.010
Time × Education	2.01	3	.718	1.56	.200
Time × Experimental Condition	3.62	3	1.21	2.81	.035
Error	118.48	92			
Between-subject effects					
Age	1674.64	1	1674.64	2.91	.031
Education	129.60	1	129.60	.225	.636
Experimental condition	197.50	1	197.50	.343	.210
Error	52355.33	91			

Intervention Effects on Functional Health Literacy

A second repeated measures ANCOVA model was conducted to examine the effects of the assignment to an experimental condition on functional health literacy across time (Table 3). In this general linear model, age (in years) and educational level were covariates and the participant's assignment to an experimental condition was the between-subject factor. The Mauchly's test indicated that the statistical assumption of sphericity had not been violated (Mauchly's $W = .96$, $\chi^2(5) = 3.28$, $P = .66$). There were no statistically significant interaction effects within-subjects and experimental condition ($F(3) = 1.21$, $P = .30$) or between-subject effects ($F(1) = .003$, $P = .95$) observed in this sample of adults living with HTN. However, statistical significance was nearly achieved for the following within-subjects effects: change in functional health literacy scores across time ($F(3) = 2.65$, $P = .05$), and the interaction between functional literacy scores and age ($F(3) = 2.42$, $P = .07$).

Discussion

This study examined the effects of two electronic self-management interventions on the quality of patient-provider interaction and functional health literacy among individuals living with HTN. In this sample of predominantly underrepresented racial minorities and women, individuals who were exposed to the eSMART-HTN demonstrated improvements in the quality of the patient-provider interaction and a modest increase in their functional health literacy across time compared to individuals who were exposed to the attention control condition. The results of this study highlight the potential benefits of eHealth interventions. Using simulated virtual clinic visits can influence behavioral mechanisms, such as improving the quality of the patient-provider interaction, which can increase initiation of self-management behaviors among persons living with HTN.

Serious game technology and the application of gamification to eHealth interventions is a relatively new area

of behavior change science. However, serious game technology has been shown to improve knowledge and better self-management behaviors (Charlier et al., 2016; Fleming et al., 2016; D. Johnson et al., 2016). The present study explored the potential benefits of an avatar-based, serious game technology focused on improving the modifiable behavioral targets of patient-provider communication and functional health literacy. Similar to simulation performed in real-world settings, we posited that our avatar-based, serious game intervention would be a suitable medium to allow adults living with HTN to engage in experiential learning and facilitate the practice of using a structured communication system with virtual healthcare providers to improve their understanding about managing HTN and apply the communication behaviors in virtual interaction to their real-world interactions with healthcare providers.

Using a serious game technology for virtual simulations is a promising method to facilitate experiential learning and practice of interpersonal communication skills to enhance the quality of the patient-provider interaction, which in turn can influence HTN self-management behaviors. Several studies have demonstrated the effectiveness of serious games using virtual simulations to improve aspects of interpersonal communication between individuals managing a chronic condition and their healthcare providers (Gunn et al., 2020; LeRouge et al., 2016; Pinto et al., 2013). Similar to the positive effects demonstrated by others, participants exposed to eSMART-HTN had higher scores for the quality of their provider interactions compared to participants who were exposed to the attention control condition. Although the within-subject effect on quality of the patient-provider interaction is promising, the pilot nature of the study, in terms of sample size, constrained our ability to establish a between-subject effect. Serious games incorporating virtual simulations, such as eSMART-HTN, can help enhance the quality of the interaction between individuals managing a chronic condition and their healthcare providers, and in turn, lead to better HTN self-management.

Functional health literacy can have substantial influence on self-management behaviors, health decisions, and the health of individuals living with a chronic condition (Heijmans et al., 2015). In the present study, the eSMART-HTN intervention was designed to expose adults living with HTN to virtual interactions with healthcare providers and a communication strategy that would enable participants to ask questions to promote higher states of functional health literacy. However, participants exposed to the eSMART-HTN intervention did not demonstrate a statistically significant change in their functional health literacy. It is plausible that our use of a single-item indicator, a valid component of a brief screening tool for functional health literacy, did not fully

account for characteristics associated with the functional health literacy of our study participants, contributing to a lack of sensitivity to detect the effects of the eSMART-HTN and our null findings.

Strengths and Limitations

As with most studies, the present study had several limitations that should be noted. First, we recognized the limitations of the selected sampling methods and the use of unequal randomization of subjects to an experimental condition, which may have resulted in a biased sample with respect to age, race, gender, education level, and inadequate statistical power to detect statistically significant between-group differences in PPI and functional health literacy. Second, we captured functional health literacy with a valid, single indicator, but which may not have been sensitive enough to the effects of the eSMART-HTN intervention. These limitations should be addressed in future research.

Conclusion

Use of eHealth interventions with virtual simulations can help to improve the interactions between patients and their healthcare providers. However, further research examining the effects of eHealth interventions using virtual simulation strategies to improve the quality of patient-provider interaction and functional health literacy is warranted and holds promise of improving the self-management behaviors and health of persons living with HTN.


Declaration of Conflicting Interests

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