Facilitating patient portal engagement: a channel expansion and behavior change wheel perspective

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Introduction: Given the low patient portal adoption rates, the contradictory findings on the relationship between patient-provider communication and patient portal use, and the unclear mechanism of why doctor-patient communication might facilitate portal use as indicated in some existing studies, patient portal engagement warrants further examination.

Methods: Guided by the behavior change wheel framework and the channel expansion theory, this study examined the facilitators of patient portal engagement and tested the relationship between the facilitators (e.g., social opportunity and psychological capability) through analyzing the HINTS national survey data ($N = 1251$).

Results: We found that patient portal access (a physical opportunity) and physician advocacy (a social opportunity) were two significant predictors of portal engagement while educational attainment was not. We did not find any direct correlation between patient-centered communication (PCC) and patient portal engagement, but instead, found a significant indirect relationship between the two.

Discussion: To the best of our knowledge, this is the first study to employ the behavior change wheel and channel expansion theory to explain patient portal engagement. Theoretically, our study extended the behavior change theory by further explaining the relationship between the key components (e.g., capability, opportunity) of behavior change. Practical strategies to increase patient portal engagement were proposed.

KEYWORDS

patient portal engagement, the behavior change wheel, the channel expansion theory, patient-centered communication, patient portal access

Introduction

A patient portal is a secure online website that patients can use (e.g., to access personal health record) 24/7 from anywhere with Internet coverage (The Office of the National Coordinator for Health Information Technology, 2017). Despite the various potential benefits of patient portals (e.g., enhancing information sharing, improving patient safety, facilitating patient-provider communication, facilitating disease self-management, and empowering patients) (Miller et al., 2016; Rathert et al., 2017; Ammenwerth, 2018; Dendere et al., 2019), and despite the electronic health record (EHR) incentive programs to advocate and promote the meaningful use of EHRs to improve patient care (Ricciardi et al., 2013; Centers for Medicare and Medicaid Services, 2023), patient portal adoption rates have remained low, ranging from 37 to 54% (Anthony et al., 2018; Turner et al., 2020; Wright et al., 2022).

Among the empirical studies that have examined the facilitators of and barriers to online patient portal use, some conflicting results have been observed. For instance, some studies (e.g., Tieu et al., 2015) indicated that patient-provider communication is a facilitator while other studies (e.g., Zaidi et al., 2022) did not find such a significant relationship. The most prevalent barrier of portal use indicated by portal nonusers was the preference for in-person communication with providers (Anthony et al., 2018; Turner et al., 2020).

Even if patient-provider communication has a facilitating role, the mechanism of why the interpersonal communication (i.e., doctor-patient communication) can facilitate the computer- or technology-mediated communication (i.e., patient portal use) is unclear. Given the low patient portal adoption rates, the contradictory findings on the relationship between patient-provider communication and patient portal use, and the unclear mechanism of why doctor-patient communication might facilitate portal use as indicated in some existing studies, online patient portal use or engagement warrants further examination.

Guided by the behavior change wheel framework (Michie et al., 2011), the current research proposes that psychological capability (e.g., education attainment), physical opportunity (e.g., portal access), and social opportunity (e.g., physician advocacy) likely affect patients' levels of engagement in portal use. Also guided by the channel expansion theory (Carlson and Zmud, 1999), the current research proposes that patient-centered communication (PCC) likely affects portal engagement indirectly through levels of easiness in understanding the health information in patient portals. Therefore, the goals of the study are: (1) to test whether or not educational attainment, patient portal access, or physician advocacy predicts patient portal engagement, and (2) to find out the relationship between PCC and patient portal engagement.

Literature review

Functions of patient portals

Patient portals serve different functions. Basic functions include allowing patients to access their own medical information, such as medical history and records, immunizations, recent office visits. Other more advanced functions include enabling patients to schedule appointments, and exchange messages with healthcare their provider (Kruse et al., 2015). Some researchers have systematically reviewed the commonly shared functions among various patient portals. Bao et al. (2020) classified patient portal functions into two categories: clinical function and administrative function. Clinical function refers to outcomes that are directly related to patients' physical and mental health, such as viewing test results, messaging with health providers, scheduling an appointment. Administrative function is about how portal reduces the administrative burden on patients and health providers, such as updating insurance, resolving claims. Steitz et al. (2019) made a more detailed classification of patient portal's functions, which includes appointment, billing, document access, genetics, health results, immunization, medication, and messaging.

Patient portal engagement

Patient engagement is the process that patients themselves serve as an active member of the health care team and then build and maintain collaborative partnerships with health providers and provider organizations (Maurer et al., 2012). Patient portal engagement is a multi-step process, which goes from shallow to deep. Zhou et al. (2022) developed the patient portal engagement framework (PPEF) which summarized four levels of engagement: informing patients; involving patients; partnering with patients; and supporting ecology of care. Going through these four stages, a patient's role evolves from a passive information recipient to an active partner who collaborates with health providers. Portal engagement can generate some positive outcomes such as increasing medication adherence (Sarkar et al., 2014), empowering patients (Ammenwerth, 2018), reducing duplicate testing (Wakefield et al., 2020), significantly reducing patients' hospital visit times, and eventually decreasing hospitalization costs (Bao et al., 2020). However, though with various portal functions and the potential benefits, the adoption rates of patient portal, at least in the U.S., have remained low (Anthony et al., 2018; Turner et al., 2020). Given the low engagement rates, it is imperative to find out potential barriers to and facilitators of patient portal engagement.

The behavior change wheel and patient portal engagement

The behavior change wheel framework (Michie et al., 2011) can be used to systematically examine the facilitators of and barriers to patient portal engagement. According to the behavior change wheel (Michie et al., 2011, 2014), in order for the behavior of online patient portal engagement to happen, capability, opportunity, and motivation are necessary conditions (Michie et al., 2011). Capability includes physical capability (i.e., the physical skills or strength needed to perform a behavior) and psychological capability (i.e., the psychological skills or knowledge needed to engage in a behavior) (Michie et al., 2011). Patients with higher educational attainment will likely have more knowledge and skills needed for patient portal use. Studies indicated that education level (an example of psychological capability) (Sarkar et al., 2011; Osborn et al., 2013; Ancker et al., 2015; Sun et al., 2019) was a significant predictor of portal engagement. Therefore, we hypothesize that:

H1(a) educational attainment will predict patient portal engagement.

Motivation includes automatic motivation (i.e., automatic processes without much deliberate thoughts, such as wants and needs, impulses and emotions) and reflective motivation (i.e., reflective processes involving deliberate thoughts and mental processing, such as intentions and evaluations) (Michie et al., 2011). Lack of awareness or motivation (Goel et al., 2011; Turner et al., 2020) can inhibit a patient's portal use. Patients with stronger health emotions (an example of automatic motivation), and openness to new experiences (an example of reflective motivation) are more likely to use patient portals (Moqbel et al., 2020).

Opportunity includes physical opportunity (i.e., the physical environment external to an individual, such as resources, access) and social opportunity (i.e., the social environment and interpersonal relations that are supposed to influence people' perceptions of a behavior) (Michie et al., 2011). High income (an example of physical opportunity) was a facilitator of portal engagement (Ketterer et al., 2013; Osborn et al., 2013; Sun et al., 2019) while not having access to computer (another example of physical opportunity) is a barrier for patients' portal engagement (Osborn et al., 2013). Other factors related to physical opportunity were also mentioned in the existing literature. For instance, the levels of comprehensiveness of health data on patient portals (Fujioka et al., 2021) influence portal engagement whereas portal design features (Lazard et al., 2016) can influence portal acceptance by patients. Based on the definition, having access to online patient portal is a physical opportunity. Patients indicated that no patient portal access and lack of Internet access were barriers to patient portal use (Turner et al., 2020). Therefore, having access to online patient portal is likely to be a facilitator of portal engagement. We hypothesize that:

H1(b) patient portal access will predict patient portal engagement.

Provider advocacy of portal use is a social opportunity that has the potential to facilitate portal use. Some physicians do not hold a positive attitude toward a patient portal since they think it generates more workload (Miller et al., 2016). However, health providers' support can influence patients' trust on a portal (Goel et al., 2011). Providers can communicate the potential benefits of patient portals through interpersonal communication in a healthcare setting and promote the use of patient portals, which will in turn influence patients' perception of patient portals and facilitate portal engagement. The following hypothesis was proposed:

H1(c) physician advocacy of portal use will predict patient portal engagement.

Patient-provider communication and portal engagement

There are conflicting results regarding the relationship between patient-provider communication and patient portal engagement. Studies indicated that interest in the portal was predicted by dissatisfaction with the provider-patient relationship, and disinterest in the portal was predicted by satisfaction with the provider-patient relationship (Zickmund et al., 2008). National survey results indicated that preference for in-person communication with providers (Anthony et al., 2018; Turner et al., 2020) was one of the major barriers of patient portal use. While some studies (e.g., Zaidi et al., 2022) did not find a significant relationship between provider-patient communication and online portal use, some other studies (e.g., Lyles et al., 2013; Tieu et al., 2015) indicated that patient-provider communication is a facilitator of patients' online patient portal use. Patient-centered communication (PCC), a type of patient-provider communication, occurs when a provider takes a patient's needs, goals, and individual experience into consideration, gives the patient the opportunity

to make decisions and participate in their care, and it will enhance doctor-patient relationship (Epstein and Street, 2007). Higher levels of PCC could make the patients feel that there is no motivation to use the portal (Zickmund et al., 2008) or could motivate patients to take care of their health by engaging in patient portal. Therefore, the following research question (RQ) was proposed:

RQ1: What is the relationship between PCC and patient portal engagement?

Portal-mediated communication vs. doctor-patient communication

Portal-mediated communication and interpersonal communication with providers have their distinctive characteristics, benefits or disadvantages, under different tasks or circumstances. First, we consider levels of synchronicity. According to media synchronicity theory (Dennis et al., 2008), it is better to use face to face communication which has the highest degree of synchronicity when a patient first sees a doctor to understand the diagnosis and discuss a treatment plan or when complex things need to be discussed. Some physicians hold that a portal was not able to handle complex communication (Laukka et al., 2020). The high immediate and interactive nature will facilitate the process to reach shared understanding of a patient's health conditions and disease management plans (Kashian and Mirzaei, 2019). Second, compared to face-to-face communication, patient portals, are mostly text based and lack of visual cues (An and Frick, 2006). Because of the lack of visual cues (e.g., body languages and gestures) that help facilitate understanding and convey emotions in patient portals, misunderstanding can happen (Slanetz et al., 2019) when patients use the portals. "Patients with advanced disease need the cues that come with direct interaction to help them along with their care" (Fuerst, 2017, para. 8). Third, portal-mediated communication lacks the ability to communicate empathy (Laukka et al., 2020). Fourth, the advantage of text-based communication is that it provides a written record of face-to-face communication (e.g., clinical notes), and information needed for patients to manage their health and coordinate healthcare (e.g., test results, patient education). Patients don't need to worry about forgetting important things in the interpersonal setting and later they have the opportunity to learn and reflect on the content provided in the portal (An and Frick, 2006). Fifth, another advantage of portal-mediated communication is that it is place and time independent (An and Frick, 2006). Patients can access their health information 24/7, with the access to the Internet and appropriate technology (e.g., smartphones).

Based on the previous discussion of the characteristics of the communication channels, according to media richness theory (Daft and Lengel, 1986), portal-mediated communication could be considered as a leaner medium, compared to face-to-face communication, because of the following four aspects: immediate feedback, multiple cues, language variety, and personal focus (Ishii et al., 2019). The perception that portal is a lean medium in medical context could be the reason of some peoples' preference of face-to-face communication and the low rates of portal adoption.

However, according to the channel expansion theory (Carlson and Zmud, 1999), perceptions and attitudes of a medium and its characteristics vary across users because of a variety of factors, such as experience (Timmerman and Madhavapeddi, 2008). Experience can be specified into four categories: "(a) experience with a particular channel, (b) experience with a particular topic, (c) experience with a particular communicator, and (d) experience with particular organizational contexts" (Ishii et al., 2019, p. 125). Based on the channel expansion perspective (Carlson and Zmud, 1999), if a patient has more experience with their healthcare provider through PCC, the patient will be more familiar with the communicator (e.g., doctors) as well as the topic (e.g., health conditions). As the experience increases, their levels of the perception of the richness of the channel (i.e., patient portal) increase, and patients would likely feel easier to understand the health information on the patient portal. According to behavior change wheel (Michie et al., 2011), as patients feel easier to understand the health information on portal (i.e., the increase of psychological capability), they are more likely to engage in patient portals. Therefore, the following hypotheses were proposed:

H2. Higher levels of PCC will make patients feel easier to understand the health information on patient portal.

H3. If patients feel easier to understand health information on patient portals, they are more likely to engage in patient portals.

H4. There is a significant indirect relationship between PCC and patient portal engagement.

Methods

HINTS dataset and study population

The Health Information National Trends Survey (HINTS), developed by National Cancer Institute (n.d.), is used to collect nationally representative data to monitor and study health communication and health information technology. HINTS data are reliable and informative, and the items were carefully tested before the survey to ensure its validity (National Cancer Institute, n.d.). The data used in this study, HINTS 5 Cycle 4 ($N = 3,865$), were collected in 2020, and were available in 2022. HINTS data were used in this study because of its focus on patient portal use and because of its national representativeness. Patients ($N = 1,251$) who filled out the questions related to patient-centered communication and online patient portals were the focus of the analyses.

Instrumentation

The HINTS survey questions related to our hypotheses and research question were included in our investigation. Patient portal engagement can be measured by frequency of access (e.g., Wallace et al., 2016). Similarly, in our study, patient portal engagement was operationalized as the frequency of portal access ("How many times did you access your online medical record in the last 12 months?"). PCC was measure by seven items which have been used as PCC measures in previous studies (e.g., Totzkay et al., 2017). The questions asked how often the health professionals

(e.g., doctors, nurses) did each of the processes, such as "give you the change to ask all the questions you had" and "involve you in decisions about your health care as much as you wanted." Patient portal access was measured by asking participants: "Have you ever been offered online access to your medical records by your health care provider?" Physician advocacy was measured by the question: "Have any of your health care providers, including doctors, nurses, or office staff ever encouraged you to use an online medical record?" Educational attainment was measured by the question: "What is the highest grade or level of schooling you completed?" The level of easiness of understanding health information on patient portal was measured by the question: "How easy or difficult was it to understand the health information in your online medical record?"

Data analysis

In order to test hypotheses h1(a), h1(b), and h1(c), and answer the research question, multiple regression was used to analyze the data. Control variables included age, gender, health, race and ethnicity, household income. Gender, race, portal access, and physician advocacy were dummy coded. The mean score of the PCC items was used in the regression analysis. SPSS 27.0 (IBM Corp, 2020) was used for the regression analysis. Path analysis was used to test hypotheses 2, 3, and 4. In order to test the indirect effect, PCC was treated as a latent variable, and was the exogenous variable, the level of easiness of understanding health information on patient portal was a mediator, and portal engagement was the endogenous variable. Control variables included age, gender, health, race and ethnicity, household income. Bootstrapping technique, with the number of iterations being set to 5000, was used to obtain bias-corrected 95% confidence to test the indirect effect (Preacher and Hayes, 2008). Statistical software Mplus 8.0 (Muthén and Muthén, 2017) was employed to test the relationships.

Results

Participants' demographics

Participants' demographic characteristics were presented in Table 1. The mean age of the participants was 54.24. The majority of the participants were females (63.1%) and 80.7% of the participants were White. 38.4% of the participants reported to have very good health condition. 34.9% of the participants were college graduates.

Factors predicting patient portal engagement

Hypotheses 1 posited that educational attainment (H1a), patient portal access (H1b), and physician advocacy (H1c) predicted patient portal engagement. As shown in Table 2, a significant proportion of variance was predicted in portal engagement, $F_{(9,1,241)} = 7.94$, $p < 0.001$, $R^2 = 0.05$. Patient portal access ($\beta = 0.07$, $p < 0.05$) and physician advocacy ($\beta = 0.14$, $p < 0.001$) were significant predictors of portal engagement, but educational attainment ($\beta = 0.05$, $p = 0.10$) was not a significant

TABLE 1 Descriptive statistics.

Demographics	Number	Unweighted %
Age (years)	$M = 54.24$ (SD = 15.61, range: 18–98)	
Gender		
Male	461	36.9
Female	790	63.1
Race		
Non-white	242	29.3
White	1,009	80.7
Health		
Poor	25	2.0
Fair	139	11.1
Good	441	35.3
Very good	481	38.4
Excellent	165	13.2
Education		
Less than 8 years	5	0.4
8 through 11 years	13	1.0
12 years or completed high school	137	11.0
Post high school training other than college	74	5.9
Some college	260	20.8
College graduate	436	34.9
Postgraduate	326	26.1
Income		
$ 0 to $ 9,999	33	2.6
$ 10,000 to $ 14,999	40	3.2
$ 15,000 to $ 19,999	35	2.8
$ 20,000 to $ 34,999	114	9.1
$ 35,000 to $ 49,999	144	11.5
$ 50,000 to $ 74,999	223	17.8
$ 75,000 to $ 99,999	188	15.0
$ 100,000 to $ 199,999	346	27.7
$ 200,000 or more	128	10.2
Patient portal access frequency	$M = 2.06$ (SD = 1.05)	
Patient-centered communication	$M = 3.45$ (SD = 0.60, $\alpha = 0.92$)	
Patient portal access		
Yes	1,175	93.9
No	76	6.1
Physician advocacy		
Yes	1,063	85.0
No	188	15.0
Understanding of information on portal	$M = 3.34$ (SD = 0.66)	

TABLE 2 Regression analysis of portal engagement.

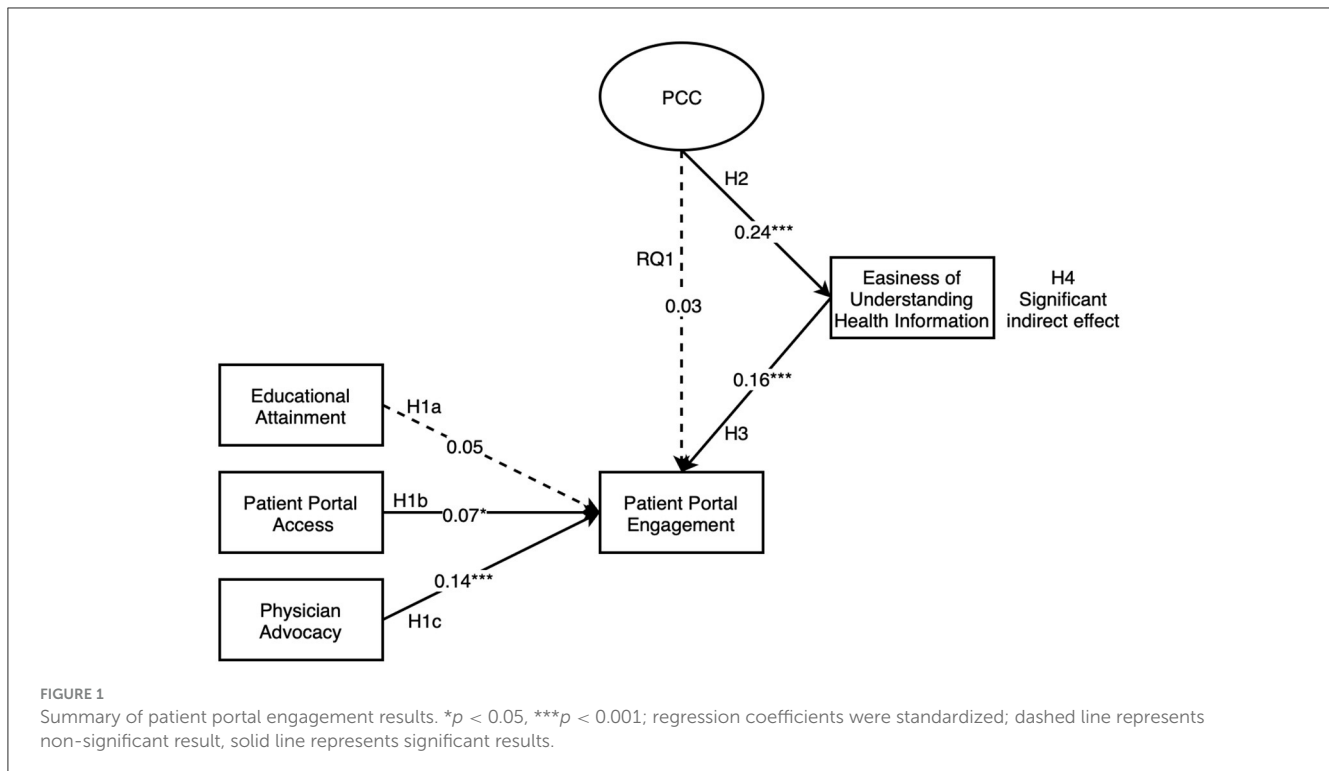| Variables	Portal engagement	
	B (SE)	β
Age	0.002 (0.002)	0.03
Health	0.199*** (0.04)	0.17
Sex	−0.002 (0.06)	−0.001
Income	−0.01 (0.02)	−0.02
Race	0.18* (0.08)	0.07
Portal access	0.29* (0.13)	0.07
Physician advocacy	0.40*** (0.08)	0.14
Education	0.04 (0.02)	0.05
PCC	0.06 (0.05)	0.03
R^2	0.05	
Adj. R^2	0.05	
F	7.94*** (9, 1,241)	

*p < 0.05.
***p < 0.001.

predictor of patient portal engagement. Therefore, hypotheses 1(b) and 1(c) were supported while hypothesis 1(a) was not supported. PCC was not a significant predictor ($\beta = 0.03$, $p = 0.25$) of portal engagement, meaning there was no direct relationship between PCC and portal engagement, and the research question was answered.

Indirect relationship between PCC and patient portal engagement

For the path analyses, the results for the overall fit of proposed model ($\chi^2 = 411.93$, df = 75, $p < 0.01$, RMSEA = 0.06, CFI = 0.93, TLI = 0.92, SRMR = 0.03) indicated acceptable fit to the data; although the p-value was significant. We used the following criteria to evaluate the model fit: values >0.90 for CFI and TLI, values smaller than 0.08 for RMSEA and SRMR (Browne and Cudeck, 1993; Hu and Bentler, 1998; McDonald and Ho, 2002). Higher levels of PCC ($\beta = 0.24$, $p < 0.001$) significantly predicted higher levels of easiness of understanding health information on patient portal. H2 was supported. Higher levels of easiness of understanding health information on patient portal ($\beta = 0.16$, $p < 0.001$) significantly predicted higher levels of patient portal engagement. H3 was supported. There was a significant indirect path from PCC to patient portal engagement [ES = 0.04, 95% CIs (0.02, 0.05)], and therefore, H4 was supported. The summary of the results is presented in Figure 1.

Discussion

This study was guided by the behavior change wheel framework (Michie et al., 2011) and the channel expansion theory (Carlson and Zmud, 1999). In this study, we found that patient portal access and physician advocacy were two significant predictors of portal

FIGURE 1
Summary of patient portal engagement results. *$p < 0.05$, ***$p < 0.001$; regression coefficients were standardized; dashed line represents non-significant result, solid line represents significant results.

engagement while educational attainment was not. We did not find any direct correlation between PCC and patient portal engagement, but found a significant indirect relationship between the two.

We found that physician advocacy was a significant predictor of portal engagement. This finding is in agreement with existing studies (e.g., Amante et al., 2014; Irizarry et al., 2015; Powell, 2017). For instance, in the systematic review (Powell, 2017) on patient-perceived facilitators of and barriers to portal use, they found that provider encouragement was indicated as one of the patient-perceived facilitators. Another study (Dendere et al., 2019) indicated that a lack of provider advocacy was a barrier of portal engagement. We found that portal access was another significant predictor of portal engagement. This is in agreement with the existing studies (e.g., Ancker et al., 2017) which demonstrated that the rates of portal adoption increased as more patients were offered the portal accounts.

However, we did not find a significant relationship between education attainment and portal engagement. This was in agreement with some existing studies (e.g., Woods et al., 2017). The finding implies that people with higher education levels do not necessarily possess higher health literacy skills (Wright et al., 2022) or digital skills (Heponiemi et al., 2022) needed to understand the information on patient portals. Some studies demonstrated that low health literacy inhibits patient's portal use behavior (Baldwin et al., 2017; Hoogenbosch et al., 2018). Therefore, future studies may operationalize psychological capability necessary for patient portal engagement as health literacy and/or digital skills, rather than educational attainment.

Existing studies are not in agreement with regard to the relationship between provider patient relationship and patient portal engagement. While some studies (e.g., Zaidi et al., 2022) did not find a significant relationship between provider-patient

communication and online portal use, some other studies (e.g., Tieu et al., 2015) indicated that patient-provider communication is a facilitator of patients' online patient portal use. Interestingly, we did not find a significant direct relationship between PCC and portal engagement, but found a significant indirect relationship between the two. We provided some evidence to explain how interpersonal doctor-patient communication could influence technology-mediated communication in an indirect way, using the channel expansion theory (Carlson and Zmud, 1999). Through patient-centered communication in the face-to-face setting, patients will gain a lot of experience (i.e., visual cues such as body language and gestures, ways of expressing things) that will help patients understand the physician (the communicator) and their health condition (the topic) better. This type of experience and understanding will serve as context of the subsequent portal-mediated communication to avoid potential misunderstanding. As the levels of experience increase, and as their levels of the perception of the richness of the channel (i.e., patient portal) increase, patients will find the health information on portal easier to understand, and they will be more likely to engage with the medium (i.e., portal). This implies that people's perception of a patient portal can be changed and their engagement with portal can also be changed through that mechanism; PCC will facilitate easier understanding of health information on portal which in turn promote portal engagement.

Implications for theory and practice

To the best of our knowledge, this is the first study to employ the behavior change wheel (Michie et al., 2011) and the

channel expansion theory (Carlson and Zmud, 1999) to explain patient portal engagement. The two theories were employed to explain the mechanism of how interpersonal communication could influence technology-mediated communication. These findings indicated that the behavior change wheel framework (Michie et al., 2011) can be used as a guide to systematically examine the facilitators of and barriers of patient portal engagement. The three necessary components, capability, opportunity, and motivation, not only predict a behavior, but also interact with each other (Michie et al., 2011). For instance, capability and opportunity can influence motivation (Michie et al., 2011). Guided by the channel expansion theory (Carlson and Zmud, 1999), our study hypothesized the relationship between social opportunity (e.g., PCC) and psychological capability, and the indirect relationship between PCC and portal engagement. Our study provided some evidence to demonstrate that social opportunity (e.g., PCC) could influence psychological capability (e.g., perceived level of difficulty in understanding health information on patient portals) which predicts a behavior (e.g., portal engagement). In this sense, our study extended the theory by further explaining the relationship between the key components (e.g., capability, opportunity) of behavior change.

Practically, the behavior change wheel (Michie et al., 2011) has been applied as a framework to guide various interventions, for instance, mHealth interventions (Chiang et al., 2018). When it is used as a theoretical framework for designing interventions to promote portal adoption or engagement, the following dimensions can be considered: capability, motivation, and opportunity. Specifically, psychological capability, physical and social opportunity are important factors to be considered when designing an intervention to promote portal engagement. The behavior change wheel (Michie et al., 2011) also has provided strategies to facilitate capability, opportunity, and motivation, such as education, modeling, and enablement.

In our study, patient portal access was found to be a significant predictor of patient portal engagement, thus enhancing patients' digital access becomes an urgent and necessary effort. In the meantime, previous studies have revealed obvious disparities in digital healthcare service access, those with low socioeconomic status (SES) are less likely to use health technologies due to lack of access (e.g., Ahmed et al., 2020). Therefore, promoting patient portal access of people with low SES should be one focus of policy makers and healthcare providers' work in the future.

The results also provided important implications in terms of healthcare providers' key roles in facilitating patients' portal engagement. The following strategies can be used to facilitate portal engagement. First, during and/or after each doctor's office visit, healthcare providers can offer patient portal information (e.g., how to access portal online, how to use it) to patients who do not have access to patient portal to increase the rates of portal adoption and engagement. Second, physicians can briefly mention the benefits of a patient portal and encourage patients to use it. Moreover, the practice of PCC will potentially change patients' perception that a patient portal is a lean medium, and will also

help patients understand better about the health information in the portal.

Limitation and future studies

There are several limitations of the study. One is that HINTS data did not have variables to measure channel perception. In future studies, we can conduct surveys to include participants' perceptions of the channel to test the relationships (i.e., from PCC to portal channel perception, to the level of difficulty in understanding health information on the patient portal, to patient portal engagement). Another limitation is that a limited number of variables representing limited categories of the behavior change model (Michie et al., 2011) were tested in this study. The model entails six categories (i.e., physical capability, psychological capability, social opportunity, physical opportunity, automatic motivation, and reflective motivation), and only three categories with one variable from each category were tested in this study. However, existing research has demonstrated a variety of variables (e.g., personal factors, health care delivery factors) influencing patient portal engagement (Irizarry et al., 2015). Future study could explore other categories of the behavior change model, such as reflective motivation. For instance, will including educational resources in patient portal (Johnson et al., 2023) promote reflective motivation, which then increases portal engagement? Another limitation is that because of the cross-sectional nature of the survey, no causal relationship can be demonstrated. Future research could use longitudinal surveys or experiments to test the relationships.

Conclusion

Guided by the behavior change wheel framework (Michie et al., 2011) and the channel expansion theory (Carlson and Zmud, 1999), this study examined the facilitators of patient portal engagement and tested the relationship between the facilitators. In order to test the relationships, HINTS national survey data ($N = 1,251$) were used. We found that patient portal access (an example of physical opportunity) and physician advocacy (an example of social opportunity) were two significant predictors of portal engagement while educational attainment was not. We did not find any direct correlation between PCC and patient portal engagement. However, we found a significant indirect relationship between PCC and portal engagement through levels of difficulty in understanding health information on the portals (an example of psychological capability). To the best of our knowledge, this is the first study to employ the behavior change wheel (Michie et al., 2011) and the channel expansion theory (Carlson and Zmud, 1999) to explain patient portal engagement, and to explain the mechanism of how interpersonal communication could influence portal-mediated communication. Theoretically, our study extended the behavior change wheel (Michie et al., 2011) by further explaining the relationship between the key components (e.g., capability, opportunity) of behavior change. Practical strategies have been proposed to increase patient portal engagement.

Data availability statement

Author contributions

WC: Conceptualization, Methodology, Writing—original draft, Writing—review & editing. XC: Writing—original draft, Writing—review & editing.

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Conflict of interest

Publisher's note

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