Digital access and health outcomes: The moderating role of socioeconomic status in health information seeking

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Abstract

Objective: Digital health disparities represent a growing equity concern in an era of increasing reliance on digital platforms for health information, yet unequal access and utilization patterns may disadvantage vulnerable populations. This study investigates how socioeconomic inequalities shape the relationship between digital access and health outcomes, specifically examining the mediating role of health information seeking and the moderating effect of socioeconomic status (SES) on the pathway from digital access to health information seeking.

Methods: This study analyzed cross-sectional data from the 2021 China General Social Survey ($N = 2265$ after applying inclusion criteria). A composite digital access index and a health information seeking index were constructed, with self-rated health as the primary outcome measure. Hierarchical multiple regression examined the association between digital access and health outcomes, controlling for SES, gender, age, and residence. Bootstrap mediation analysis (5000 replications) tested the mediating role of health information seeking, and moderation analysis examined how SES influenced the pathway from digital access to health information seeking. All analyses were performed using Stata 18.

Results: Digital access significantly predicted better health outcomes. However, health information seeking did not mediate this relationship when SES was controlled. Importantly, SES emerged as a moderator of the association between digital access and health information seeking, revealing that digital access yielded greater information-seeking benefits for higher SES individuals.

Conclusion: Digital access improves health outcomes, but not through health information seeking as commonly assumed. SES moderates the link between digital access and health information seeking, with benefits concentrated among advantaged groups, potentially exacerbating health inequalities. Effective digital health policies need address not only technology access but also the socioeconomic barriers that prevent disadvantaged populations from translating digital access into health information seeking and improved health outcomes.

Introduction

Digital access has emerged as an increasingly important factor influencing health outcomes in contemporary society. By 2021, the number of online health information users in China reached 298 million, representing a 38.7% year-on-year increase.[1] Internet connectivity now plays a growing role in shaping health-seeking behaviors, self-care practices, and healthcare utilization patterns.[1–3] Acquiring health information online can improve health outcomes by enhancing individuals' autonomy and enabling more informed health decision-making.[3,4] As information technologies transform health service delivery,[1,5] understanding the relationship between digital access and health outcomes has become critical.

The increasing availability of digital technologies provides new avenues for individuals to manage and enhance

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their health. Internet connectivity enables individuals to access health information, engage with healthcare providers, and participate in online health communities.[6–9] Studies document diverse health-related activities enabled by digital access, including following health news, seeking medical guidance, and obtaining second opinions.[7] Digital access offers unique advantages for health promotion: 24/7 availability, anonymity for sensitive health concerns, and access to diverse medical and experiential perspectives.[10–12] Through these mechanisms, digital access has the potential to support preventive behaviors, enhance health knowledge, and improve health management capabilities.[13]

The relationship between digital access and health outcomes, however, is complex and multifaceted, with research demonstrating both beneficial and potentially harmful effects. On one hand, internet connectivity facilitates access to health information, enabling individuals to make more informed health decisions, adopt preventive behaviors, and better manage chronic conditions.[8,14] Digital access supports health-promoting activities such as accessing medical advice, scheduling appointments, and participating in online health communities.[13] Internet use has been positively associated with health-related knowledge and behaviors, such as increased awareness of physical activity,[15–17] improved dietary knowledge,[18,19] and enhanced medication adherence.[9] Moreover, digital connectivity can reduce geographic barriers to healthcare access, particularly benefiting populations in underserved areas through telemedicine and remote health monitoring capabilities.[20]

On the other hand, digital access does not uniformly translate into health benefits, and may in some contexts be associated with adverse outcomes. Excessive or passive internet use has been linked to sleep disturbances, and reduced time for health-promoting activities.[21–25] The quality and credibility of online health information vary widely, with misinformation and unverified health claims potentially leading to harmful health decisions or delayed care-seeking.[26,27] Information overload, the proliferation of conflicting or overwhelming health information online, can contribute to confusion, decision paralysis, and reduced confidence in health management.[28] Additionally, excessive online health information seeking, termed "cyberchondria," may increase health anxiety rather than improve health outcomes for some individuals.[29,30] These mixed findings suggest that the relationship between digital access and health may be influenced by how individuals engage with online resources and their capacity to critically evaluate health information.

One potential mechanism through which digital access may influence health outcomes is health information seeking, which may serve as an intermediary pathway. Prior research indicates that individuals with greater internet access are more likely to engage in active health information seeking, thereby enhancing their awareness, knowledge, and self-efficacy in managing health conditions.[31–33] Through online searches, participation in health forums, and interactions with digital health resources, individuals acquire practical guidance that promotes preventive behaviors and facilitates early detection and treatment.[34,35] Conversely, limited digital access constrains these opportunities, perpetuating disparities in health literacy and informed decision-making.[3,36] Thus, health information seeking may function as an important link between digital inclusion and improved health outcomes.

Despite these potential benefits, significant disparities exist in digital access and effective utilization across socioeconomic groups. Socioeconomic status (SES) serves as a key determinant of both digital access and the skills necessary to effectively navigate online health resources.[37,38] Individuals with lower SES, older adults, those with limited education, and populations with poor connectivity are significantly less likely to engage in online health information seeking.[1,39,40] A recent meta-analysis illustrates these disparities in healthcare settings, finding that higher education increased digital health platform use by 37%, while employed individuals were 23% more likely to use such platforms compared to their unemployed counterparts.[41] These disparities extend beyond technology access to encompass critical differences in digital health literacy, which refers to the ability to locate, comprehend, and utilize online health information effectively.[42,43] Higher SES individuals typically possess greater digital literacy skills, more reliable internet access, and educational backgrounds that enable them to more effectively locate credible sources, critically evaluate information quality, and translate online information into actionable health practices.[44–46] Conversely, lower SES populations face compounding barriers including limited access to high-quality devices, restricted connectivity, lower baseline health literacy, and reduced capacity to distinguish credible from unreliable sources.[36,47–49]

Of particular concern, these socioeconomic differences in digital health capabilities may create self-reinforcing patterns of inequality. Liu et al.[50] demonstrated that individuals with better functional and critical literacy engage more actively in health information seeking, creating positive feedback loops wherein advantaged individuals continuously expand their digital health capabilities while disadvantaged populations fall progressively further behind. The pathway from digital access to health information seeking may operate differently and weakly among lower SES populations compared to their higher SES counterparts.[38,44,48,51,52] Rather than serving as an equalizing force, digital health resources differentially benefit those already advantaged, raising critical questions about whether and how digital access translates into health improvements across diverse socioeconomic contexts.[51,53,54]

Therefore, this study examines the complex relationships between SES, digital access, health information seeking,

and health outcomes through a comprehensive framework. The conceptual model positions health information seeking as a mediating variable linking digital access and health outcomes, while examining SES as a moderator of the relationship between digital access and health information seeking, and controlling for demographic factors (gender, age, and residence). This approach contributes to understanding how technological innovations interact with existing social determinants of health. Investigating these patterns may inform the development of interventions that leverage digital health tools more effectively across diverse populations, particularly for reducing health inequalities in the digital age. Based on the conceptual framework presented in Figure 1, this study proposes three hypotheses to empirically examine the relationships among digital access, health information seeking, SES, and health outcomes.

> Hypothesis 1: Digital access is positively associated with health outcomes.
> Hypothesis 2: Health information seeking mediates the relationship between digital access and health outcomes.
> Hypothesis 3: SES moderates the relationship between digital access and health information seeking.

Method

Data source

This cross-sectional study utilized data from the 2021 China General Social Survey (CGSS), a nationally representative survey that comprises 8148 respondents and providing extensive data on social change and development in China across multiple domains including sociodemographic characteristics, health, lifestyle, and social attitudes.[55] The CGSS employs rigorous scientific sampling methodology with multistage stratified random sampling techniques, providing comprehensive national coverage across all 31 provinces, autonomous regions, and municipalities in mainland China.[56]

Sample selection

The analytical sample included respondents aged 18 years or older with complete data on all study variables, including digital access (Internet usage frequency, mobile phone ownership, device access), health information seeking, self-rated health, SES (education, income, subjective social class), and demographic characteristics (gender, age, residence). After excluding participants with missing data on any key variables, the final sample comprised 2265 respondents (27.8% of the total CGSS sample, $N = 8148$). Missing data were handled using the listwise deletion method to maintain data integrity. Little's MCAR test was conducted to examine the randomness of missing data, and the

nonsignificant result ($p > .05$) indicated that the data were missing completely at random, supporting the appropriateness of the listwise deletion approach.[57]

Sample size adequacy was assessed following established guidelines for multiple regression analysis. The analytical sample ($N = 2265$) far exceeded the recommended minimum of $N \geq 50 + 8k$, where k represents the number of predictors.[58] With seven predictors in the most complex model, the recommended minimum would be 106 participants; thus, the sample exceeded this threshold by more than 20-fold, ensuring sufficient statistical power to detect meaningful effects.

Measures

Digital access: Following established digital divide frameworks,[59,60] a composite measure of digital access was constructed incorporating three dimensions: (1) Internet usage frequency in the past 12 months (five-point scale), reflecting effective access through sustained connectivity; (2) mobile phone ownership (binary), indicating device access; and (3) cross-device internet access experience (binary), capturing access versatility. An expanded conceptualization of access by van Deursen and van Dijk[60] was adopted that includes usage frequency as a behavioral manifestation of meaningful connectivity, distinguishing effective access from merely nominal availability. All components were standardized to 0–1 scales and averaged ($\alpha = 0.78$), with higher scores indicating greater digital access. This operationalization aligns with contemporary digital divide research that recognizes access as a multidimensional construct extending beyond mere availability to include actual connectivity patterns[59,61]

Health outcomes: Self-rated health status was measured using a validated five-point scale ("How would you rate your current physical health?") and standardized to a 0–1 range. This measure demonstrates strong predictive validity for objective health outcomes and is widely used in population health research as a reliable indicator of overall health status and mortality risk.[62]

Health information seeking: A composite index was developed based on Lambert and Loiselle's[63] multidimensional framework, incorporating three health information domains: general health information searching, healthy lifestyle information seeking, and vaccination information seeking (all past 12 months). Components were standardized and averaged ($\alpha = 0.72$), with higher scores indicating more active health information engagement.

Socioeconomic status (SES): Following established multidimensional approaches to measuring social stratification,[64,65] a composite SES index was constructed incorporating: (1) educational attainment (13-point scale from no formal education to graduate degree), (2) annual household income (log-transformed and normalized), and (3) subjective
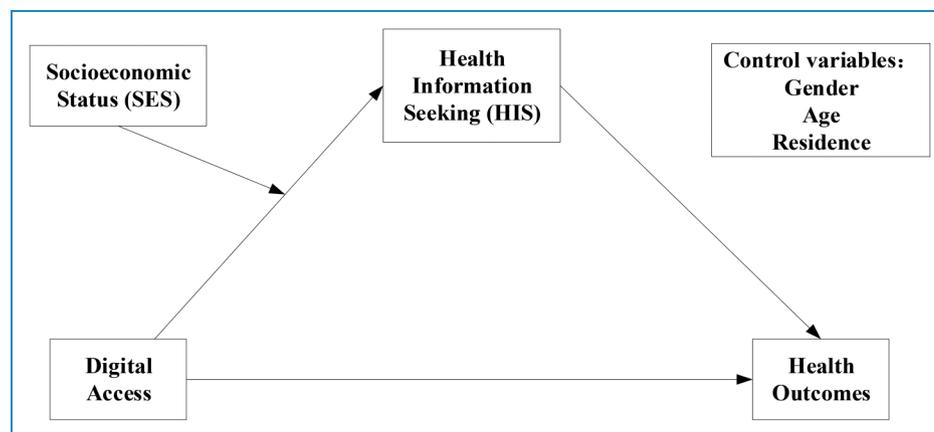
Figure 1. Conceptual framework.

social class position (five-point scale). All components were standardized to 0–1 scales.

Control variables: Demographic controls included gender (female = 1), age (continuous), and residence (urban = 1), selected based on established associations with both digital access and health outcomes in stratified populations.

Statistical analysis

A sequential analytical approach using Stata 18 was employed. Preliminary analyses included descriptive statistics to characterize the study sample and Pearson correlation analysis to examine bivariate relationships among study variables and assess potential multicollinearity issues. A multistep analytical approach was employed to address the research objectives. Hierarchical multiple regression was conducted to test main effects of digital access on health outcomes while controlling for SES and demographic variables including age, gender, and residence. Bootstrap mediation analysis with 5000 replications was performed to test whether health information seeking mediated the relationship between digital access and health outcomes, following established procedures for indirect effect testing. Moderation analysis examined whether SES moderated the association between digital access and health information seeking using interaction terms.

Result

Descriptive statistics and correlations

Descriptive statistics for all study variables are presented in Table 1. The study included 2265 participants with a mean age of 51.37 ($SD = 16.95$, range: 18–92 years). The sample was predominantly female (54.83%, $n = 1242$) compared to male participants (45.17%, $n = 1023$). Most participants resided in urban areas (68.74%, $n = 1557$) while 31.26% ($n = 708$) lived in rural locations. Participants demonstrated

high digital access ($M = 0.76$, $SD = 0.30$) but moderate health information seeking ($M = 0.27$, $SD = 0.24$) and self-rated health ($M = 0.62$, $SD = 0.27$). SES showed moderate levels ($M = 0.42$, $SD = 0.18$).

Bivariate correlations among the key study variables are summarized in Table 2. No multicollinearity issues were observed with all $r < 0.70$.[66] Digital access correlated strongly with health information seeking ($r = 0.64$, $p < .001$) and moderately with health outcomes ($r = 0.33$, $p < .001$).

Regression analysis

Table 3 presents hierarchical regression results predicting health outcomes. Model 1 shows that SES is the strongest predictor ($\beta = 0.275$, $p < .001$), along with significant effects for female ($\beta = -0.021$, $p < .05$), age ($\beta = -0.005$, $p < .001$), and urban residence ($\beta = 0.037$, $p < .01$). Model 2 introduces digital access, which demonstrates a significant positive effect on health outcomes ($\beta = 0.091$, $p < .001$), increasing the explained variance to 18.1%. Importantly, this effect persists after controlling for SES ($\beta = 0.245$, $p < .001$) and demographic factors. These results support H1, demonstrating that digital access independently predicts better health outcomes after controlling for SES and demographic characteristics.

Mediation analysis

Table 4 presents the mediation analysis examining whether health information seeking mediates the relationship between digital access and health outcomes. All analyses controlled for SES, gender, age, and residence. The results show that digital access significantly predicts health information seeking (path a: $\beta = 0.412$, $p < .001$) and has a significant total effect on health outcomes (path c: $\beta = 0.091$, $p < .001$). However, health information seeking does not significantly predict health outcomes after controlling for digital access (path b: $\beta = 0.035$, $p = .213$). Bootstrap

Table 1. Descriptive statistics of study variables.

Variable	Measurement	N/n	Mean/percentage	SD	Min	Max
Digital access	Standardized composite score	2265	0.76	0.30	0	1
Health information seeking	Standardized composite score	2265	0.27	0.24	0	1
Health outcomes	Standardized self-reported health status	2265	0.62	0.27	0	1
Socioeconomic status	Standardized composite score	2265	0.42	0.18	0	0.90
Gender						
	0 = Male	1023	45.17%			
	1 = Female	1242	54.83%			
Age	Continuous	2265	51.37	16.95	18	92
Residence						
	0 = Rural	708	31.26%			
	1 = Urban	1557	68.74%			

Notes: All composite indices range from 0 to 1, with higher values indicating greater levels of the respective construct.
$N = 2265$ for all variables.

analysis with 5000 replications confirms that the indirect effect is not significant ($\beta = 0.015$, 95% CI [−0.008, 0.038], $p = .214$), as the confidence interval includes zero. The direct effect remains significant (path c': $\beta = 0.076$, $p = .004$). Therefore, H2 is not supported, as the positive association between digital access and health information seeking does not result in improved health outcomes when accounting for socioeconomic factors. This suggests that digital connectivity operates through mechanisms beyond information seeking alone.

Moderation analysis

Moderation analysis examined whether SES moderated the relationship between digital access and health information seeking (Table 5). The model explained 18.0% of the variance in health information seeking (Adj. $R^2 = 0.180$, $F(6, 2258) = 83.82$, $p < .001$). Significant main effects emerged for digital access ($\beta = 0.429$, $p < .001$) and SES ($\beta = 0.152$, $p < .001$). Importantly, the interaction term was significant ($\beta = 0.223$, $p = .003$), supporting Hypothesis 4. This finding suggests that the association between digital access and health information seeking is stronger among individuals with higher SES.

Discussion

This study examined the relationships between digital access, health information seeking, and health outcomes while accounting for socioeconomic differences using data from Chinese adults. The findings revealed that digital access directly predicts better health outcomes, but health information seeking does not mediate this relationship when socioeconomic factors are controlled. Instead, SES emerged as a significant moderator, amplifying the positive effect of digital access on health information seeking. These results suggest that digital technologies influence health through mechanisms beyond information acquisition alone and that socioeconomic advantages enable more effective utilization of digital resources, potentially exacerbating rather than reducing health disparities in the digital age.

Digital access and health outcomes

The finding that digital access significantly predicts better health outcomes ($\beta = 0.091$, $p < .001$) aligns with the growing body of evidence documenting the health-promoting potential of internet connectivity.[6–9,14] This positive association persisted even after controlling for SES and demographic characteristics, suggesting that digital access confers independent health benefits. These results support perspectives emphasizing the beneficial aspects of digital connectivity such as enhanced access to health information, improved healthcare navigation, and expanded opportunities for health management.[8,13,14] The direct effect observed in this study is consistent with research demonstrating how digital technologies enable informed health decisions, facilitate preventive behaviors,[15–17] and reduce geographic barriers to healthcare access.[20]

Table 2. Intercorrelations among study variables.

Variable	1	2	3	4	5	6	7
1. Digital access	—						
2. Health information seeking	0.64***	—					
3. Socioeconomic status	0.37***	0.34***	—				
4. Health outcomes	0.33***	0.27***	0.29***	—			
5. Gender (female = 1)	−0.02	0.01	−0.06*	−0.14***	—		
6. Age	−0.61***	−0.49***	−0.36***	−0.27***	−0.02	—	
7. Residence (urban = 1)	0.20***	0.15***	0.14***	0.27***	0.03	−0.10***	—

Notes: N = 2265.
All indices range from 0 to 1, with higher scores indicating greater levels of the respective construct.
Gender: 0 = male, 1 = female; residence: 0 = rural, 1 = urban.
*$p < .05$. **$p < .01$. ***$p < .001$.

However, the findings also underscore the complexity of digital-health relationships documented in the literature. While a significant positive effect was observed, the modest effect size ($\beta = 0.091$) and the substantial role of SES ($\beta = 0.245$) suggest that digital access alone is insufficient to substantially improve health outcomes. The positive association does not preclude the potential negative effects documented in prior research, such as information overload,[28] health anxiety or cyberchondria,[29,30] sleep disturbance,[21–23] or exposure to misinformation,[26,27] which may operate through different mechanisms or manifest in specific subpopulations. Rather, at the population level, the health-promoting aspects of digital access outweigh potential harms, while highlighting that the translation of digital connectivity into health benefits is critically shaped by socioeconomic context.

Table 3. Hierarchical regression models predicting health outcomes.

Variable	Model 1	Model 2
Digital access		0.091***
		(0.022)
Socioeconomic status	0.275***	0.245***
	(0.032)	(0.032)
Female	−0.021*	−0.021*
	(0.010)	(0.010)
Age	−0.005***	−0.004***
	(0.000)	(0.000)
Urban	0.037**	0.032**
	(0.012)	(0.012)
Constant	0.742***	0.643***
	(0.026)	(0.035)
Observations	2265	2265
R-squared	0.175	0.181

Note: Standard errors in parentheses.
***$p < .001$, **$p < .01$, *$p < .05$.

Health information seeking: No mediation

Despite the strong association between digital access and health information seeking, health information seeking did not significantly predict health outcomes when digital access and SES were controlled ($\beta = 0.035$, $p = .213$). The indirect effect through information seeking was not statistically significant ($\beta = 0.015$, 95% CI [−0.008, 0.038]), indicating that the presumed mediating pathway does not operate as theorized. This null finding challenges the expectation that health information seeking links digital connectivity to improved health outcomes.[34,35] Instead, the results suggest that the relationship initially observed between information seeking and health outcomes in prior research may be confounded by SES, which emerged as a powerful predictor of both health information seeking ($\beta = 0.152$, $p < .001$; Table 5) and health outcomes ($\beta = 0.245$–0.275, $p < .001$; Table 3). While digital access facilitates information seeking, this behavior does not independently contribute to better health outcomes when socioeconomic factors are properly accounted for.

Table 4. Mediation analysis results.

Pathway	Coefficient	SE	*p*-value	95% bootstrap CI	Result
Path coefficients					
Digital access → health information seeking (*a*)	0.412***	0.016	< .001	[0.380, 0.444]	Significant
Health information seeking → health outcomes (*b*)	0.035	0.028	0.213	[−0.019, 0.092]	Not significant
Digital access → health outcomes (total, *c*)	0.091***	0.022	< .001	[0.047, 0.135]	Significant
Digital access → health outcomes (direct, *c'*)	0.076**	0.026	0 .004	[0.025, 0.128]	Significant
Mediation effects					
Indirect effect (*ab*)	0.015	0.012	0.214	[−0.008, 0.038]	Not significant

Notes: Bootstrap results based on 5000 replications with bias-corrected percentile confidence intervals.
All paths control for socioeconomic status, gender, age, and urban residence.
***$p < .001$, **$p < .01$, *$p < .05$.

Table 5. Moderation analysis results.

Variable	β	SE	*t*	*p*	95% CI	Result
Main effects						
Digital access	0.429	0.018	24.35	<.001	[0.394, 0.463]	Significant
Socioeconomic status (SES)	0.152	0.024	6.24	<.001	[0.104, 0.199]	Significant
Interaction effect						
Digital media × SES	0.223	0.076	2.95	.003	[0.075, 0.373]	Significant
Model summary						
Adj. R^2	0.180					
F (6, 2258)	83.82***					

Note: Dependent variable is health information seeking.
All models control for gender, age, and residence.
Continuous variables were mean-centered before creating the interaction term.
***$p < .001$, **$p < .01$, *$p < .05$.

Several factors may explain the absence of a significant mediating effect of health information seeking. Digital connectivity may facilitate health through more direct mechanisms such as online healthcare service utilization. These include telemedicine consultations, appointment scheduling, and electronic prescriptions that connect individuals to resources.[13] Additionally, digital access may support health through passive exposure to health-promoting content via social media or online communities,[15–17] psychological benefits including reduced isolation and enhanced social support,[67,68] and digital health management tools like symptom trackers and medication reminders.[8,14]

These pathways may operate independently of intentional health information seeking, suggesting that the health benefits of digital access extend beyond traditional information-seeking behaviors.

Socioeconomic moderation effects

SES significantly moderates the relationship between digital access and health information seeking ($\beta = 0.223$, $p = .003$) directly confirms theoretical predictions regarding socioeconomic disparities in digital health engagement.[37,38] The positive interaction coefficient demonstrates that digital

access yields greater information-seeking benefits for higher-SES individuals, consistent with substantial evidence documenting how socioeconomic advantages enable more effective digital health utilization.[41–45] Higher-SES individuals possess superior digital literacy skills, more reliable internet connectivity, and educational backgrounds facilitating critical evaluation of online health information.[42,43]

Rather than democratizing health information access, the findings suggest that digital connectivity differentially benefits those already advantaged. Lower-SES populations are constrained by limited device quality, restricted connectivity, lower baseline health literacy, and diminished capacity to evaluate source credibility,[36,47–49] making them less able to translate digital access into meaningful health information seeking. This pattern supports by Liu et al.[50] that digital health engagement as a self-reinforcing process wherein advantaged individuals continuously expand their capabilities while disadvantaged populations progressively fall behind. The results align with concerns that the digital health revolution may maintain or amplify existing social gradients in health.[51,53,54]

Implications and limitations

These findings have important implications for digital health. The results found digital access positively influences health outcomes but the results were not supporting the hypothesis that health information seeking mediates the digital access-health relationship. Instead, SES functions as a critical moderator that amplifies benefits for advantaged individuals while constraining them for disadvantaged populations. These findings indicate that expanding digital access alone is insufficient for equitable health improvement. Effective interventions should address digital health literacy, ensure quality device access and connectivity for lower-SES populations. By providing comprehensive approaches that address both access and the socioeconomic factors shaping effective digital engagement, digital health innovations can serve as instruments of health equity rather than amplify existing health disparities.

Several important limitations should be acknowledged. First, the cross-sectional design inherently restricts causal inference and limits the ability to establish temporal sequencing among variables. Second, reliance on self-reported measures may introduce social desirability bias and recall inaccuracies, particularly regarding the 12-month recall period for digital behaviors. Third, the assessment of physical health relied on a single self-rated measure, which may be subject to perceptual and situational biases. Although widely used as a general indicator of health status in population studies, this subjective measure has inherent limitations, as it does not differentiate between transient conditions and chronic health problems, potentially reducing the precision of the health outcome assessment. Finally, the study focused exclusively on Chinese adults, which may limit the generalizability of findings to other cultural or demographic contexts.

Conclusions

This study demonstrates that digital access directly improves health outcomes but not through health information seeking as commonly assumed. Notably, SES serves as a significant moderator of the association between digital access and information seeking, with benefits concentrated among advantaged groups, suggesting that effective reduction of health inequalities requires interventions that address the socioeconomic determinants of digital literacy and health engagement capacity that shape how different populations translate digital access into health benefits, beyond mere infrastructure provision.

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Ethical approval

Ethical review and approval were not required for this study in accordance with local legislation and institutional requirements. The study used publicly available data from the CGSS, for which ethical approval and written informed consent were obtained at the time of data collection.

Contributorship

Yingying Cai was responsible for conceptualization, methodology, data curation, formal analysis, and drafting the original manuscript, as well as creating visualizations.

Declaration of conflicting interests

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Data availability statement

The original contributions presented in the study are included in the article/supplemental material, further inquiries can be directed to the corresponding author.

Generative AI statement

The author declare that no Gen AI was used in the creation of this manuscript.

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