DIGITAL HEALTH

Frequent and diverse use of electronic health records in the United States: A trend analysis of national surveys

Han Zheng[1,2] and Shaohai Jiang[3] (iD)

Abstract

Objective: Considering the increasing integration of electronic health records (EHRs) into medical practice by healthcare organizations, it is especially pertinent to understand its actual usage by the general public in recent years. This study aims to explore factors associated with the frequency and diversity of EHR usage in the United States over time.

Methods: We analyzed three iterations (2017, 2018, and 2019) of the Health Information National Trends Survey (HINTS). HINTS is a national cross-sectional survey conducted by the National Cancer Institute to document attitudes and perceptions about health information access and use among American adults.

Results: Both frequency and diversity of EHR usage have slightly increased across the years. However, its overall usage still remained low. Three technology-related enablers (access to digital devices, access to the Internet, and perceived usefulness of EHRs) were positively related to EHR usage in all three iterations. In addition, perceived health status was a constant and negative predictor of EHR usage over years. Doctor–patient communication was positively associated with the frequency of EHR usage in two survey waves.

Conclusions: More initiatives to increase EHR usage in the United States are needed. We advocate for providing affordable Internet access and smartphone to underserved populations; in medical encounters, doctors should have more patient-centered communication, introduce the benefits of EHRs to patients, and promote EHR adoption in terms of frequency and diversity.

Electronic health records (EHRs) are a digital version of a patient's chart such as personal contact information, medical history, test results, and diagnoses and treatments.[1] EHRs can be accessed through a variety of channels. For example, the patient portal is the most common source for patients to view their EHRs. Besides, many health information service websites (e.g. WebMD) also provide access to personal health records.[2] In recent years, with the mobile revolution, people can access EHRs through mobile apps.[3] With access to EHRs, patients can view past clinical notes, review lab test results and medications, use the messaging system to communicate with healthcare providers, and check bills of clinical visits. The adoption of EHRs is beneficial to both healthcare institutions and individual patients. First, EHRs can help healthcare institutions to

[1]School of Information Management, Wuhan University, China
[2]Wee Kim Wee School of Communication and Information, Nanyang Technological University, Singapore
[3]Department of Communications and New Media, National University of Singapore, Singapore

Corresponding author:
Shaohai Jiang, Department of Communications and New Media, National University of Singapore, Blk AS6, #03-41, 11 Computing Drive, Singapore, 117416.
Email: cnmjs@nus.edu.sg

reduce medical costs, track patient data over time, and improve healthcare quality.[4–6] Second, access to medical records allows patients to better understand their medical history and health condition, save time and cost, increase access to care, and reduce the inconvenience of travel for medical and administrative purposes.[7–9] Such services provided through EHRs can facilitate patient empowerment, which indicates that the role of the patient is shifting from a patronized patient to an engaged and informed patient.[10] With the legislation of the 2009 Health Information Technology for Economic and Clinical Health (HITECH) Act, most hospitals and clinics in the United States had adopted EHRs and given patients access to their health records by 2014.[11] More recently, in February 2019, new regulations were proposed by the US Department of Health and Human Services to support secure and seamless access to EHRs at no cost to users.[12]

Considering the increasing integration of EHRs into medical practice by healthcare organizations, it is especially pertinent to understand its actual usage by the general public. Past studies showed that individuals might be reluctant to use EHRs for concerns about privacy and less personalized care.[13,14] Healthcare providers may also be unwilling to actively use this online tool due to concerns about information security and interruption of routine workflow.[15,16] While a significant body of research has examined EHR usage in various healthcare settings, mainly using small and convenient samples from subpopulations,[11,17–21] limited research has explored how different types of factors contribute to EHR usage.

To address the research gap in the existing literature, this study analyzed three iterations (2017, 2018, and 2019) of nationally representative samples from the Health Information National Trends Survey (HINTS) to explore (1) the trends of EHR use, in terms of frequency and diversity, among general populations in the United States, (2) the effects of three health-related factors (perceived health status, self-efficacy in health management, and doctor–patient communication), and three technology-related enablers (access to digital devices, access to the Internet, and perceived usefulness of EHRs) on EHR use, and (3) whether the influences of health-related and technology-related factors on EHR use are durable over time.

Literature review

Much of the existing research has focused on socio-demographic characteristics, such as age, education, gender, and income, and their impacts on EHR usage.[18,22,23] Although useful, a more theoretical and in-depth understanding of *why* these individual differences matter is needed. For example, health inequality and technology inequality among individuals might affect the adoption of EHRs.[24] Information foraging theory suggests that

people's information searching behavior is determined by their information needs and such behavior persists when the information obtained from a particular channel is useful and this channel is easy to access.[25] In the context of EHRs, when people's health needs and technology-related access are satisfied, they are more willing to adopt EHRs. Therefore, we argue that the exploration of EHR usage needs to incorporate both technology-related enablers and health-related factors. Based on information foraging theory and existing EHR-related studies,[18,25,26] we propose a theoretical framework that explains factors associated with EHR usage (see Figure 1). In particular, we hypothesize that three technology-related enablers (i.e. access to digital devices, access to the Internet, and perceived usefulness of EHRs) are positively related to EHR usage. In addition, we hypothesize that self-efficacy in health management and doctor–patient communication are positively related to EHR usage whereas perceived health status is negatively related to EHR usage.

Furthermore, most of the previous studies have investigated whether or not people use EHRs or EHR adoption rate,[18] while limited research has taken the multi-dimensional concept of technology use into account. For instance, *frequency* of EHR use could be different from *diversity* of EHR use although both concepts describe the adoption of EHR. Frequent access to EHRs describes how often people access EHRs, which does not necessarily mean they have utilized a great variety of functions afforded by EHRs. Using different services via EHRs (e.g. tracking examination results, communicating with doctors) is a critical step in ensuring that health information needs of the public are adequately addressed, maximizing the health benefits of EHRs.[26] Therefore, the current study conceptualizes EHR usage as a multi-dimensional construct (i.e. frequency and diversity) when examining factors associated with EHR.

Finally, since technological innovations in the medical field are dynamically and inextricably related to population health, examining EHR usage and its associated factors could be more informative if investigated over time.[24] Put differently, understanding what factors are durable in predicting EHR usage over time could help scholars and medical professionals to develop intervention strategies that increase EHR adoption among the general public.[18] Therefore, based on our proposed framework, we further ask a research question: What factors are associated with the frequency and diversity of EHR usage over time?

Methods

Sample

To examine factors associated with EHR usage, this study analyzed the following three waves of responses from
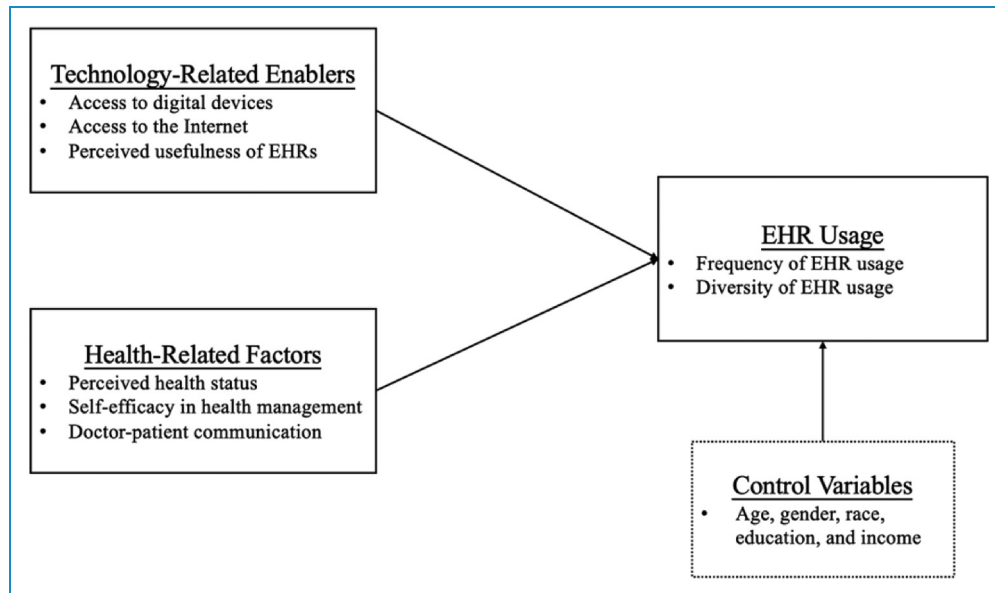
Figure 1. Factors associated with EHR usage.

HINTS: 2017 (HINTS 5 cycle 1), 2018 (HINTS 5 cycle 2), and 2019 (HINTS 5 cycle 3). HINTS is a national cross-sectional survey conducted by the National Cancer Institute to document attitudes and perceptions about health information access and use among American adults.[27,28] The sample size was 3285 in HINTS 5 cycle 1, 3504 in HINTS 5 cycle 2, and 5438 in HINTS 5 cycle 3. The reason for selecting these three waves is that previous iterations only had questions about whether or not people have used EHRs, while in our study, we focused on the frequency and diversity of EHR usage that were included in the recent waves of HINTS.

Measures

For health-related factors, *perceived health status* was assessed by asking respondents to rate on a 5-point Likert-type scale their perception of general health (1 = "Poor" and 5 = "Excellent"). *Self-efficacy in health management* was operationalized by asking participants how confident they were about their ability to take good care of their own health (1 = "Not confident at all" and 5 = "Completely confident"). *Doctor–patient communication* was measured with seven items that asked respondents how often their doctors did the following (1 = "Never" and 4 = "Always"): (a) "Give you the chance to ask all the health-related questions you had," (b) "Give the attention you needed to your feelings and emotions," (c) "Involve you in decisions about your health care as much as you wanted," (d) "Make sure you understood the things you needed to do to take care of your health," (e) "Explain things in a way you could understand," (f) "Spend enough time with you," and (g) "Help you deal with

feelings of uncertainty about your health or health care." The items were summed up and then averaged to create one index to reflect the overall level of doctor–patient communication.

In terms of technology-related enablers, *access to digital devices* was measured by asking respondents if they had (1) smartphone (e.g. iPhone, Android, etc.) and (2) tablet computer (an iPad, Kindle, etc.). The responses were dichotomous (1 = "Yes" and 0 = "No") and the two items were added up to create one index to indicate the accessibility of digital devices. *Access to the Internet* was measured using 4 items to ask participants if they accessed the Internet through (a) "A regular dial-up telephone line," (b) "Broadband such as DSL, cable, or FiOS," (c) "A cellular network (i.e. phone, 3G/4G)," and (d) "A wireless network (Wi-Fi)." The responses were dichotomous (1 = "Yes" and 0 = "No") and added up to create one index to indicate Internet access. The *perceived usefulness of EHRs* was measured by asking participants to indicate how useful their EHRs were for monitoring health (1 = "I do not use my EHRs to monitor my health" and 5 = "Very useful").

The *frequency of EHR usage* was measured by asking participants how many times they accessed their EHRs in the last 12 months (0 = "0," 1 = "1 to 2 times," 2 = "3 to 5 times," 3 = "6 to 9 times," 4 = "10 or more times." *Diversity of EHR usage* was assessed using four dichotomous items (1 = "Yes" and 0 = "No") that required respondents to report in the past 12 months, if they have used their EHRs to (a) "Securely message healthcare provider and staff (for example, email)," (b) "Download your health information to your computer or mobile device, such as a cell or tablet," (c) "Add health information to share with your healthcare provider, such as health

Table 1. Descriptive statistics for study variables.

	2017 (N = 3285) Mean (SD) or %	2018 (N = 3504) Mean (SD) or %	2019 (N = 5438) Mean (SD) or %
Age	56.34 (15.80)	57.02 (16.52)	56.93 (16.65)
Gender			
Male	39.7%	39.8%	41.1%
Female	60.3%	60.2%	58.9%
Race			
White	70.9%	71.9%	70.3%
Others	29.1%	28.1%	29.7%
Education			
High school and below	25.36%	25.86%	23.54%
Post high school or some college	31.84%	31.11%	32.14%
College and above	42.80%	43.04%	44.32%
Income			
$0–$19,999	17.02%	16.52%	16.62%
$20,000–$49,999	34.46%	35.65%	34.65%
$50,000–$99,999	27.37%	26.57%	26.39%
$100,000 or more	21.15%	21.26%	22.34%
Perceived health status (1–5)	3.38 (0.95)	3.42 (0.96)	3.41 (0.94)
Self-efficacy in health management (1–5)	3.87 (0.85)	3.92 (0.83)	3.92 (0.86)
Doctor–patient communication (1–4)	3.39 (0.62)	3.39 (0.59)	3.42 (0.54)
Access to digital devices (0–2)	1.31 (0.79)	1.27 (0.78)	1.32 (0.76)
Access to the Internet (0–4)	1.48 (1.13)	1.47 (1.1)	1.53 (1.1)
Perceived usefulness of EHRs (1–5)	4.13 (0.59)	4.05 (0.61)	4.15 (0.68)
Frequency of EHR usage (0–4)	0.55 (0.98)	0.57 (1.01)	0.76 (1.14)
	Non-use: 69.5%	Non-use: 68.6%	Non-use: 61.2%
	1–2 times: 15.1%	1–2 times: 14.8%	1–2 times: 16.5%
	3–5 times: 9.5%	3–5 times: 10.3%	3–5 times: 12.5%
	6–9 times: 3.2%	6–9 times: 3%	6–9 times: 5.1%

(continued)

Table 1. Continued.

	2017 (N = 3285) Mean (SD) or %	2018 (N = 3504) Mean (SD) or %	2019 (N = 5438) Mean (SD) or %
	Over 10 times: 2.7%	Over 10 times: 3.3%	Over 10 times: 4.7%
Diversity of EHR usage (0–4)	0.3 (0.75)	0.39 (0.89)	0.49 (0.99)
	Non-use: 82.6%	Non-use: 79.2%	Non-use: 74.2%
	1 function: 9.7%	1 function: 9.9%	1 function: 12.1%
	2 functions: 4.4%	2 functions: 5.6%	2 functions: 6.7%
	3 functions: 1.9%	3 functions: 3.2%	3 functions: 4.1%
	4 functions: 1.4%	4 functions: 2.1%	4 functions: 2.9%

concerns, symptoms and side effects," and (d) "Help you make a decision about how to treat an illness or condition." We counted the total number of functions participants engaged in as the measure of the diversity of EHR usage.

Lastly, *sociodemographic characteristics* were assessed as control variables in this study, including age in years, gender (1 = male and 0 = female), race (1 = white and 0 = others), education (ranging from 1 = "High school and below" to 3 = "College and above"), and household annual income (ranging from 1 = "$0 to $19,999" to 4 = "$100,000 or more).

Data analysis

First, descriptive analyses were conducted to show sample characteristics and their distribution. Second, a correlation analysis was conducted to show the interrelations between the study variables. To identify factors associated with EHR usage, ordinary least squared (OLS) regression analysis was employed to analyze the pooled sample, because participants from each wave had similar characteristics and the survey items were the same across the three waves. Third, to examine whether these predictors were constant over the years, six separate OLS regression analyses were employed to predict the frequency and diversity of EHR usage in the three waves of HINTS. In all the regression models, social demographic characteristics were first entered as control variables, followed by health-related factors and technology-related enablers as independent variables, and frequency or diversity of EHR usage was treated as the dependent variable. All data analyses were conducted in R version 3.6.1.

Results

Sample characteristics

Table 1 summarizes the sample characteristics of this study. The average age of the respondents in the three waves was around 56 years. About 40% were male; 70.3–71.9% were white people. More than one-third of the respondents had an education level of "college and above," with an annual household income between $20,000 and $49,999.

In general, the EHR usage slightly increased over the 3 years. With regard to frequency of EHR usage, in 2017, 30.5% of the respondents reported that they accessed their EHR at least 1–2 times in the past 12 months, and this rate increased to 31.4% in 2018, and 38.8% in 2019. The indexed value increased from 0.55 in 2017 to 0.76 in 2019. Similarly, the average diversity of EHR usage also had a small but steady rise during the 3 years, with index values changing from 0.3 in 2017 to 0.49 in 2019. For example, 4.4% of the respondents reported that they used two functions in the EHR system, increasing to 5.6% in 2018 and 6.7% in 2019. A correlation matrix of the study variables is presented in Table 2, providing some initial evidence of how the determinants were interrelated.

Frequency and diversity of EHR usage

Table 3 summarizes factors associated with frequency and diversity of EHR usage by analyzing the pooled sample. First, for frequency of EHR usage, we found that female, white people with older age, and higher education and household income were more likely to use EHR frequently. Doctor–patient communication was positively related to the frequency of EHR usage whereas perceived health status was a negative predictor of frequency of EHR usage. The relationship between self-efficacy in health management and frequency of EHR usage was insignificant. All the three technology-related enablers, namely, access to digital devices, access to the Internet, and perceived usefulness of EHRs were positively related to the frequency of EHR usage. Moreover, we found that females with older age, higher education, and household income were more likely to use diverse functions of EHRs. Self-efficacy in health

Table 2. Correlation matrix of study variables.

	Age	Gender	Race	Education	Income	PHS	SEL	DPC	ADD	AI	PUE	FEU	DEU
Age	-												
Gender	0.04***	-											
Race	0.05***	0.06***	-										
Education	−0.19***	0.04***	0.11***	-									
Income	−0.18***	0.12***	0.19***	0.42***	-								
Perceived health status (PHS)	−0.16***	0.02*	0.11***	0.26***	0.30***	-							
Self-efficacy (SEL)	−0.05***	−0.03**	0.03**	0.11***	0.16***	0.57***	-						
Doctor–patient communication (DPC)	0.07***	−0.01	0.02*	−0.02*	0.04***	0.13***	0.22***	-					
Access to digital devices (ADD)	−0.35***	−0.01	0.08***	0.31***	0.37***	0.20***	0.11***	0.02***	-				
Access to the Internet (AI)	−0.44***	0.05***	0.13***	0.36***	0.38***	0.21***	0.08***	−0.01	0.51***	-			
Perceived usefulness of EHRs (PUE)	−0.05***	0.01	−0.01	0.03***	0.04***	0.03***	0.05***	0.08***	0.06***	0.06***	-		
Frequency of EHR usage (FEU)	−0.08***	−0.05***	0.10***	0.23***	0.22***	−0.05***	0.04***	0.04***	0.25***	0.25***	0.17***	-	
Diversity of EHR usage (DEU)	−0.10***	−0.03**	0.05***	0.19***	0.18***	−0.05***	0.05***	0.04***	0.21***	0.23***	0.24***	0.67***	-

Note: * p <0.05; ** p <0.01; *** p <0.001.

Table 3. Factors associated with frequency and diversity of EHR usage (pooled sample).

	Frequency of EHR usage	Diversity of EHR usage
Socio-demographics		
Age	0.004*** (0.001)	0.001* (0.001)
Gender (male)	−0.165*** (0.019)	−0.086*** (0.016)
Race (white)	0.109*** (0.021)	0.014 (0.017)
Income	0.107*** (0.011)	0.064*** (0.009)
Education	0.154*** (0.013)	0.109*** (0.011)
Health-related factors		
Perceived health status	−0.083*** (0.012)	−0.055*** (0.011)
Self-efficacy in health management	0.019 (0.013)	0.023* (0.011)
Doctor–patient communication	0.007** (0.002)	0.005* (0.002)
Technology-related enablers		
Access to digital devices	0.168*** (0.014)	0.101*** (0.012)
Access to the Internet	0.134*** (0.010)	0.106*** (0.009)
Perceived usefulness of EHRs	0.246*** (0.014)	0.316*** (0.012)
Adjusted R-squared	0.14	0.13
No. observations	12,227	12,227

Note: $*p < 0.05$; $**p < 0.01$; $***p < 0.001$; standard errors in parentheses.

management and doctor–patient communication were positively related to the diversity of EHR usage whereas perceived health status was negatively related to the diversity of EHR usage. Similarly, all the three technology-related enablers were positively related to the diversity of EHR usage.

Table 4 shows factors affecting the frequency of EHR usage in the 3 consecutive years. First, for socio-demographic factors, we found that age, gender (female), income, and education were constant, positive predictors of frequency of EHR usage. Second, with regard to health-related factors, perceived health status was a constant negative predictor of the frequency of EHR usage. Self-efficacy in health management was only weakly associated with the frequency of EHR usage in 2018. Doctor–patient communication was positively related to the frequency of EHR usage in 2017 and 2019. Lastly, the three technology-related enablers were positively associated with the frequency of EHR usage over the three waves.

Table 5 demonstrates factors associated with the diversity of EHR usage in the 3 assessment years. First, for

demographic characteristics, we found that gender (female), income, and education were constant, positive predictors of the diversity of EHR usage. However, age and race were not significant predictors of the diversity of EHR usage over the years. Second, in terms of health-related factors, perceived health status was negatively associated with the diversity of EHR usage in three iterations. Self-efficacy in health management was positively associated with the diversity of EHR usage in 2018. Doctor–patient communication was positively related to the diversity of EHR usage in 2019. Lastly, all the technology-related enablers remained a positive relationship with the diversity of EHR usage over the 3 years.

According to our results, among the three health-related factors, perceived health status was a constant, negative predictor of frequency and diversity of EHR usage. We further tested whether those with poor health conditions had different levels of EHR usage from those with good health conditions. In doing so, we recoded the variable "perceived health status" into "perceived low health

Table 4. Factors associated with frequency of EHR usage in 2017, 2018, and 2019.

	Year 2017	Year 2018	Year 2019
Socio-demographics			
Age	0.003* (0.001)	0.003** (0.001)	0.004*** (0.001)
Gender (male)	−0.125*** (0.033)	−0.146*** (0.033)	−0.199*** (0.029)
Race (white)	0.113** (0.037)	0.051 (0.036)	0.150*** (0.032)
Income	0.133*** (0.019)	0.059*** (0.009)	0.041*** (0.008)
Education	0.083*** (0.023)	0.078*** (0.012)	0.105*** (0.011)
Health-related factors			
Perceived health status	−0.073*** (0.022)	−0.119*** (0.021)	−0.070*** (0.020)
Self-efficacy in health management	0.003 (0.023)	0.075** (0.024)	−0.011 (0.021)
Doctor–patient communication	0.009* (0.004)	0.001 (0.004)	0.009* (0.004)
Technology-related enablers			
Access to digital devices	0.145*** (0.025)	0.158*** (0.025)	0.186*** (0.023)
Access to the Internet	0.089*** (0.018)	0.122*** (0.018)	0.158*** (0.017)
Perceived usefulness of EHRs	0.246*** (0.027)	0.249*** (0.026)	0.236*** (0.021)
Adjusted R-squared	0.12	0.15	0.15
No. observations	3285	3504	5438

Note: *p <0.05; **p <0.01; ***p <0.001; standard errors in parentheses.

status" and "perceived high health status." Results from the independent-samples t-test indicated a significant difference in frequency of EHR usage between people with perceived low health status ($M = 0.66$, $SD = 1.06$) and people with perceived high health status ($M = 0.57$, $SD = 1.12$), [$t(12,225) = -3.68$, p <0.001]. Similarly, there was a significant difference in diversity of EHR usage between people with perceived low health status ($M = 0.42$, $SD = 0.92$) and people with perceived high health status ($M = 0.34$, $SD = 0.84$), [$t(12,225) = -3.71$, p <0.001]. To further examine the digital divide, we recoded the variable "access to digital devices" into "low access to digital devices" and "high access to digital devices." The independent-samples t-test showed that there was a difference in frequency of EHR usage between people with low access to digital devices ($M = 0.41$, $SD = 0.89$) and people with high access to digital devices ($M = 0.88$, $SD = 1.18$), [$t(12,225) = -24.89$, p <0.001]. Likewise, a significant difference in diversity of EHR usage was found between people with low access to digital devices ($M = 0.24$, $SD = 0.70$) and people with high access to digital devices ($M = 0.59$, $SD = 1.05$), [$t(12,225) = -21.62$, p <0.001].

Discussion

The current study examined EHR usage among American adults, with three iterations of HINTS datasets (2017, 2018, and 2019). We found that although both frequency and diversity of EHR use have slightly increased over years, overall, the usage of EHR still remained low, incongruent with the well-established EHR access provided by most healthcare organizations. This demonstrates the discrepancy between access to EHR provided to the public and the actual use of it. In the past decade, many national initiatives, such as the HITECH Act, have been implemented by government agencies to facilitate EHR adoption.[11] Also, community-based intervention programs have been increasingly targeted at eHealth promotion.[29] The low adoption of EHRs might suggest that individuals' barriers

Table 5. Factors associated with the diversity of EHR usage in 2017, 2018, and 2019.

	Year 2017	Year 2018	Year 2019
Socio-demographics			
Age	0.001 (0.001)	0.001 (0.001)	0.002 (0.001)
Gender (male)	−0.053* (0.026)	−0.071* (0.029)	−0.109*** (0.026)
Race (white)	0.018 (0.029)	0.039 (0.031)	0.004 (0.028)
Income	0.022** (0.007)	0.042*** (0.008)	0.025*** (0.007)
Education	0.028** (0.009)	0.061*** (0.010)	0.081*** (0.009)
Health-related factors			
Perceived health status	−0.038* (0.017)	−0.081*** (0.019)	−0.051** (0.017)
Self-efficacy in health management	0.010 (0.018)	0.058** (0.021)	0.004 (0.018)
Doctor–patient communication	0.004 (0.003)	−0.001 (0.003)	0.008* (0.003)
Technology-related enablers			
Access to digital devices	0.095*** (0.020)	0.093*** (0.022)	0.109*** (0.019)
Access to the Internet	0.066*** (0.014)	0.088*** (0.016)	0.134*** (0.015)
Perceived usefulness of EHRs	0.286*** (0.021)	0.377*** (0.023)	0.295*** (0.019)
Adjusted R-squared	0.10	0.15	0.14
No. observations	3285	3504	5438

Note: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; standard errors in parentheses.

or concerns regarding EHR use were not effectively addressed by past health education and promotion efforts. For example, many people might not use EHRs to contact doctors, because they still prefer to visit and directly communicate with their doctors in person due to the complexity of medical issues and psychological needs.[11] In addition, patients, especially Black and Hispanic people, might be concerned about the confidentiality and safety of their personal information in the EHR system.[11,30] Therefore, more efforts that respond to people's preferences and concerns are needed to facilitate the utilization of EHR.

EHR use is an information acquisition behavior (health vs non-health content) via digital platforms (electronic vs paper-based medical records). Therefore, a comprehensive examination of EHR should incorporate both health and technology perspectives. In this study, we explored the impacts of health-related factors and technology-related enablers on EHR use. First, among the three health factors, perceived health status was negatively associated with EHR usage. Notably, this negative association was significant across all three waves. In other words, the poorer health, the more frequent and diverse use of EHRs. One possible explanation could be that people who report poor health status could be those with chronic diseases; they need to conduct medical tests periodically and use a variety of services in the EHR system to track their medical records and seek more relevant information.[31] Additionally, a perceived low level of health status might lead people to feel anxious about health, and such anxiety prompts them to use EHRs for better self-management.[26] Moreover, we demonstrated that in two survey waves, a high-quality doctor–patient communication increased people's frequency of EHR usage. A positive communicative experience with doctors can enhance patients' trust toward the healthcare system, where EHRs have offered a new approach to delivering health services.[20] Particularly, for patients who worry that their health records are accessed by unauthorized parties, patient trust built upon quality medical communication would become a key driver of subsequent EHR adoption.

Second, all the technology-related factors were significant predictors of EHR usage over time. Specifically, access to the Internet and digital devices (e.g. smartphones and tablets) is essential for the adoption of EHRs. This finding echoes the literature on the digital divide, which examines whether individuals have physical Internet access (e.g. broadband) and digital devices (e.g. smartphone) to access the Internet.[32] This serves as the prerequisite for technology use for health purposes. Although it seems that the Internet is ubiquitous in people's daily life, the inequalities in digital access still exist among underserved populations. As Internet use has become a social determinant of health, those without such access might be confronted with health disparities.[18] In addition, we found that the perceived usefulness of EHRs had a significant effect on EHR usage. This is consistent with the technology acceptance model,[33] which states that when people view a particular technology as useful and beneficial, they would have a favorable attitude toward the technology, leading to greater use of it. Empirical evidence also suggests that EHR usability is a key determinant of patient outcomes whereas employing EHR systems with less perceived usefulness is related to less EHR adoption.[34]

This study has several limitations that open opportunities for future research. First, some variables in the HINTS survey were assessed using single-item measures. Future studies can use multi-item scales to enhance reliability and validity. Second, this study only examined two aspects of EHR usage: frequency and diversity. HINTS data did not ask the average duration of EHR use. It is possible that some respondents might use EHRs less frequently but spend a longer time for each use. Future research should consider different dimensions of EHR use. Third, this study mainly focused on drivers of EHR usage. The impact of such usage on individuals' health outcomes needs further examination in future research. Fourth, the cross-sectional design of HINTS survey prohibits causal interpretations of the data. Experimental studies are encouraged in future research to test the causal effects of various factors on EHR usage. Finally, the relatively low adjusted R-squared in our regression models suggests that other factors might play a more significant role in promoting EHR use. For example, according to the technology acceptance model, perceived ease of use is a strong predictor of technology use, particularly when the technology is new and hard to use.[35] Also, the digital divide literature indicates that despite the importance of material access of digital divide (e.g. physical Internet access), the cognitive access (e.g. knowledge and skills of technology use) has been increasingly crucial.[36,37] Thus, future studies should examine other potential technology-related enablers such as perceived ease of use from the technology acceptance model,[33] and computer literacy from theories of behavior.[38,39]

Despite these limitations, our study has important research implications. First, we contributed to the literature by proposing a framework to examine factors affecting individuals' EHR usage. This framework covered both health- and technology-related factors, and can be adopted by health education researchers to examine the utilization of other health information technologies in future studies.[38] Second, in contrast to previous studies that mainly focused on the adoption rate of EHRs,[18] we investigated its frequency and diversity simultaneously. The findings of this study revealed that both frequency and diversity of EHR usage were rather low in the general population, and they were affected by different technology enablers and health factors over time. This suggests the need for a synthesis of prior research to understand how individuals use EHR systems across the years.

Our study also offers several practical implications. First, given the constantly low usage of EHRs, it is critical to promote this new eHealth practice via multiple communication channels. For example, in medical encounters, healthcare providers can introduce the benefits of EHRs to patients and actively encourage to use them.[39] Mass media campaign is also needed to educate the public about the ongoing eHealth revolution, including EHRs.[42] To promote EHR usage, targeted intervention programs toward patients are essential. Healthcare organizations can organize workshops and utilize community outreach to educate patients about the benefits of EHRs, and teach them how to effectively use them. Second, considering that access to the Internet and digital device is a significant driving force of EHRs, the government and telecommunication service providers should continue to strengthen the ICT infrastructure and provide high-speed and convenient Internet access to the public. Also, affordable Internet service and smartphones should be provided, particularly to low-income communities. Government agencies can provide subsidy programs to underserved populations and offer training to equip them with necessary health literacy and digital literacy. Third, good-quality doctor–patient communication can also promote EHR usage. Therefore, we advocate for more patient-centered communication training in medical education as well as continuing education for health professionals.[10] Doctors should proactively build healing relationships with patients to facilitate mutual trust, which helps address patients' safety concerns for using EHRs. Fourth, when designing an EHR system, health informatics professionals need to figure out what functions or services are useful to potential users. Conducting formative research to understand target audiences' preferences and barriers is critical.[43] With these insights, a customized and user-friendly EHR system can then be created to satisfy patients' needs.[19,44] Lastly, at the policy level, although Health Information Technology for Economic and Clinical Health Act mandated the use of EHR in all healthcare organizations, we call for other regulatory initiatives to better promote EHR adoption. For example, to address users' data security concerns, stricter law enforcement to stop disclosing patient data to unauthorized parties is critical. Additionally, given the increasing usage of a patient portal for medical communication, organizational policies about payment structure to compensate for doctors' time spent with patients via EHRs are needed.

ORCID iD: Shaohai Jiang https://orcid.org/0000-0002-8265-9778

References

1. Kruse CS, Stein A, Thomas H, et al. The use of electronic health records to support population health: a systematic review of the literature. *J Med Syst* 2018; 42: 1–16.

2. Ahmed T, bin Sharif S, Joy TA, et al. Design of a cost-effective customized electronic health record system to handle patient management during Covid-19 pandemic. *AIUB J Sci Eng* 2021; 20: 41–46.

3. Kharrazi H, Chisholm R, VanNasdale D, et al. Mobile personal health records: an evaluation of features and functionality. *Int J Med Inform* 2012; 81: 579–593.

4. Ben-Assuli O, Ziv A, Sagi D, et al. Cost-effectiveness evaluation of EHR: simulation of an abdominal aortic aneurysm in the emergency department. *J Med Syst* 2016; 40: 141.

5. Beiser M, Lu V, Paul S, et al. Electronic health record usage patterns: assessing telemedicine's impact on the provider experience during the COVID-19 pandemic. *Telemed e-Health* 2021; 27: 934–938.

6. Poba-Nzaou P, Kume N and Kobayashi S. Developing and sustaining an open source electronic health record: evidence from a field study in Japan. *J Med Syst* 2020; 44: 159.

7. Shah SGS, Fitton R, Hannan A, et al. Accessing personal medical records online: a means to what ends? *Int J Med Inform* 2015; 84: 111–118.

8. van der Nat DJ, Taks M, Huiskes VJB, et al. A comparison between medication reconciliation by a pharmacy technician and the use of an online personal health record by patients for identifying medication discrepancies in patients' drug lists prior to elective admissions. *Int J Med Inform* 2021; 147: 104370.

9. Santoro JD, Sandoval Karamian AG, Ruzhnikov M, et al. Use of electronic medical record templates improves quality of care for patients with infantile spasms. *Heal Inf Manag J* 2021; 50: 47–54.

10. Ammenwerth E, Hörbst A, Lannig S, et al. Effects of adult patient portals on patient empowerment and health-related outcomes: a systematic review. *MedInfo* 2019; 264: 1106–1110.

11. Khan S, Lewis-Thames MW, Han Y, et al. A comparative analysis of online medical record utilization and perception by cancer survivorship. *Med Care* 2020; 58: 1075–1081.

12. US Department of Health and Human Services. HHS proposes new rules to improve the interoperability of electronic health information, www.hhs.gov/about/news/2019/02/11/hhs-proposes-new-rules-improve-interoperability-electronic-health-information.html (2019) (accessed February 22 2022).

13. Hollo Z and Martin DE. An equitable approach to enhancing the privacy of consumer information on my health record in Australia. *Heal Inf Manag J* 2021: 18333583211019764.

14. Sayed ME. Knowledge, attitude and behaviour of dental health care providers towards health electronic record systems in Saudi Arabia. *Heal Inf Libr J* 2021; 38: e12290.

15. Jiang S and Street RL. Factors influencing communication with doctors via the internet: a cross-sectional analysis of 2014 HINTS survey. *Health Commun* 2017; 32: 180–188.

16. AlQahtani M, AlShaibani W, AlAmri E, et al. Electronic health record-related stress among nurses: determinants and solutions. *Telemed e-Health* 2020; 27: 544–550.

17. Alkureishi MA, Lee WW, Lyons M, et al. Impact of electronic medical record use on the patient–doctor relationship and communication: a systematic review. *J Gen Intern Med* 2016; 31: 548–560.

18. Hong YA, Jiang S and Liu PL. Use of patient portals of electronic health records remains low from 2014 to 2018: results from a national survey and policy implications. *Am J Heal Promot* 2020; 34: 677–680.

19. Freund O, Reychav I, McHaney R, et al. The ability of older adults to use customized online medical databases to improve their health-related knowledge. *Int J Med Inform* 2017; 102: 1–11.

20. Jung C and Padman R. Virtualized healthcare delivery: understanding users and their usage patterns of online medical consultations. *Int J Med Inform* 2014; 83: 901–914.

21. Lämsä E, Timonen J, Mäntyselkä P, et al. Pharmacy customers' experiences with the national online service for viewing electronic prescriptions in Finland. *Int J Med Inform* 2017; 97: 221–228.

22. Andreassen HK, Bujnowska-Fedak MM, Chronaki CE, et al. European citizens' use of e-health services: a study of seven countries. *BMC Public Health* 2007; 7: 1–7.

23. Crameri K-A, Maher L, Van Dam P, et al. Personal electronic healthcare records: what influences consumers to engage with their clinical data online? A literature review. *Heal Inf Manag J* 2022; 51(1): 3–12. doi:10.1177/1833358319895369.

24. Qian Y, Ni Z, Gui W, et al. Exploring the landscape, hot topics, and trends of electronic health records literature with topics detection and evolution analysis. *Int J Comput Intell Syst* 2021; 14: 744–757.

25. Pirolli P. *Information foraging theory: adaptive interaction with information*. New York, NY: Oxford University Press, 2007.

26. Xiao N, Sharman R, Rao HR, et al. Factors influencing online health information search: an empirical analysis of a national cancer-related survey. *Decis Support Syst* 2014; 57: 417–427.

27. Nelson D, Kreps G, Hesse B, et al. The health information national trends survey (HINTS): development, design, and dissemination. *J Health Commun* 2004; 9: 443–460.

28. Xie Z, Jo A and Hong Y-R. Electronic wearable device and physical activity among US adults: an analysis of 2019 HINTS data. *Int J Med Inform* 2020; 144: 104297.

29. Oliffe JL, Rossnagel E, Bottorff JL, et al. Community-based men's health promotion programs: eight lessons learnt and their caveats. *Health Promot Int* 2020; 35: 1230–1240.

30. Elkefi S, Yu Z and Asan O. Online medical record nonuse among patients: data analysis study of the 2019 health information national trends survey. *J Med Internet Res* 2021; 23: e24767.

31. Rexhepi H, Åhlfeldt R-M, Cajander Å, et al. Cancer patients' attitudes and experiences of online access to their electronic medical records: a qualitative study. *Health Informatics J* 2018; 24: 115–124.

32. Van Deursen AJAM and Van Dijk JAGM. The first-level digital divide shifts from inequalities in physical access to inequalities in material access. *New Media Soc* 2019; 21: 354–375.

33. Davis FD, Bagozzi RP and Warshaw PR. User acceptance of computer technology: a comparison of two theoretical models. *Manage Sci* 1989; 35: 982–1003.

34. Neprash HT, Everhart A, McAlpine D, et al. Measuring primary care exam length using electronic health record data. *Med Care* 2021; 59: 62–66.

35. Marangunić N and Granić A. Technology acceptance model: a literature review from 1986 to 2013. *Univers Access Inf Soc* 2015; 14: 81–95.

36. Zheng H, Goh DH-L, Lee EWJ, et al. Understanding the effects of message cues on COVID-19 information sharing on Twitter. *J Assoc Inf Sci Technol* 2022; 73: 847–862.

37. Jiang S and Liu PL. Digital divide and internet health information seeking among cancer survivors: a trend analysis from 2011 to 2017. *Psycho-Oncology* 2020; 29: 61–67.

38. Wu C, Huang S and Yuan Q. Seven important theories in information system empirical research: A systematic review and future directions. *Data Inf Manag* 2022; 6: 100006.

39. Poynton TA. Computer literacy across the lifespan: a review with implications for educators. *Comput Human Behav* 2005; 21: 861–872.

40. Johnson EA and Carrington JM. Clinical research integration within the electronic health record: a literature review. *CIN Comput Informatics. Nurs* 2021; 39: 129–135.

41. Epstein RH, Dexter F and Schwenk ES. Provider access to legacy electronic anesthesia records following implementation of an electronic health record system. *J Med Syst* 2019; 43: 105.

42. Xie R, Chu SKW, Chiu DKW, et al. Exploring public response to COVID-19 on weibo with LDA topic modeling and sentiment analysis. *Data Inf Manag* 2021; 5: 86–99.

43. Tubaishat A. Evaluation of electronic health record implementation in hospitals. *CIN Comput Informatics, Nurs* 2017; 35: 364–372.

44. Turvey CL, Fuhrmeister LA, Klein DM, et al. Patient and provider experience of electronic patient portals and secure messaging in mental health treatment. *Telemed e-Health* 2022; 28: 189–198 DOI: 10.1089/tmj.2020.0395. Epub ahead of print 21 April 2021.