Original Research Article

Exploring the Relationship Between Health Information Technology and Use of Prescribed Antihypertensive Medications

Abstract

Objective: We aimed to assess the correlation between various internet uses for health-related purposes and the utilization of prescribed antihypertensive medications. Additionally, we aimed to explore how socioeconomic status influences this relationship.

Method: This study was a cross-sectional analysis of 8,224 participants, representing 69,033,231 adults in the United States with hypertension who were prescribed antihypertensive medications. Out of these respondents, 7,837 individuals (88.8%) reported adherence to their prescribed medication regimen. The study examined several independent variables, including internet usage for (1) accessing health information, (2) filling prescriptions, (3) scheduling medical appointments, and (4) communicating with healthcare providers via email. The dependent variable under investigation was the usage of antihypertensive medications following prescription. Multiple logistic regression was employed to analyze the relationship between internet use for health-related purposes, adherence to prescribed antihypertensive medications, and the influence of socioeconomic status on this relationship. By utilizing this statistical approach, the researchers could assess the variables' associations while avoiding potential plagiarism issues.

Result: After controlling for other factors, individuals who utilized the Internet for refilling prescription medications were found to have 1.65 times higher odds (95% CI 1.26, 2.16, $p < .001$) of taking prescribed antihypertensive medications compared to those who did not use the Internet for this purpose. Among hypertensive individuals who used the Internet for prescription refills, specific subgroups showed even higher odds of taking prescribed antihypertensive medications. Specifically, those who were employed had an adjusted odds ratio (AOR) of 2.04 (95% CI 1.39, 2.99, $p < .001$), college graduates had an AOR of 1.86 (95% CI 1.14, 3.04, $p = .013$). Individuals earning ≥ $20,000/year had an AOR of 2.74 (95% CI 1.68, 4.46, $p < .001$) compared to their unemployed counterparts, non-college graduates, or less than $20,000/year.

Conclusion: The study suggests a potential association between online prescription refills and adherence to antihypertensive medications, with this relationship being particularly pronounced among individuals

with higher socioeconomic status. Further research is warranted to explore the connection between health-related internet usage and medication adherence.

Keywords: Health, information, technology, antihypertensives, adherence

Introduction

Hypertension is a well-known cause of morbidity in the United States (US), with a prevalence of 45.4%, contributing to approximately 270,000 per year hypertension-related cardiovascular diseases, according to a 2018 report by the Center for Disease Control (CDC)[1]. Given the high prevalence of hypertension-related complications, effective measures to manage hypertension remain of utmost importance. Traditionally, managing hypertension involves using lifestyle modifications and antihypertensive medications, measures that have been shown to manage hypertension effectively and, as a result, reduce its complications. Despite these approaches, the prevalence of hypertension and hypertension-related cardiovascular diseases remains high, with challenges like antihypertensive medication non-adherence contributing significantly to it [2–4]. There have been several reported reasons for non-adherence to antihypertensive medications; some include poor patient-clinician communication, low socioeconomic factors, high pill burden, and poor access to health care [5–8]. Although different interventions that address these factors have shown encouraging results, newer approaches may improve adherence to antihypertensive medications, one of which is health information technology.

Different health technological tools have been studied recently, all of which have the common theme of using health care information to make decisions expected to improve the quality of healthcare delivery [9]. Some of these tools include mobile applications, text messaging, and advanced functions of electronic health records. Reports of their efficacy in improving healthcare quality have been mixed, and issues about the accessibility of these tools remain of enormous concern, given the potential of worsening health disparities. In the Hypertension Adherence Program in Pharmacy (HAPPy) trial, the use of prescription reminders via short message service (SMS) and telephone calls, in addition to other interventions, resulted

in a 22.6% increase in adherence to antihypertensive medications [10]. In the study of different technological approaches to improve medication adherence among asthmatics, interactive voice recognition software resulted in a modest increase in inhaled corticosteroid (ICS) therapy adherence [11]. Contrastingly, other studies have reported negative findings, with two reporting that using the Internet as a source of information led to poor adherence to medications and vaccines due to negative feelings users experienced from the information they found online [12,13].

Concerning the accessibility of HIT and its impact on the overall quality of health care. Poor access to HIT has been linked to low electronic health literacy, associated with poor socioeconomic status [14,15]. This implies that individuals in a low socioeconomic class may benefit less from this technological intervention. This challenge echoes one of the concerns from experts of the Health Information Technology for Economic and Clinical Health (HITECH) Act that the quality of health care may not improve as much as intended with the use of electronic health records with advanced functions such as online medication refill requests, communication tools and appointment scheduling [16]. Given these benefits and concerns, we set out to analyze the relationship between health information technology use, in this case, the use of the Internet for health purposes and the use of prescribed antihypertensive medications, as well as the impact of socioeconomic status on this relationship. We hypothesize that using health information technology will be associated with a positive effect on antihypertensive medication adherence.

Method

Study design

This cross-sectional study utilizes the sample adult core data of the 2018 National Health Interview Survey (NHIS). The NHIS is a survey of the non-institutionalized civilian population of the United States (US) conducted by the Centers for Disease Control and Prevention. The data contained sociodemographics, health information, and medical condition variables. Further details of this survey data are available elsewhere [17]. Since the data was publicly available, an IRB review was not required.

Study population

We identified 8,224 respondents representing 69,033,231 US adults with hypertension from the NHIS who answered yes to the question, *"Was any medicine ever prescribed by a doctor for your high blood pressure?"* Among them, 7,837/8224 (88.8%) respondents representing 610,000,000 adults answered yes to the question, *"Are you now taking any medicine prescribed by a doctor for your high blood pressure?"* These individuals who answered yes to antihypertensive medication were classified as adherent to antihypertensive medications.

Adherence to prescribed medication refers to how closely a patient follows their healthcare provider's recommendations regarding the timing, dosage, and frequency of their prescribed medications. Adherence is crucial for the effectiveness of medical treatments and the overall management of health conditions. There are several factors and criteria that contribute to adherence.

Measures

Sociodemographic variables

Age (18 -39, 40 – 64, and ≥ 65 years), race (white, black, Asians, others), gender (female and male), marital status (married, formerly married, and never married), smoking status (current smokers, former smokers, and never smoked) and body mass index (underweight, normal, overweight, and obese).

Socioeconomic factors

Income category (<$20,000/year and ≥ $20,000/year), employment status (employed and unemployed), and educational status (did not graduate high school, graduated high school, graduated college).

Independent variables

Health information technology use: use of the Internet to (1) fill up prescriptions, (2) communicate with a health care provider, (3) look up health information, and (4) schedule medical appointments.

Dependent variable

Adherence to or taking prescribed antihypertensive medications.

Statistical analysis

A sample weight was applied during the data analysis to ensure the generalizability of the results. A descriptive statistic was used to assess the sociodemographic proportion of participants who use HIT in different forms and to analyze the distribution of different uses of HIT by taking prescribed antihypertensive medication status. A multiple logistics regression model was used to analyze the relationship between different uses of HIT and taking prescribed antihypertensive medications with confounders adjusted for. A second model analyzed the interaction between socioeconomic status and HIT on antihypertensive medication use. The analysis was performed using STATA 14.0 with a p-value of <.05.

Results

Table 1 below shows the sociodemographic distribution of the study participants by different forms of health information use. Regarding all uses of HIT, respondents who use the various forms mainly were 40 – 64 years old, white, high school graduates, obese, employed, earn ≥ $20,000/year and have never smoked. The distribution differed only by gender, such that respondents who used the Internet to fill prescriptions and communicate with a healthcare provider were mainly males. In contrast, those who used the Internet to schedule medical appointments and look up health information were primarily females.

Table 1. Sociodemographic distribution of study participants by health information technology use

Variable	Variable Subset	Fill up prescriptions online N (weighted %)	Communicate with a healthcare provider N (weighted %)	Schedule medical appointment N (weighted %)	Look up health information N (weighted %)
Age in years	-	-	-	-	-
-	18 – 39	89 (9.4%)	93 (8.9%)	91 (10.9%)	291 (10.0%)

	40 – 64	566 (54.7%)	653 (54.3%)	524 (55.0%)	1832 (54.7%)
	≥ 65	479 (35.9%)	546 (36.8%)	393(34.1%)	1592 (35.3%)
Gender	-	-	-	-	-
-	Female	559 (48.6%)	661 (48.9%)	538 (52.3%)	2077 (53.8%)
	Male	575 (51.4%)	631 (51.1%)	470 (47.7%)	1638 (46.2%)
Race	-	-	-	-	-
-	White	963 (84.0%)	1062 (81.7%)	810 (79.1%)	3001 (79.2%)
	Black	116 (10.9%)	145 (11.5%)	134 (13.5%)	461 (13.6%)
	Asians	28 (3.1%)	44 (4.5%)	35 (4.9%)	129 (4.3%)
	Others	27 (2.0%)	41 (2.4%)	29 (2.5%)	124 (2.9%)
Educational level	-	-	-	-	-
-	< high school (HS)	38 (3.5%)	31 (2.3%)	29 (3.5%)	167 (4.6%)
	Graduated HS	584 (52.0%)	629 (49.1%)	499 (50.4%)	2073(55.6%)
	Graduated college	510 (44.5%)	631 (48.6%)	478 (46.1%)	1471 (39.8%)
Marital status	-	-	-	-	-
-	Married	642 (67.5%)	708 (67.0%)	543 (64.6%)	1880 (62.0%)
	Formerly married	305 (18.2%)	378 (18.7%)	283 (19.0%)	1237 (22.7%)
	Never married	185 (14.3%)	205 (14.4%)	181 (16.4%)	592 (15.3%)
BMI	-	-	-	-	-
-	<18.5	1 (0.1%)	5 (0.3%)	5 (0.3%)	17 (0.4%)
	18.5 – 24.9	201 (16.7%)	231 (17.4%)	187 (17.6%)	668 (16.9%)
	25 -29.9	364 (31.7%)	427 (32.9%)	306 (30.5%)	1229 (33.9%)
	≥ 30	568 (51.6%)	629 (49.4%)	510 (51.7%)	1801 (48.9%)
Employment	-	-	-	-	-
	Unemployed	592 (48.5%)	626 (44.0%)	467 (42.8%)	1938 (48.0%)

-	Employed	541 (51.5%)	665 (56.0%)	541 (57.2%)	1775 (52.0%)
Income per year	-	-	-	-	-
-	<$20,000	96 (14.1%)	104 (12.0%)	75 (11.4%)	334 (15.6%)
	≥ $20,000	519 (85.9%)	632 (88.0%)	520 (88.6%)	1615 (84.4%)
Smoking status	-	-	-	-	-
-	Never	588 (54.6%)	723 (59.5%)	573 (60.0%)	1981 (55.9%)
	Former	439 (36.4%)	452 (32.2%)	335 (30.3%)	1256 (31.9%)
	Current	107 (9.0%)	117 (8.3%)	100 (9.7%)	447 (12.3%)

Table 2 below shows the proportion of respondents who use different forms of HIT by antihypertensive use status. Among 6349 respondents who reported taking prescribed antihypertensives, 3261 (41.3%) of them use the Internet to look up health information, 1151 (15.0%) use the Internet to communicate with a health care provider, 1040 (13.7%) use the Internet to fill prescriptions and 897 (12.7%) use the Internet to schedule medical appointments.

Table 2. A weighted percentage of respondents who use different forms of HIT antihypertensive medications use status

Variable	Currently not taking their antihypertensive medications N (weighted percentage)	Taking their antihypertensive medications N (weighted percentage)
Communicate with a healthcare provider	141 (2.0%)	1151 (15.0%)
Schedule medical appointment	111 (1.5%)	897 (12.7%)
Filled prescription	94 (1.3%)	1040 (13.7%)
Look up health information	454 (6.2%)	3261 (41.3%)

Table 3 below shows different forms of health information technology use and the odds of taking prescribed antihypertensive medications. Those who use the Internet to fill up prescription medications as compared to those who do not have 47% higher odds (OR 1.47, 95% CI 1.14,1.90, p .003) of taking their prescribed antihypertensive medications. This odd further increased to 65% (AOR 1.65, 95% CI 1.26, 2.16, p <.001) after controlling for covariates. Individuals who use the Internet to look up health information had 30% less odds (OR 0.71, 95% CI 0.59, 0.86, p <.001) of taking their antihypertensive medications as compared to those who do not. However, this was not significant after controlling for covariates (AOR 0.87, 95% CI 0.71, 1.06, p .164).

Table 3. Crude and adjusted odds of antihypertensive medication adherence by different uses of health information technology

Variable	Odds ratio (95% CI)	*p*	Adjusted odds ratio (95% CI)	*p*
Look up health information	0.71 (0.59 – 0.86)	<.001	0.87 (0.71 – 1.06) [a]	.164
Fill out medication prescriptions	1.47 (1.14 – 1.90)	.003	1.65 (1.26 – 2.16) [b]	<.001
Schedule medical appointments	1.07 (0.82 – 1.40)	.625	1.23 (0.93 – 1.65) [c]	.152
Communicate with a healthcare provider	0.93 (0.73 -1.19)	.576	0.99 (0.77 – 1.27) [d]	.950

a Adjusted for age, gender, race, marital status, body mass index, and smoking status

b Adjusted for age, race, marital status, body mass index, and smoking status

c Adjusted for age, marital status, body mass index, and smoking status

d Adjusted for age, race, marital status, and smoking status

Table 4 below shows the effect of the interaction between socioeconomic factors on the relationship between health information technology and taking prescribed antihypertensive medications. Respondents who were employed and used the Internet to fill out prescriptions had insignificant odds (OR 1.13; 95% CI 0.80, 1.59, p .493) of taking their prescribed antihypertensive medications as compared to those who were unemployed and did not use the Internet to fill out a prescription. This odd became significant after adjusting for covariates (AOR 2.04; 95% CI 1.39, 2.99, p <.001).

As compared to respondents who did not graduate HS and did not use the Internet to fill prescriptions, respondents who graduated college and used the Internet to fill out prescriptions had a 67% higher odd

(OR 1.67; 95% CI 1.04, 2.69, p .033) of being adherent to antihypertensive medications, and this odd increased to 86% after adjusting for covariates (AOR 1.86; 95% CI 1.14, 3.04, p .013).

Respondents who earn ≥ $20,000/year and use the Internet to fill prescriptions as compared to respondents who earn < $20,000/year and do not use the Internet to fill prescriptions had a significant odd (OR 2.68; 95% CI 1.74, 4.12, p <.001) of taking their antihypertensive medications. This odd was similar after adjusting for covariates (AOR 2.74; 95% CI 1.68, 4.46, p <.001).

Table 4. An interaction analysis of the socioeconomic status and online medications refills on adherence to antihypertensive medications

Variable	OR (95% CI)	*p*	AOR (95% CI)	*p*
By employment status	-	-	-	-
Respondents who are unemployed and do not use the Internet to fill out prescriptions	1.00	-	1.00	-
Respondents who are employed and do not use the Internet to fill out prescriptions	0.56 (0.46 – 0.69)	<.001	0.95 (0.76 – 1.19)	.657
Respondents who are unemployed and use the Internet to fill out prescriptions	1.12 (0.75 – 1.68)	.589	1.17 (0.77 - 1.77)	.460
Respondents who are employed and use the Internet to fill out prescriptions.	1.13 (0.80 – 1.59)	.493	2.04 (1.39 - 2.99)	<.001
By education	-	-	-	-
Respondents who did not graduate HS and do not use the Internet to fill a prescription	1.00	-	1.00	-
Respondents who graduated HS and do not use the Internet to fill a prescription	0.68 (0.50 – 0.91)	**.010**	0.74 (0.55 – 0.99)	**.045**
Respondents who graduated college and do not use the Internet to fill a prescription	0.85 (0.61 – 1.18)	.334	0.87 (0.62 -1.22)	.422
Respondents who did not graduate HS and use the Internet to fill a prescription	0.67 (0.24 - 1.89)	.448	0.77 (0.30 - 2.01)	.596

Respondents who graduated HS and use the Internet to fill a prescription	0.87 (0.58 – 1.29)	.483	1.09 (0.72 – 1.65)	.694
Respondents who graduated college and use the Internet to fill a prescription	1.67 (1.04 - 2.69)	**.033**	1.86 (1.14 – 3.04)	**.013**
By income category	-	-	-	-
Respondents who earn < $20,000/year and do not use the Internet to fill a prescription	1.00	-	1.00	-
Respondents who earn >/=$20,000/ year and do not use the Internet to fill a prescription	1.42 (1.04 – 1.94)	.**027**	1.33 (0.92 – 1.94)	**.133**
Respondents who earn less than < $20,000/ a year and use the Internet to fill a prescription	1.74 (0.81 – 3.74)	.154	1.50 (0.65 – 3.47)	.343
Respondents who earn >/= $20,000/ year and use the Internet to fill a prescription	2.68 (1.74 – 4.12)	**<.001**	2.74 (1.68 – 4.46)	**<.001**

Discussion

We set out to analyze the relationship between different forms of the use of the Internet for health purposes and the odds of taking prescribed antihypertensive medications and evaluate the interaction effect of socioeconomic status on this relationship. We found out that among the forms of HIT evaluated, using the Internet to fill prescriptions was associated with a significant odd of taking prescribed antihypertensive medications. As compared to respondents who do not use the Internet to refill prescription medications and are either unemployed, earn < $20,000 per year, or did not graduate high school, respondents who do not use the Internet to refill prescription medications and are either employed, have a higher level of education or earn ≥ $20,000 per year were not more likely to take prescribed antihypertensive medications. However, all three measures of socioeconomic status had a positive

interaction effect on the relationship between online prescription medication refills and taking prescribed antihypertensive medications. The findings of this study re-emphasize three of five factors identified by the American College of Preventive Medicine as key in the adherence to prescription medications which are socioeconomic factors, patient-related factors, and health care system factors, with the others being medication condition-related factors, and therapy-related factors [18].

The available evidence suggests that improving access to health care can lead to increased medication adherence. In a review of the management of adherence to antihypertensive medication, Burnier and Egan reported that the problem of antihypertensive medication adherence can be addressed by easing access to antihypertensive medications [19]. In our study, as compared to those who do not, individuals who use the Internet to fill up prescription medications had a 40% increase in the odds of taking prescribed antihypertensive medications, increasing further to 65% after adjusting for confounders. Other studies have reported similar positive associations between online refills and medication adherence. Sarkar et al. reported an absolute decline of 6% in non-adherence in individuals prescribed statins for dyslipidemia [20]. McInnes et al. reported adherence of more than 90% to antiretroviral medications among veterans who use personal health record functions such as online refills [21], and Lyles et al. reported a significant improvement over time in statin adherence by individuals who exclusively refill prescriptions online [22]. It is possible that refilling antihypertensive medications online creates an ease of access that could serve as an important strategy in improving medication adherence in individuals with hypertension and may extend to other populations. This increased likelihood of adoring prescribed medications may also be due to the higher engagement with electronic health record portals and online refills of medications compared to other Internet uses. This may imply that a higher engagement with the health care system through health portals may lead to an increase in healthy behaviors such as medication adherence.

Interestingly, there was no difference in taking prescribed antihypertensive medications between those who use HIT in other forms besides online refills of prescription medications and those who did not. We found no difference in taking prescribed antihypertensive medications concerning using the Internet to

look up health information. This was inconsistent with reports from other studies on using the Internet to gather health information, as findings of a positive [23] and a negative association with medication adherence have been reported [[24]]. This inconsistency was also found between using the Internet to communicate with a health care provider and antihypertensive medication adherence, as studies have shown that patient-provider communication is associated with a positive medication adherence outcome [[25–27]]. However, it is important to mention that these studies with a reported positive association evaluated in-person communication instead of online communication, which we analyzed. Another reason may be related to the less engaging nature of the health care system these other uses provide, and as such healthy habits are less likely to be encouraged with these methods.

Beyond these mixed findings, the interaction analysis showed that as opposed to a lower socioeconomic status, a higher socioeconomic status had a positive effect on the relationship between the use of health information to fill prescription medication and taking prescribed antihypertensive medications. Studies from Wong et al. and Paccoud et al. reported a more affluent socioeconomic status's positive effect on the use of health information technology [[28,29]]. However, just like other studies that have been done, the relationship with medication adherence was not studied. This effect may be related to other factors, such as the better health literacy of individuals in higher socioeconomic groups [[30]] and the higher likelihood of Internet use [[31,32]]. Individuals of a lower social status have been reported to use the Internet less effectively and profitably [[33]]. Given these arguments, although the implication of our findings is positive concerning medication adherence, encouraging the use of HIT to access health care may have the potential of marginalizing minorities.

This study has a few strengths worthy of mention. First, we evaluated the interaction of socioeconomic status on the relationship between a form of HIT use and taking prescribed antihypertensive medications. We felt this was important as socioeconomic status has been shown to influence access to HIT. As shown in this study, the relationship between HIT and adherence to antihypertensives may be affected by this influence. We analyzed different uses of HIT in patient care and felt this was necessary as there are

different uses of HIT, and patients may use it for different reasons. Sampling weights were applied during the data analysis, allowing the results to be generalized to the US population. Despite these strengths, some weaknesses do exist. First, although sampling weights were applied, the proportion of HIT users who were and were not adherent to antihypertensive medications was not uniform, which may have influenced our results. Second, as this is a cross-sectional study, causation cannot be implied, and just because people use HIT and are adherent to medications those not necessarily mean that this is the reason why, as there are other factors not controlled for, such as the duration of hypertension, relationship with a primary care provider, and access to the Internet.

Conclusion

Not all health information technology use forms are associated with increased adherence to antihypertensive medications. As shown in other studies, communicating with a healthcare provider online may not have the same effect on medication adherence as in-person communication. Being able to refill medications online may improve adherence to antihypertensive populations. Higher socioeconomic status may be associated with a positive effect on the relationship between online medication refills and medication adherence. Further studies are needed to evaluate the relationship between different forms of health information technology use and adherence to medications and the potential for marginalization of minorities.

Data Availability: The data used in this study was from publicly available data (NIS)

Ethical approval: This Paper does not require ethical approval.

Disclosure statement

American Heart Association accepted the abstract at the 2021 hypertension conference, https://doi.org/10.1161/hyp.78.suppl_1.P135.

Data statement

Data used for this analysis is available at https://www.cdc.gov/nchs/nhis/1997-2018.htm.

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