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# Empowering older adults: bridging the digital divide in online health information seeking

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The proliferation of digital technology and the widespread adoption of smartphones provide older adults with valuable opportunities to seek health information. However, older adults do not reap the health benefits equally from using these digital technologies. This study draws on social cognitive theory to explore how to promote older adults to seek health information online to alleviate digital inequality. This study surveyed 277 older adults and analyzed the data using structural equation modeling. The findings confirm that self-efficacy and health-related outcome expectations are primary predictors of online health information seeking among older adults. Furthermore, this study identifies the sources of self-efficacy and health-related outcome expectations among older adults. Specifically, past experience and emotional state are significant sources of self-efficacy, while past experience, vicarious experience, verbal persuasion, and emotional state are crucial for enhancing health-related outcome expectations. Moreover, this study reveals health status negatively moderates the relationship between health-related outcome expectations and health information-seeking intention. These findings have important implications for research and practicality.

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## Introduction

In societies with aging populations, older adults face increasing health threats (World Health Organization, 2015). As a result, they require more health information to make informed decisions and manage their health effectively (Medlock et al. 2015). The proliferation of digital technology and the widespread adoption of smartphones provide older adults with valuable opportunities to seek health information. For instance, older adults can interact with AI-empowered chatbots through their smartphones to access health information (Xin Wang et al. 2021). They also obtain health information through smartphone channels, such as social media and professional health websites (Deng et al. 2015). The proportion of older Internet users has increased from 6.7% to 13.0% after the pandemic, almost all older adults have access to the Internet with smartphones (CNNIC, 2023). However, nearly half of them still lack basic digital skills, such as information acquisition (CNNIC, 2023), and not all older adults benefit equally from using the Internet (Jiang and Luo, 2024). To ensure the equal participation of older adults in the digital society, building a smart, healthy, age-friendly environment (Kolo-touchkina et al. 2023), not just improving digital accessibility (Han and Nam, 2021).

The primary cause of this inequality is the digital divide, which is related to the existence of a gap between those who can and cannot use smartphones effectively (Wang et al. 2022). The most immediate negative consequence of the digital divide is the isolation of older adults from digital health services, such as telehealth, online medical appointment platforms and virtual geriatric clinics (Martins Van Jaarsveld, 2020; Zhu et al. 2024). The lack of basic technology skills and awareness of the availability and value of digital health services hinder digital health equity among older adults (Kaihlainen et al. 2022). Evidence shows that low self-efficacy and distrust can lead older adults to resist digital health services (Ezeudoka and Fan, 2024). Moreover, the digital divide negatively impacts older adults' physical and mental health (Cui et al. 2024; Y. Liu et al. 2024). Especially for older adults in rural China, the digital divide has negatively affected their mental well-being due to limited access to information (Tang et al. 2024). Conversely, access to and use of online health resources enhances both well-being and resilience among older adults (Hofer et al. 2019; Kamalpour et al. 2021).

How can we increase digital health equity and empower older adults to seek health information online? Social cognitive theory suggests that enhancing self-efficacy and outcome expectations by the social environment is an effective strategy (Lam and Lee, 2006; Wei et al. 2011). Previous studies have demonstrated that self-efficacy and outcome expectations are the key predictors of information behavior among older adults, such as information seeking (Ma et al. 2023), learning (Shang and Zuo, 2020), and sharing (Zhou et al. 2021). Although Bandura (1977) identified four sources of self-efficacy, the existing literature often overlooks the sources of self-efficacy and outcome expectations of older adults, a vulnerable group in the digital age. As digitalization continues to advance, it is critical to ensure that older adults are able to benefit equally. Therefore, this study aims to explore how to enable older adults to seek health information online from a social-cognitive perspective.

This study attempts to address this issue by achieving two research goals: the first is to identify the source of self-efficacy and health-related outcome expectations among older adults, and the second is to explore the impact of personal factors on online health information seeking among older adults with varying health status. This work contributes to the social cognitive theory by identifying the sources of expectation beliefs in older adults. Furthermore, this study enriches the literature on online health information seeking by understanding how to empower different

older adults. Finally, this study enriches the literature on smart, healthy, age-friendly environments (SHAFE) by providing an inclusive perspective aimed at bridging the digital divide and increasing digital health equity.

## Theoretical foundation and literature review

**Online health information seeking.** During and after the pandemic, there has been a significant increase in online health information search behavior (Alzghaibi, 2023). Seeking health information through smartphones has become an important way to support medical decision-making (Langford et al. 2020). Seeking health information plays a crucial role in relieving negative emotions (T. Liu et al. 2024), promoting prevention behavior (Zheng et al. 2022), cancer screening (Ngien and Jiang, 2024), and having a healthy lifestyle (Jia et al. 2024). The mobile Internet offers various channels for health information seeking, including search engines, social platforms, health websites, and online health communities (Deng et al. 2015; Zhang et al. 2017). Many studies have examined how individuals engage in health information seeking, focusing on their motivation and the barriers they encounter. The antecedents of health information seeking include personal, technical, and environmental factors.

Socio-demographic characteristics significantly influence health information seeking on the Internet (Demirci et al. 2021). Specifically, women, young individuals, and those with higher levels of education are more likely to seek health information online (Xiaohui Wang et al. 2021). Self-efficacy is a key factor influencing health information seeking; individuals with adequate literacy and competence are more inclined to seek health information online (Kim, 2015). Health literacy, by enhancing self-efficacy, also promotes individuals to seek health information (Niu et al. 2021). Additionally, Lagoe and Atkin (2015) found that health anxiety and Internet self-efficacy are psychological determinants of online health information seeking in the digital age. A meta-analysis further highlighted that self-efficacy and health literacy influence individuals' health information seeking (Chang and Huang, 2020). For older adults, low literacy and self-efficacy are significant barriers to seeking health information (Zhao et al. 2022). Conversely, when older adults possess sufficient self-efficacy and health literacy, they are more likely to seek and learn health information (Pourrazavi et al. 2022; Shang and Zuo, 2020). Evidence suggests that older adults with higher self-efficacy are more likely to use social media for information, which in turn reduces loneliness and enhances their happiness (Chen and Gao, 2023).

Technical factors often outweigh personal factors in determining whether individuals seek health information (Xiaohui Wang et al. 2021). Given the significance of health to individuals, the quality of health information is crucial during the health information-seeking process (Deng et al. 2015). Chang and Huang (2020) identified credibility and availability as dominant predictors of health information seeking. Cao et al. (2016) further emphasized that these characteristics influence health information access by affecting cognitive factors, including self-efficacy and expected benefits. According to the comprehensive model of information seeking, utility is a key predictor (Johnson and Meischke, 1993). Kim (2015) also suggested that usefulness should be a focal point in research on online health information seeking. Previous studies have shown that perceived benefits or utility play a positive role in health information seeking (Ren et al. 2019; Xiaohui Wang et al. 2021). For older adults, usefulness is particularly important when seeking health information (Pourrazavi et al. 2022). Their behavior depends on health awareness and perceived benefits (Ma et al. 2023). Based on the technology

acceptance model, Chang and Im (2014) also found that perceived usefulness has a positive impact on internet health information seeking among older adults.

Environmental factors also play a crucial role in health information seeking. Chang and Huang (2020) found that social norm is the most influential factor. On mobile social media platforms, social support positively impacts health information seeking by enhancing self-efficacy (Deng and Liu, 2017). This social support is especially important for older adults with difficulties using information technology (Zhao et al. 2022). Social support not only boosts health awareness among older adults (Ma et al. 2023), but also improves their information and skill literacy when seeking health information (Xiong and Zuo, 2019). In addition, health opinion leaders positively influence the health information-seeking behavior of older adults (Li and Chang, 2024).

**Social cognitive theory.** Social cognitive theory (SCT) offers a comprehensive framework for comprehending, forecasting, and influencing human behavior, and it serves as the foundation for various intervention strategies (Bandura, 1986, 1997). At the heart of SCT is “triadic reciprocity”, which refers to the dynamic interaction between the physical and social environment, personal factors (such as beliefs and cognitions), and the behaviors exhibited (Bandura, 1986). Bandura proposed two sets of personal factors, self-efficacy and outcome expectations, that guide individual behavior (Bandura, 1977).

Self-efficacy refers to an individual's belief regarding one's capacity to engage in specific behaviors (Bandura, 1977, 1982). It plays a central role in human agency, influencing an individual's choices and behavior (Bandura, 1982). The sources of self-efficacy include four types of personal life experiences: mastery of past experience, vicarious experience, verbal persuasion and emotional state (Bandura, 1977). Among these, active mastery of past experience has the greatest significant impact because active mastery means that people have directly done and repeated the experience many times. Successfully completing a task boosts confidence, while failure, particularly in the early stages of social learning, can lead to self-doubt and discourage continued efforts (Ambrose and Chiravuri, 2010). Vicarious experience, which involves observing the behavior of others, also enhances self-efficacy. Observing others completing a task without adverse consequences often increases their confidence in their ability. However, vicarious experience is not as reliable as direct mastery of experience (Gardner and Rozell, 2000). Verbal persuasion enhances individuals' self-efficacy by providing guidance and encouragement from someone important. However, the effect of

verbal persuasion is not as stable as mastery of past experience and vicarious experience because it lacks the grounding in actual experience (Bandura, 1977). Finally, emotional state also affects self-efficacy, as individuals assess their ability to complete tasks based on emotion. Fear and anxiety can lead to avoidance behavior and hinder the formation of self-efficacy (Gardner and Rozell, 2000; Torkzadeh et al. 2006), while positive emotions can boost confidence and improve self-efficacy (Lent et al. 2017).

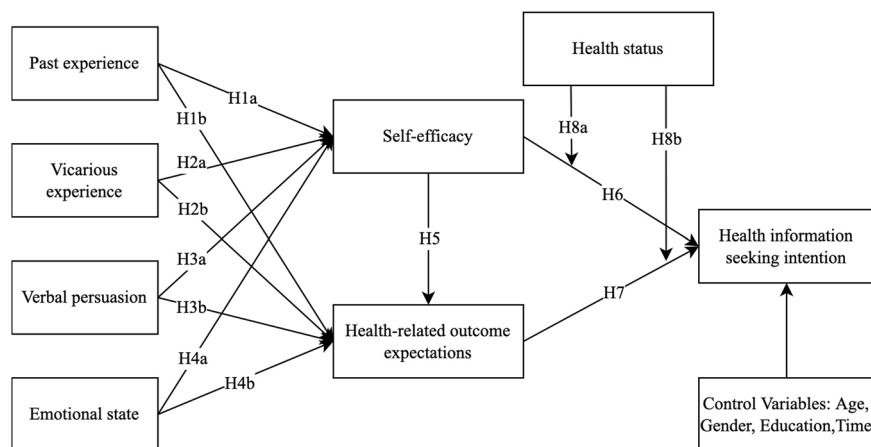
Another important expectation belief is outcome expectations, which refer to individuals' anticipations of action outcomes (Bandura, 1997). Individuals are more prone to opt for an action when recognizing its potential for valuable outcomes. The sources of self-efficacy-mastery of past experiences, vicarious experiences, verbal persuasion, and emotional state are also the antecedent outcome expectations (Ambrose and Chiravuri, 2010; Bandura, 1977). Specifically, successful past experiences bolster individuals' confidence that they can achieve positive results in the future. Vicarious experiences enhance outcome expectations by allowing individuals to observe the positive consequences of actions performed by others. Verbal persuasion means people accept valuable information, such as what behavior an individual can take and will achieve positive results. Finally, emotional states play a critical role in shaping outcome expectations: fear and anxiety can lower outcome expectations (Guo et al. 2013), while a positive attitude can raise outcome expectations (Lim, 2009).

Social cognitive theory has been widely applied to explore older adults' information behaviors, including information acquisition, learning, and sharing (Ma et al. 2023; Shang and Zuo, 2020; Zhou et al. 2021). In this study, self-efficacy refers to an individual's belief in their ability to seek health information through a smartphone (Bandura, 1977). To cope with health threats and manage their health, older adults increasingly turn to their smartphones to seek health information. Health-related outcome expectations refer to an individual's expectation regarding the health outcome of seeking health information through their smartphone (Bandura, 1977; Lin and Chang, 2018).

### Hypothesis development

In this section, we develop the hypotheses, and a conceptual model based on social cognitive theory, and health information seeking related literature. Figure 1 summarizes the proposed conceptual model.

**The antecedents of self-efficacy and health-related outcome expectations.** According to social cognitive theory, the sources of self-efficacy and outcome expectations include mastery experience, vicarious experience, verbal persuasion from others, and



**Fig. 1** The conceptual model.

physiological and affective states (Bandura, 1977). An individual's past experience positively influences self-efficacy and outcome expectations because it involves both direct and repeated engagements with a task (Ambrose and Chiravuri, 2010). When older adults sought health information through smartphones in the past, they would believe they could accomplish the same task if they had health needs in the future. At the same time, past successful experiences enhance their perceptions of outcome expectations, as they have already experienced the benefits of seeking health information. Evidence shows that past experience positively influences self-efficacy and outcome expectations (Lim, 2009; Stone and Baker-Eveleth, 2013). Therefore, this study proposes the following hypothesis:

H1a: Past experience has a positive impact on self-efficacy.

H1b: Past experience has a positive impact on health-related outcome expectations.

Vicarious experience is achieved by observing other's behavior and performance (Bandura, 1977). When individuals observe others successfully completing a task, particularly those similar to themselves, their confidence in their ability to perform the task is strengthened (Ambrose and Chiravuri, 2010). This observation also leads them to believe they can achieve similar benefits (Bandura, 1977). Older adults often make behavioral decisions by comparing themselves with others (Helsper, 2017). For instance, when older adults see their peers successfully using smartphones to seek health information in response to health threats, they become confident in their ability to do the same and realize the potential benefits (Tsai et al. 2017). Evidence has shown that others' behavior can influence users' self-efficacy and outcome expectations when using computers (Compeau and Higgins, 1995). Therefore, this study proposes the following hypothesis:

H2a: Vicarious experience has a positive impact on self-efficacy.

H2b: Vicarious experience has a positive impact on health-related outcome expectations.

Verbal persuasion is a widely utilized method due to its ease and availability (Bandura, 1977). Through suggestion, individuals can be led to believe in their ability to successfully perform a task (Ambrose and Chiravuri, 2010; Bandura, 1977). Telling yourself what can happen to complete a task through others can help improve an individual's perception of outcome expectation. Verbal persuasion, especially from peers and family members, is crucial in helping older adults develop their self-efficacy and personal outcome expectations (Lam and Lee, 2006). When older adults confront challenges in seeking health information through smartphones, encouragement from others who are important can foster a positive mindset, enabling them to overcome obstacles. In this case, older adults believe they can effectively seek health information to cope with health threats. Studies have shown that verbal persuasion significantly impacts users' self-efficacy and outcome expectations (Compeau and Higgins, 1995; Lu and Hsiao, 2007; Stone and Baker-Eveleth, 2013). Therefore, this study proposes the following hypothesis:

H3a: Verbal persuasion has a positive impact on self-efficacy.

H3b: Verbal persuasion has a positive impact on health-related outcome expectations.

Emotional state refers to the positive or negative emotions experienced when seeking health information (Lim, 2009). These emotional states can significantly influence the cognition and behavior of older adults when they use information technology. For instance, Older adults with negative attitudes toward mobile health are often reluctant to adopt and use such technologies (Hoque and Sorwar, 2017). Furthermore, older adults experience negative emotions, such as resistance and anxiety, toward mobile health services. In this case, they will likely perceive mobile health services as difficult to use and view the potential benefits

pessimistically (Guo et al. 2013). This negativity can undermine their self-efficacy and outcome expectations when accessing online healthcare resources. Conversely, studies have shown positive emotions can enhance self-efficacy and outcome expectations (Lent et al. 2017; Lim, 2009). Therefore, this study proposes the following hypothesis:

H4a: Emotional state has a positive impact on self-efficacy.

H4b: Emotional state has a positive impact on health-related outcome expectations.

### **The impacts of self-efficacy and outcome expectations on seeking intention.**

As people age and experience physical decline, their health needs increase significantly (Qian and Gui, 2021). To meet their own health needs, individuals actively seek health information to cope with health threats. According to SCT, when people believe they have the ability and confidence to perform a particular task and anticipate the expected benefit, they are more likely to accomplish that task (Bandura, 1977). Moreover, the outcomes people anticipate generally depend on their judgments of their ability to perform this behavior (Ambrose and Chiravuri, 2010). In digital technology use, older adults' outcome expectations are influenced by their self-efficacy (Lam and Lee, 2006). This means that when older adults believe they can access health resources, they expect to rely on these health resources for health management and then take the initiative to obtain health resources (Ma et al. 2023). Self-efficacy is a key factor in motivating individuals to seek health information (Chang and Huang, 2020; Lagoe and Atkin, 2015). If people perceive benefits from seeking health information, it involves learning health knowledge or changing health values by seeking health information through the Internet (Ren et al. 2019). When older adults have the ability to independently seek health information and expect to improve their health management, they are more inclined to use smartphones for this purpose. Additionally, technology self-efficacy and the usefulness of health information positively influence online health information seeking among older adults (Zhao et al. 2022). Therefore, this study proposes the following hypothesis:

H5: Self-efficacy has a positive impact on health-related outcome expectations.

H6: Self-efficacy has a positive impact on seeking intention.

H7: Health-related outcome expectations have a positive impact on seeking intention.

**The moderating effect of health status.** Health needs drive older adults to engage in health-related activities on the Internet, such as obtaining and using health information (Rockmann and Gewald, 2017). Older adults with illnesses are more likely to use digital technology to access health resources (Aranha et al. 2024; Sedrak et al. 2020). Seeking health information online becomes a crucial strategy for these individuals to cope with health threats. When older adults possess adequate skills and recognize the benefits of seeking health information, they are more likely to seek it proactively when facing health challenges. Previous studies have shown that health status can significantly moderate the relationship between trust in mobile health and health information search behavior (Deng et al. 2015). Therefore, the following hypothesis is proposed in this study:

H8a: Health status negatively moderates the positive effects of self-efficacy on health information-seeking intentions.

H8b: Health status negatively moderates the positive effects of health-related outcome expectations on health information-seeking intentions.



**Table 1 Demographic information of respondents (N = 277).**

Variable	Item	Frequency	Percentage
Gender	Male	147	53.1
	Female	130	46.9
Education	Elementary school or lower	23	8.3
	Junior high school	43	15.5
	Senior high School	86	31.1
	College degree	38	13.7
	Bachelor degree	77	27.8
	Master degree or higher	10	3.6
Years of smartphone usage	≤2 years	22	7.9
	>2 years and <6 years	96	34.7
	≥6 years	159	57.4

### Research methodology

**Instrument.** Based on well-established studies, we operationalized all principal constructs by adapting previously validated measures. The scale for past experience was adapted from Carter et al. (2020). The scale for Vicarious experience, Verbal Persuasion, and Emotional state were adapted from Lim (2009). The scale for self-efficacy was adapted from Niehaves and Plattfaut (2014), and the scale for health-related outcome expectations was adapted from Mou et al. (2016). The scale for health status was adapted from Aranha et al. (2024). Finally, the health information-seeking intention scale was adapted from Li and Wang (2018). We conducted a pilot survey with 20 older adults. They provided feedback on the questionnaire, highlighting unclear or challenging questions. We then made necessary adjustments accordingly. The final scales are presented in Appendix 1.

**Data collection and sample.** This study focused on how to promote older adults' seeking health information through smartphones. In China, "older adults" generally refer to people over 60. In addition, seniors can retire at 60 in some industries and institutions. We collected data through random online questionnaires distributed on the survey platform Credamo ([www.credamo.com](http://www.credamo.com)). The platform has a three million+ sample panel, which is close to the sample distribution of Chinese netizens. Furthermore, this platform allows the selection of sample groups of different age groups. We chose to distribute online questionnaires randomly to the platform's elderly group. We developed screening questions to ensure that respondents were older adults (age 60 and above) who had used smartphones. The screening questions include "whether you use a smartphone" and "whether you are over 60 years old". This study used quality assurance mechanisms to verify that the respondents took the survey seriously. The survey was accessible for two months, starting in January 2024, and yielded 405 data points. Of these, all of them had used smartphones, but 99 respondents were younger than 60 years old and did not meet the sample requirements for this study, so the data was deleted. Additionally, 29 respondents were eliminated due to failing the quality assurance question. This left a total of 277 responses that satisfied the sample frame requirements.

### Results

We calculated the minimum sample size required for this study to ensure sufficient statistical power and robustness. According to the method by Christopher Westland (2010), there are eight latent variables and 24 indicator variables; the lower bound for an

**Table 2 Results of convergent validity.**

Construct	Item	Factor loading	Cronbach's alpha	CR	AVE
Past experience	PE1	0.881	0.843	0.904	0.759
	PE2	0.887			
	PE3	0.844			
Vicarious experience	VE1	0.833	0.786	0.875	0.699
	VE2	0.830			
	VE3	0.845			
Verbal persuasion	VP1	0.901	0.814	0.914	0.842
	VP2	0.934			
Emotional state	ES1	0.912	0.751	0.889	0.800
	ES2	0.876			
Self-efficacy	SE1	0.780	0.826	0.893	0.737
	SE2	0.894			
	SE3	0.896			
Health-related outcome expectations	OE1	0.881	0.897	0.928	0.763
	OE2	0.886			
	OE3	0.866			
	OE4	0.862			
Health status	HS1	0.897	0.872	0.921	0.796
	HS2	0.889			
	HS3	0.890			
Health information seeking intention	HIS1	0.870	0.852	0.900	0.693
	HIS2	0.828			
	HIS3	0.828			
	HIS4	0.802			

adequate sample size for this study is 200. Therefore, the sample size of 277 meets the SEM guidelines and ensures the reliability of the results (Benitez et al. 2020; Guenther et al. 2023). The age of these respondents between 60 and 86 years (Mean = 64.404, SD = 4.411). Table 1 shows the detailed demographic information.

**Measurement model.** We chose the partial least square (PLS) to test the hypothesis of structural equation modeling (SEM). The primary advantages of PLS-SEM include the relaxation of normal distributional assumptions required by the maximum likelihood method used to estimate models in CB-SEM, as well as PLS-SEM's ability to estimate much more complex models with smaller sample sizes (Hair et al. 2019; Khan et al. 2019; Shiau et al. 2019). Compared to CB-SEM, PLS-SEM is more suitable for this study, as it performs better when the structural model is complex, when the analysis is for a prediction perspective when the sample size is smaller due to a small population, when distribution lacks normality, and when research requires latent variable scores for consequent analyses (Gefen et al. 2011; Hair et al. 2019; Khan et al. 2019; Shiau et al. 2020; Shiau et al. 2019). Since our context includes all these things, we consider PLS an appropriate SEM method for this study.

This study used SmartPLS to examine the measurement model for reliability, convergent validity, and discriminant validity. Composite reliability (CR) and Cronbach's alpha were used to verify the reliability of the survey instrument. Following the suggestions of (Fornell and Larcker, 1981), the CR and Cronbach's alpha values should be >0.7. Factor loading and average variance extracted (AVE) were used to verify the convergent validity. Factor loading should be >0.7, and AVE should be >0.5 (Fornell and Larcker, 1981). Table 2 shows that the values of the standardized CR, Cronbach's alpha, AVE, and factor loadings were acceptable. Convergent validity was thus satisfied.

As shown in Table 3, following the suggestions of (Fornell and Larcker, 1981) and (Hair et al. 2017), based on the square root of

Table 3 Results of discriminant validity.										
Construct	M	SD	PE	VE	VP	ES	SE	OE	HS	HISI
PE	3.245	0.915	<b>0.871</b>							
VE	4.042	0.748	0.457	<b>0.836</b>						
VP	3.749	0.998	0.393	0.677	<b>0.918</b>					
ES	4.363	0.672	0.315	0.613	0.546	<b>0.894</b>				
SE	4.017	0.904	0.382	0.204	0.108	0.254	<b>0.858</b>			
OE	4.089	0.806	0.465	0.554	0.485	0.608	0.486	<b>0.874</b>		
HS	3.946	0.832	0.331	0.312	0.214	0.260	0.320	0.214	<b>0.892</b>	
HISI	4.308	0.639	0.443	0.678	0.531	0.704	0.312	0.650	0.384	<b>0.832</b>

Bold values are the square root of AVE.

PE past experience, VE vicarious experience, VP verbal persuasion, ES emotional state, SE self-efficacy, OE health-related outcome expectations, HS health status, HISI Health information seeking intention.

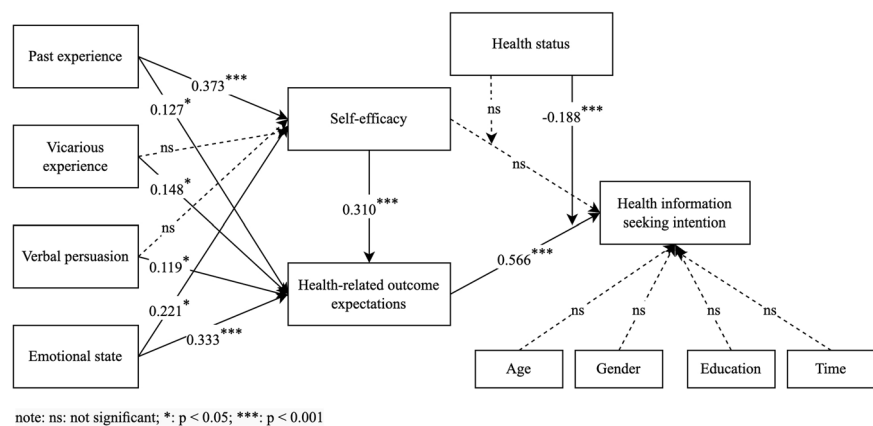


Fig. 2 Path coefficients and significance.

the AVE assessment of discriminant validity, all constructs shared more variance with their indicators than with the other constructs, which reinforces the discriminant validity of our model. Using the HTMT criterion, we also found that discriminant validity is not an issue for this study (the HTMT ratios were between 0.122 and 0.882, all below the cut-off value of 0.9) (Henseler et al. 2015). To examine the possible severity of common method bias, the variance inflation factor values for all constructs were between 1.035 and 2.334, less than the recommended cut-off of 3.3 (Latan et al. 2017). Thus, test results suggested that common method bias was not a significant issue for this study.

**Structural model.** The path coefficient and significance levels of each hypothesis were examined, and the explained variance ( $R^2$ ) of the dependent construct was calculated. The results are shown in Fig. 2. The model explained 54.4% of the variance in health information-seeking intention. SRMR, as a model fit measure for PLS-SEM, a value <0.10 or 0.08, is considered a good fit (Guenther et al. 2023; Hu and Bentler, 1998). The SRMR of this is 0.053, which indicates an acceptable model. None of the control variables had a significant effect on health information-seeking intention.

The hypothesis testing results are summarized in Table 4. The results indicate that past experience and emotional state have a significantly positive effect on self-efficacy, supporting H1a and H4a. However, vicarious experience and verbal persuasion have no effect on self-efficacy, so H2a and H3a are not supported. Additionally, past experience, vicarious experience, verbal persuasion and emotional state all have significantly positive effects on health-related outcome expectations. Thus, H1b, H2b, H3b, and H4b are supported.

The results indicate that self-efficacy positively influences health-related outcome expectations, supporting H6. However, self-efficacy does not have a significant effect on health information-seeking intention, and H5 is not supported. Health-related outcome expectations positively influence the intention to seek health information, and H7 is supported. Regarding the moderating role of health status, the analysis shows that health status negatively moderates the effect of health-related outcome expectations on health information-seeking intention; the results are shown in Fig. 3. However, health status does not moderate the effect of self-efficacy on health information-seeking intention. Thus, H8a is not supported and H8b is supported.

Bootstrapping was employed to examine the mediating role of health-related outcome expectations between self-efficacy and health information-seeking intention. As detailed in Table 5, the results reveal that a mediated effect exists, but there is no direct effect. This indicates that health-related outcome expectations are an indirect-only mediation between self-efficacy and health information-seeking intention, pointing to a fully mediating role (Zhao et al. 2010).

Discussion

**Key findings.** Our findings provide a more comprehensive understanding of older adults' health information seeking. Consistent with the findings of Ma et al. (2023), self-efficacy and health-related outcome expectation emerge as dominant predictors of health information seeking among older adults. The results suggest that health-related outcome expectations positively influence health information-seeking intentions among older adults. Although self-efficacy does not directly affect health information-seeking intention, it positively impacts seeking intentions by enhancing health-related outcome expectations.

**Table 4 Hypothesis testing.**

Hypothesis	Path coefficient	SE	T-value	Results
H1a PE → SE	0.373***	0.059	6.314	Supported
H1b PE → OE	0.127*	0.051	2.474	Supported
H2a VE → SE	0.011 <sup>ns</sup>	0.079	0.141	Not Supported
H2b VE → OE	0.148*	0.065	2.270	Supported
H3a VP → SE	-0.167 <sup>ns</sup>	0.093	1.807	Not Supported
H3b VP → OE	0.119*	0.058	2.040	Supported
H4a ES → SE	0.221*	0.092	2.400	Supported
H4b ES → OE	0.333***	0.060	5.563	Supported
H5 SE → OE	0.310***	0.050	6.240	Supported
H6 SE → HISI	-0.051 <sup>ns</sup>	0.059	0.865	Not Supported
H7 OE → HISI	0.566***	0.053	10.628	Supported
H8a HS × SE → HISI	0.021 <sup>ns</sup>	0.053	0.400	Not Supported
H8b HS × OE → HISI	-0.188***	0.056	3.370	Supported

ns: not significant; \* $p < 0.05$ ; \*\*\* $p < 0.001$ .**Table 5 Mediating role of health-related outcome expectations.**

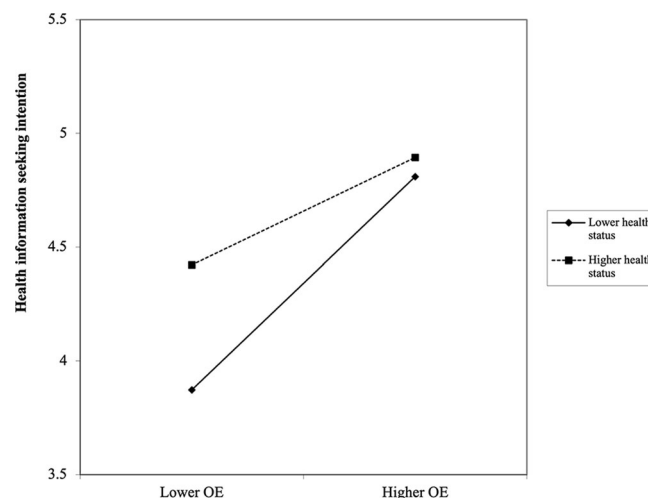
Intermediate path	Path coefficient	SE	T-value	Bootstrap 95% CIs	
				Lower	Upper
SE → OE → HSIS	0.176***	0.034	5.180	0.113	0.246
SE → HSIS	-0.051 <sup>ns</sup>	0.059	0.865	-0.169	0.063
Total effects	0.125*	0.054	2.317	0.019	0.232

ns: not significant; \* $p < 0.05$ ; \*\*\* $p < 0.001$ .

When older adults believe they have the ability to seek health information through smartphones, they will believe they can benefit from it. Consequently, they are more motivated to actively seek health information on their smartphones to deal with health threats. Similar patterns have been observed in studies exploring knowledge-sharing intention (Cai and Shi, 2022), knowledge community continuance intention (Zhou, 2018), and user satisfaction with e-business (Chang et al. 2011).

Furthermore, this study identifies key sources of self-efficacy and health-related expectations among older adults. Previous research, such as the case study by Lin et al. (2013), highlighted that the sources of self-efficacy for middle-aged and older adults include performance accomplishments or experiences, vicarious experiences, verbal persuasion, and emotional state. This study, specifically focusing on older adults, found that past experiences and emotional states positively promoted self-efficacy, while vicarious experiences and verbal persuasion did not have a notable effect.

The active mastery of experience is a crucial source of older adults' self-efficacy. This finding is consistent with other studies demonstrating how past experience positively affects individual and collective self-efficacy (Lu and Hsiao, 2007; Stone and Baker-Eveleth, 2013; Yoo et al. 2023). As Bandura (1977) points out, past experiences are most effective for improving self-efficacy, as individuals can practice and repeat past practice. Older adults rely on past experience when making self-efficacy judgments. Evidence suggests that older adults with more past experience perceive seeking health information online as simple and effortless (Chang and Im, 2014). When older adults successfully navigate challenges and access health information online through their efforts, they are more likely to believe in their capabilities for

**Fig. 3** The moderating effect of health status.

the same task in the future. In addition, a positive attitude towards seeking health information is also important for enhancing self-efficacy. Studies have shown that when individuals harbor a negative attitude toward using new digital technologies, such as fear and anxiety, their sense of self-efficacy is diminished (Hasan and Ahmed, 2010; Lin et al. 2013). This is because negativity can make older adults feel that digital technology is difficult to use and cause them to doubt their digital capabilities (Cimperman et al. 2016). Conversely, positive emotions stimulate older adults' inner motivation and desire (Kim and Preis, 2016), making them more relaxed in responding to challenges and confident in their ability to overcome difficulties and succeed.

Simply observing others makes it difficult for older adults to improve their self-efficacy. This finding aligns with the results of Singh et al. (2022), who observed that vicarious experience did not significantly predict health promotion self-efficacy. A plausible explanation is that the subjective nature of vicarious experience can lead to negative outcomes. Wilde and Hsu (2019) have found that the facilitative effect of vicarious learning on self-efficacy varies across individuals. Those with lower personal ability tend to experience a weaker impact from vicarious experiences in promoting self-efficacy. This is because they make negative self-comparisons of vicarious experiences, which hinders the improvement of self-efficacy (Wilde and Hsu, 2019). For example, older adults may feel too old to use new technology like younger generations (Mariano et al. 2021). Another plausible explanation is inconsistency in the effectiveness of vicarious experiences across different populations and contexts. When older adults see peers similar to themselves using mHealth services, they believe they can do the same (McKenna et al. 2023). In contrast, when they observe younger generations using mHealth, they may feel unable to keep up (Quan-Haase et al. 2018). Additionally, verbal persuasion does not affect self-efficacy. The credibility and persuasiveness of the source are crucial to the effectiveness of verbal persuasion. If the source lacks authority or relevance, verbal persuasion is less likely to be effective (Lim, 2009). Families are one of the main sources of verbal persuasion in China; the reverse transfer of information from children to parents challenges the authority of older adults within the family (Perez et al. 2019). This generational gap can lead to a disconnect in communication, where older adults may feel pressured rather than supported. This may explain the insignificant impact of verbal persuasion.

Furthermore, our findings suggest that a multifaceted approach, incorporating past experience, vicarious learning,

verbal persuasion, and emotional support, is essential for promoting positive health-related outcome expectations among older adults. The positive impact of past experience aligns with Lim (2009), suggesting that familiarity and repeated success in similar tasks build confidence in achieving beneficial outcomes. The role of vicarious experiences, as highlighted by Lent et al. (2017), further supports the idea that observing others successfully navigate tasks can enhance an individual's outcome expectations of similar tasks. This finding emphasizes the importance of role models and social learning in shaping health-related behaviors. Verbal persuasion also plays a critical role in enhancing health-related outcome expectations among older adults. Studies showed that encouragement and positive reinforcement from others can significantly enhance personal confidence in the potential benefits of their actions (Lu and Hsiao, 2007; Stone and Baker-Eveleth, 2013). Perdana and Mokhtar (2022) further elaborate on this by demonstrating how others' opinions can influence older adults' perceived benefits of using digital technology, which is crucial for adapting to new digital health tools. Finally, positive emotional states also enhance older adults' health-related outcome expectations, which is consistent with the findings of Lim (2009).

This study further examined the moderating effect of health status. While previous meta-analyses have indicated that health status is not a direct predictor of health information seeking (Chang and Huang, 2020), our findings suggest that health status negatively moderates the relationship between health-related outcome expectations and seeking intention. Specifically, when older adults perceive their health to be poor, the impact of health-related outcome expectations on health information-seeking intention becomes stronger. This heightened effect occurs because older adults, when they suffer from health threats, are more motivated to seek health resources to address health problems actively (Rockmann and Gewald, 2017). Similarly, Deng et al. (2015) found that perceived poor health status strengthens the relationship between trust in the mobile web and health information-seeking behavior.

**Theoretical contributions.** This study enriches the literature on social cognitive theory by identifying the key sources of expectant beliefs in older adults. Our findings emphasize the crucial role of direct experiences and a positive emotional state in bolstering self-efficacy among older adults in health information-seeking contexts. Consistent with the previous case study (Lin et al. 2013), past experience and emotional state are the primary sources of self-efficacy. This indicates that older adults primarily develop self-efficacy through their experiences and cognitive processes. Due to cognitive decline, they depend on direct and repeated experiences to improve self-efficacy. In contrast, the experience gained from others is limited to improving actual ability because older adults lack the opportunity for hands-on practice. In response to the call of Lin et al. (2013), this study also identifies that positive emotional states play a significant role in boosting self-efficacy among older adults. In addition, this study found that past experience, vicarious experience, verbal persuasion, and emotional state are older adults' source of outcome expectations, which is aligned with Ambrose and Chiravuri (2010). Enhancing outcome expectations requires not only personal experience but also the experience of others. The findings enrich the understanding of improving self-efficacy and outcome expectations among older adults in the digital age.

This study provides new insights into enabling older adults to seek health information online. Previous studies have proposed strategies to bridge the digital divide by improving the expectation beliefs of older adults, such as providing social

support (Lam and Lee, 2006; Tsai et al. 2017), offering digital technology education (Huang et al. 2024), and implementing behavioral modeling (Ma et al. 2020). We demonstrate that life experiences—such as past experiences, vicarious experiences, verbal persuasion, and emotional states—play a critical role in shaping health information-seeking intentions by influencing older adults' cognition (self-efficacy and outcome expectations). Society should support older adults in their daily lives across these four aspects while also considering their health status to enable them to access health resources.

This study provides an inclusive approach to fostering a smart, healthy age-friendly environment. Previous studies have pointed out that due to the digital divide, more than simply providing a smart technology environment is needed to promote social participation among older adults (Torku et al. 2021). It is equally important to focus on empowering older adults, which should be the key priority of smart, healthy, age-friendly environmental governance (Chen and Hartt, 2021; Torku et al. 2021). Our research enriches existing research on SHAFE by providing solutions to address digital inequality and bridging the digital divide in mHealth. Li and Woolrych (2021) pointed out that the challenges in implementing a smart, age-friendly environment are low technological take and difficulties in perceiving how smart technology might benefit health and well-being. Our research focuses on enhancing self-efficacy and health-related outcome expectations among older adults, highlighting specific pathways for empowering them through supportive social environments, which is a basis for developing intervention strategies. Furthermore, our findings have important implications for formulating public policies by responding to calls for age-friendly policies that should shift the focus to empowering older adults (Xu et al. 2023). Specifically, this study demonstrates how older adults can be empowered to improve self-efficacy and outcome expectations to ensure agency and autonomy in seeking health information.

**Practical implications.** Our findings suggest some practical approaches from four key perspectives to alleviate digital inequality and empower older adults to seek health information online. First, accumulating successful experiences is crucial for older adults. Communities, senior universities, or volunteer organizations should offer regular training courses on "Smart-phones for Health." Attention should be given to leveraging existing skills for transfer learning. This involves understanding the skills that older adults already possess and guiding them in applying those skills to new technologies or functions. Additionally, training can begin with simple functions, gradually introducing more complex ones as users become familiar. These functions should also address older adults' true health management needs, thereby enhancing their expectations for health management outcomes. Considering the cognitive decline in older adults, it is crucial to emphasize hands-on practice and regular review. Encouraging older adults to repeat the task of seeking health information themselves and regularly revisiting what they have learned ensures that they truly master these skills and reap health benefits. This approach helps older adults build confidence, enhancing their sense of control and achievement when seeking health information online.

Second, vicarious experience is essential for older adults to improve outcome expectations. Through live demonstrations or video tutorials, older adults can observe and imitate the technical operations and the positive results that can be achieved. Additionally, it is vital to provide a platform for older adults to learn from each other. Older adults can be encouraged to join health technology learning communities, which will provide them with the opportunity to observe the progress and achievements of



their peers. These approaches can help older adults believe they are experiencing similar benefits, increasing their outcome expectations.

Third, verbal persuasion from family members and peers is crucial for older adults seeking health information. Communities should encourage family members and peers to offer greater support to older adults, helping them recognize the importance and value of accessing health resources. This requires emphasizing the potential benefits of health information access during communication. Additionally, sharing success stories is a key strategy in verbal persuasion. By highlighting the achievements of older role models who have successfully accessed health information, other older adults can see the positive changes brought about by using health resources, strengthening their outcome expectations. For example, the community can regularly share the success stories of older adults and invite the individuals featured to share their experiences and achievements.

Finally, maintaining a positive emotional state is crucial in older adults' self-efficacy and outcome expectations. When older adults progress in learning to search for health information, timely positive feedback and encouragement should be provided to boost their self-confidence. For example, when an older adult reaches a learning milestone or overcomes a challenge, it should be celebrated appropriately to enhance their accomplishment. Additionally, it is important to provide emotional support for older adults. Especially when older adults face challenges, it can create a relaxed and enjoyable atmosphere. We should patiently listen to older adults' difficulties and setbacks during the learning process, understand their feelings, and offer positive support and encouragement.

**Limitations and future research.** This study has some limitations, which provide opportunities for future research. First, we focus on the four sources of expected beliefs, and future research should focus on more older adults' characteristics (e.g., resistance to change and information processing speed) to thoroughly understand the sources of expectation beliefs among older adults. Second, future studies could investigate how social roles affect self-efficacy, particularly how peers and children contribute differently to enhancing older adults' self-efficacy. Third, an ideal research design would involve longitudinal analysis conducted over multiple time points to capture the relationship among the antecedents of personal factors, self-efficacy, outcome expectations, and health information-seeking behavior. Future research could employ a longitudinal design to test this model further. Finally, since this study was conducted within a Chinese cultural context, exploring the sources of self-efficacy and outcome expectations among older adults in Western cultures is important. Future research could explore whether the sources of self-efficacy and outcome expectations differ among older adults from various cultural backgrounds when they seek health information. For example, examining whether the effects of vicarious experience and verbal persuasion on older adults vary between collectivist and individualist cultural contexts.

## Conclusion

Mitigating digital inequality and empowering older adults to seek health information is critical. Based on social cognition theory, this study highlights how to enable older adults to seek health information. Our findings demonstrate that health-related outcome expectations positively influence health information-seeking intention, while self-efficacy indirectly impacts intention through its effect on health-related outcome expectations. By identifying the key sources of older adults' self-efficacy and health-related outcome expectations, we advance research on

bridging the digital divide and promoting digital health equity. Ultimately, our goal is to inform appropriate strategies that ensure older adults can genuinely benefit from digital technology.

## Data availability

The dataset analyzed during the current study was available in the supplementary file.

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## Author contributions

Zian Fang: Conceptualization, methodology, formal analysis, writing—original draft preparation. Yongmei Liu: Conceptualization, supervision, funding acquisition, writing—review and editing. Bo Peng: Data curation, methodology.

## Competing interests

The authors declare no competing interests.

## Ethical approval

This study has been performed in accordance with the Declaration of Helsinki. Approval was granted by the Academic Committee of Business School at Central South University on January 4, 2024, and the study complied with ethical standards (ID: CSUBS20240104). The Academic Committee reviewed and approved the study protocol, involving research design and methods, eligibility criteria for participants, data collection and privacy protection, and informed consent. All online questionnaires were obtained by considering the informed consent of the respondents, and all respondents completed it voluntarily and anonymously.

## Informed consent

The study was conducted on January 8, 2024, lasting for 2 months. All participants provided informed consent before completing the formal questionnaire. At the beginning of each web-based questionnaire, they were apprised of the study's objectives, procedures, the confidentiality of their responses, and that the data collected would be used solely for academic research. Furthermore, it was made clear that any personal information would be presented anonymously, and that they retained the right to withdraw from the study at any point. All participants clicked on the “Agree” button to complete the informed consent process, agreeing to participate, to the use of their data for research purposes, and to the publication of anonymized findings.

## Additional information

**Supplementary information** The online version contains supplementary material available at <https://doi.org/10.1057/s41599-024-04312-7>.

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