Internet Use and Older Adults Health: A Chain Mediation Model Through Self-efficacy, Health Literacy, and Physical Exercise

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Table of Contents

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Abstract

Background: With the widespread use of the internet, the number of elderly internet users is rapidly increasing. Internet use may affect the health of older adults. It is important to explore the relationship between internet use and older adults' health.

Objective: This study aims to explore the relationship between internet use and self-rated health among Chinese older adults, while also analyzing the mediating roles of self-efficacy, health literacy, and physical exercise. Additionally, it will explore the moderating effect of education level in this context.

Methods: Utilizing the 2021 PBICR dataset, this study selected a study population of 1,147 older adults aged 60 and above. Through the integrated application of methods such as multiple linear regression and Bootstrap testing, this study constructed a moderated chained mediation model to investigate the mediation pathways and marginal effects of internet use on the health of older adults.

Results: Internet use significantly boosts the self-rated health of older adults?B=4.109?P<.01?, with this enhancement manifesting through three mediating factors: self-efficacy, health literacy, and physical exercise (P-values were less than 0.001). These factors can operate independently or form a continuous chain of mediation. Additionally, education level moderates the relationship between internet use and both self-efficacy?B=1.834?P<.01?and physical exercise?B=0.174?P<.05?, suggesting that among older adults with higher education levels, the beneficial effect of internet use on self-rated health is more pronounced.

Conclusions: This study explains how internet use impacts the self-rated health of older adults through self-efficacy, health literacy, and physical exercise, enriching research on the intermediary pathways of internet use affecting older adults' health. It provides a useful reference for actively responding to the aging of the population.

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Original Paper

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Results: Internet use significantly boosts the self-rated health of older adults（B=4.109，*P*= .003）, with this enhancement manifesting through three mediating factors: self-efficacy, health literacy, and physical exercise (P-values were less than 0.001). These factors can operate independently or form a continuous chain of mediation. Additionally, education level moderates the relationship between internet use and both self-efficacy （B=1.834，*P* = .013）and physical exercise（B=0.174，*P* = .046）, suggesting that among older adults with higher education levels, the beneficial effect of internet use on self-rated health is more pronounced.

Conclusions: This study explains how internet use impacts the self-rated health of older adults through self-efficacy, health literacy, and physical exercise, enriching research on the intermediary pathways of internet use affecting older adults' health. It provides a useful reference for actively responding to the aging of the population.

KEYWORDS

internet use; older adults; self-efficacy; health literacy; physical exercise

Introduction

Background

The wave of population aging is sweeping across the globe, and as one of the most populous countries. By the end of 2023, the population aged 60 and above in China reached 296.97 million, accounting for 21.1% of the total population[1]. Meanwhile, since the 21st century, with the development and popularization of the internet, the number of older adult internet users has been growing steadily. According to The 53th Statistical Report on China' s Internet Development[2] in 2023, the Chinese internet user population reached 1.092 billion, with those aged 60 and above accounting for 15.6% (170 million) of the total, and this proportion continues to expand as the internet becomes more ubiquitous. Nowadays, internet use has permeated every aspect of older adults' lives, allowing them to connect with family and friends, stay informed on current events, and remain actively engaged with society. It also facilitates their daily lives by providing access to videos, health-related information, and online shopping. These changes may become significant factors influencing the health of older adults. Therefore, it is imperative to explore further the relationship between internet use and health among older adults.

Previous studies have examined the relationship between internet use and health among older adults. Most findings indicate that internet use contributes positively to older adults' health outcomes and health behaviors. In terms of health outcomes, internet use helps reduce loneliness and depression among older adults[3], enhances their subjective well-being[4], improves cognitive health[5], and lowers the incidence of chronic diseases[6]. As for health behaviors, internet use encourages behaviors such as quitting smoking, adopting healthy eating habits, increasing exercise frequency, and promoting health screenings[7, 8]. However, some studies suggest that excessive internet use may have negative effects on older adults, such as reducing real-life social interactions[9] and lowering life satisfaction[10]. Furthermore, some studies have explored the pathways through which internet use affects the health of older adults. Many studies have focused on the role of social capital from the perspective of social engagement, exploring how factors like social participation[11], social trust[12], and social support[13] mediate the relationship between internet use and older adults' health. Yet, there is relatively little research on the impact pathways from the micro-individual perspective of older adults. Although studies have pointed out the positive effects of internet use on older adults' self-efficacy[14], health literacy[14], and lifestyle behaviors[15], further empirical research is needed to verify how these factors influence older adults' health outcomes.

In this regard, this paper adopts a perspective based on individual perceptions of older adults. Using data from the Psychology and Behavior Investigation of Chinese Residents (PBICR), it employs methods such as multiple linear regression and Bootstrap testing to empirically analyze the impact of internet use on older adults' health. This study reveals the mediating roles of self-efficacy, health literacy, and physical exercise in the relationship between internet use and older adults' health, and to explore the differences in these effects across various education levels. Furthermore, it seeks to provide policy insights for actively addressing population aging and promoting healthy public health initiatives.

Theoretical Foundation

Media Effects Theory

Media effects theory attempts to explain the uses and impacts of media on individuals, groups, or societies as a whole[16]. It refers to both deliberate and unintended short-term and long-term changes in cognitions, emotions, attitudes, and behavior that result from media use, whether on an individual or collective level[17]. These effects are often indirect, with cognitive mental states acting as a mediating(or intervening) variable between media use and media outcomes[16]. This theory has been broadly applied in various domains, such as journalism and health education. Scholars have conducted extensive empirical research based on this theory, exploring how media can alter human health behaviors[18, 19]. The internet, as a highly convenient medium, transcends the traditional constraints of time and space, enabling easy access for older adults to a wealth of health information, disease prevention knowledge, and nutritional advice. Internet use not only facilitates the processing and internalization of health information among older adults but also fosters more positive and scientific health beliefs, enhancing their health literacy. Consequently, it guides them towards adopting positive health behaviors, such as improving dietary habits, increasing physical exercise, and undergoing regular health check-ups. These behavioral changes contribute not only to the improvement of physiological health indicators like blood pressure and blood sugar[20, 21] but also to the enhancement of their mental health, reducing negative emotions such as anxiety and depression[22, 23].

Health Belief Model

The Health Belief Model (HBM) is a socio-psychological model of physical behavior change developed by social psychologists in the U.S. Public Health Service in the 1950s. It is designed to explain and predict health-related behaviors[24]. According to this model, individuals are more likely to change their health behaviors when they perceive a

threat from a disease, believe that taking action can prevent it, and feel confident in their ability to adopt recommended actions. In HBM, when individuals possess a high level of self-efficacy, they have greater confidence in their ability to successfully execute health behaviors and achieve healthy outcomes. Consequently, they are more likely to overcome obstacles to behavior change and adopt healthy behaviors. This model has been widely applied in numerous health education and promotion projects, such as vaccination, smoking cessation, and cancer screening, achieving remarkable results[25, 26]. Wong et al.'s research found that an interactive web-based sexual health literacy program improve self-efficacy regarding condom use[27]. Another study found that social media can enhance self-efficacy and contribute to the betterment of psychobehavioral responses to infectious diseases[28].

Research Hypotheses

Relationship between Internet Use and Health among Older Adults

Existing research has revealed that internet use among older adults impacts their self-rated health, mental health, physical health, and chronic disease management. In terms of physical health, internet use improves cognitive function by increasing activity participation[29], and positively influences objective physical health[30]. In chronic disease management, internet use effectively increases physical activity, aiding in the prevention of obesity, heart disease, hypertension, diabetes, and other chronic conditions[31].Among indicators of health, self-rated health is a comprehensive measure and a powerful predictor of well-being[32]. Research has shown that internet use may enhance self-rated health. For instance, Zhou et al. found a positive correlation between internet use and self-rated health[33]; Liu et al. discovered that Chinese older adult internet users reported better health[13]. Therefore, this study focuses on self-rated health and proposes the following hypothesis:

H1 The internet use of older adults positively influences their self-rated health levels.

Mediating Role of Self-Efficacy

Self-efficacy is an individual's perceived ability and confidence in facing challenges across various situations, representing a relatively stable psychological trait[34]. According to the HBM, a high sense of self-efficacy promotes health. In the process of internet use, older adults can conveniently acquire knowledge and master new skills, such as online shopping, posting, or creating videos, which bolster their confidence and self-efficacy. Additionally, the internet offers older adults extensive social channels, enabling them to transcend time and space constraints to maintain contact with family and friends and share life moments. This social support network also enhances their self-efficacy. Numerous prior studies have found a correlation between internet use and self-efficacy: among older adults, those who use the internet more frequently have a higher self-efficacy than those who use it rarely or not at all[35]; the use of Information and Communication Technology (ICT) can improve older adults' sense of self-efficacy, significantly enhancing their life satisfaction and alleviating feelings of loneliness and depression[36, 37]. These findings suggest a significant positive correlation between internet use and self-efficacy among older adults. Internet use may improve older adults' health by enhancing their self-efficacy. Therefore, the following research hypothesis is proposed.

H2 The self-efficacy is a mediator between internet use and self-rated health among older adults.

Mediating Role of Health Literacy

Health literacy is defined as the ability to acquire, process, understand, and communicate information related to health. This capability facilitates healthy decision-making and the management of health conditions[38]. Higher levels of health literacy are advantageous for both physical and mental well-being[39, 40]. Internet use has the potential to elevate health literacy by enhancing access to health information[41]. It provides older adults with convenient channels to obtain scientific and authoritative health knowledge and information. This information not only boosts their health literacy but also guides them to adopt healthier lifestyles, such as balanced diets and moderate exercise, thereby promoting their overall well-being. Moreover, individuals with higher health literacy are more likely to understand and adhere to medical advice and protocols, leading to improved health outcomes[42]. Studies have found a significant correlation between frequent internet use, good health status, and higher health literacy[43]. Therefore, the following research hypothesis is proposed:

H3 The health literacy is a mediator between internet use and self-rated health among older adults.

Mediating Role of Physical Exercise

Health behaviors typically refer to a series of positive lifestyle choices aimed at disease prevention and promotion of physical and mental well-being. Physical exercise is a crucial determinant of health, capable of preventing numerous diseases, including cardiovascular diseases[44]. Prior studies have indicated a link between high levels of internet use and high levels of physical exercise[45]. Guo et al., using data from the 2018 China Health and Retirement Longitudinal Study (CHARLS), found that internet use and its frequency significantly increased the probability and frequency of physical exercise participation among middle-aged and older adults[15]. Physical exercise not only benefits physical

health but also positively influences emotional states such as anxiety, stress, and depression through physiological and biochemical mechanisms, including the promotion of dopamine secretion[46], thereby contributing to mental well-being. Zhang et.al pointed out that the internet facilitates physical exercise in multiple ways, and active exercise further impacts individuals' mental health status[47]. Liu et al. found that longer internet use predicted lower levels of depressive symptoms, and the frequency of physical activities such as exercise mediated the longitudinal relationship between internet use and depressive symptoms among older adults[48]. Therefore, the fourth research hypothesis of this paper is proposed:

H4 Physical exercise is a mediator between internet use and self-rated health among older adults.

Chain Mediating Effects of Self-Efficacy, Health Literacy, and Physical Exercise

The impacts of self-efficacy, health literacy, and physical exercise on health are interconnected. Firstly, enhanced self-efficacy significantly promotes health literacy. Researchers have found a correlation: individuals with high self-efficacy acquire useful health skills and discern true information, boosting health literacy[49]. Older adults with high self-efficacy exhibit greater initiative in engaging in healthy social activities and adopting healthy lifestyles, aiding health literacy improvement[50].

Secondly, increased self-efficacy elevates physical exercise levels[51, 52]. High self-efficacy reflects individuals' beliefs in controlling behavior and achieving goals, enabling older adults to believe in their ability to undertake tasks and reach objectives[53], thus motivating them to actively engage in physical activities and complete exercise plans.

Concurrently, health literacy benefits physical exercise. Studies by Buja, Lam, et al.[54, 55]have shown a significant positive correlation between high health literacy and high physical activity levels. Health literacy involves acquiring, processing, and understanding health information and making appropriate decisions. It enhances individuals' control over their health and decisions, impacting their daily life[56], and has shown a significant positive correlation between high health literacy and high physical activity levels[57]. High health literacy enables older adults to accurately assess their health status, adopt health advice, and lay a solid foundation for physical exercise.

Finally, self-efficacy, health literacy, and physical exercise may play a chain mediating effect between internet use and self-rated health among older adults. Internet use broadens their social circles and enhances their self-efficacy, further promoting health literacy. With increased health knowledge and understanding, older adults become more conscious of physical exercise, ultimately affecting their health. Therefore, the following research hypothesis is proposed:

H5 Self-efficacy and health literacy play a chain mediating effect between internet use and self-rated health among older adults.

H6 Self-efficacy and physical exercise play a chain mediating effect between internet use and self-rated health among older adults.

H7 Health literacy and physical exercise play a chain mediating effect between internet use and self-rated health among older adults.

H8 Self-efficacy, health literacy, and physical exercise play a chain mediating effect between internet use and self-rated health among older adults.

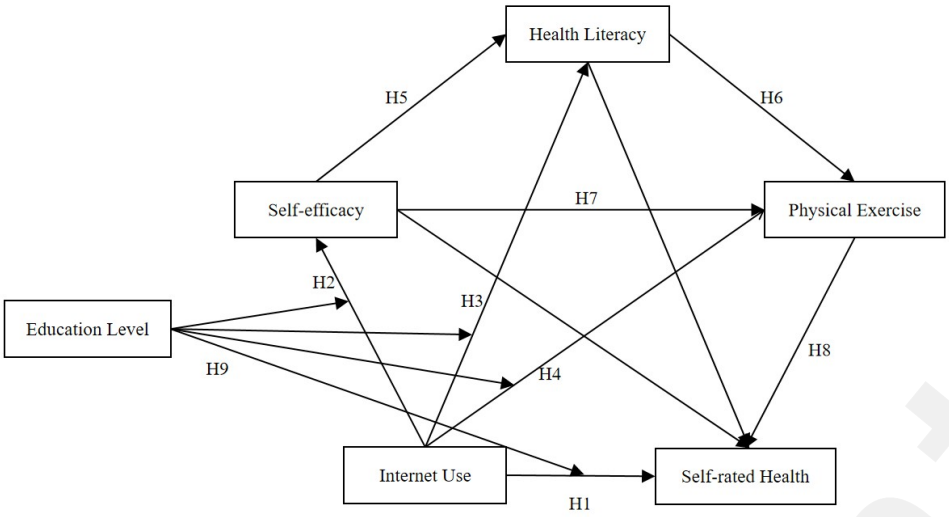
Moderating Effect of Education Level

Previous studies have found that education level is a significant factor influencing internet use among older adults. Different education levels reflect disparities in cultural capital[58], potentially affecting the relationship between internet use and health among older adults[59]. Specifically, older adults with higher education levels have greater access to the internet and are more likely to acquire, understand, and learn from health-related information online compared to those with lower education levels. Therefore, this paper argues that different education levels result in distinct pathways through which internet use affects the health of older adults, and education level moderates the mediating pathway between internet use and physical and mental health among older adults. Based on this, the following hypothesis is proposed:

H9 Education play a positive moderating effect between internet use and self-rated health among older adults.

Based on the above research hypotheses, the theoretical hypothesis model is shown in Figure 1.

Figure 1. Hypothesis model. H: hypothesis. H1：Internet Use→Self-rated Health; H2：Internet Use→Self-efficacy→Self-rated Health; H3：Internet Use→Health Literacy→Self-rated Health; H4：Internet Use→Physical Exercise→Self-rated Health; H5：Internet Use→Self-efficacy→Health Literacy→Self-rated Health; H6：Internet Use→Self-efficacy→Physical Exercise→Self-rated Health; H7：Internet Use→Health Literacy→Physical Exercise→Self-rated Health; H8：Internet Use→Self-efficacy→Health Literacy→Physical Exercise→Self-rated Health; H9：Adjustment of Education Level :"Internet Use→Self-rated Health".



Methods

Data Source

The data used in this study is the results of the 2021 survey of the PBICR Project. Organized by the School of Public Health at Peking University, the PBICR Project has conducted annual surveys since 2020, collecting data across four waves. The most recent publicly available data is from 2021. The survey covers 23 provinces, 5 autonomous regions, and 4 municipalities in China. It employs a multi-stage sampling method with quota sampling to select residents from 120 cities. Participants are aged 12 years and older, with 11,032 valid questionnaires collected after data screening and logical checks. The focus of this study is on individuals aged 60 years or older. After excluding those who did not meet this age criterion, the final sample consisted of 1,147 individuals. The survey was approved by the ethical review committees (JKWH-2021-01; JNUKY-2021-018).

Variable Setting

Explained variable

Self-rated health was chosen as the explained variable. The survey question used to assess self-rated health was, “How would you rate your health today?” Respondents were asked to rate their health on a scale from 0 to 100, with higher scores indicating better self-rated health.

Explanatory Variable

The Explanatory variable in this study is internet use. The relevant question in the survey was, “How often do you typically use the following media?” Participants who reported never using personal computers (including tablets) or smartphones were coded as 0, while all others were coded as 1.

Control Variables

Control variables in this study were selected based on individual, family, and socio-economic factors, including age, gender, education level, marital status, residence, per capita monthly household income, political affiliation, nationality, living alone, medical insurance, and number of chronic diseases. The specific settings for each variable are presented in Table 1.

Table 1. Definition of Each Variable.

Variable Type	Variable Name	Variable Definition
Explained Variable	Self-rated Health	Self-rated health score ranged from 0 to 100
Explanatory Variable	Internet Use	Yes=1, No=0
Covariates	Age	60~69=1, 70~79=2, ≥80=3
	Gender	Female=0, Male=1
	Education Level	Junior high school and below=1, High school or vocational school=2, University (including junior college) and above=3

	Marital Status	Married=1, Divorced=2, Unmarried=3, Widowed=4
	Residence	Urban=1, Rural=0
	Per Capita Monthly Household Income	≤3000=1, 3001~6000=2, 6000=3
	Political Affiliation	Party Member =1, Non-Party Member = 0,
	Nationality	Han=1, Other=0
	Living Alone	Living alone=1, Other=0
	Medical Insurance	Participate in medical insurance (including urban employee medical insurance, urban and rural resident medical insurance, commercial medical insurance, and public medical insurance)=1, Out-of-pocket Spending=0
	Number of Chronic Diseases	Suffering from 1 or no chronic disease=1, Suffering from 2 chronic diseases=2, Suffering from 3 chronic diseases=3, Suffering from 4 or more chronic diseases=4
Mediator Variable	Self-efficacy	Self efficacy score ranged from 8 to 40
	Health Literacy	Inadequate=1, Problematic=2, Sufficient=3, Excellent=4
	Physical Exercise	0 minutes=1, Within 150 minutes=2, Over 150 minutes=3

Mediator Variables

The mediator variables selected for this study included self-efficacy, health literacy, and physical exercise (Table 1).

Self-efficacy was measured using the New General Self-Efficacy Scale (NGSES), developed by Chen et al. in 2001[60]. The NGSES consists of 8 items, with responses ranging from 1 (strongly disagree) to 5 (strongly agree). The total score ranges from 8 to 40, with higher scores reflecting greater levels of general self-efficacy.

Health literacy was assessed using the 12-item Short-Form Health Literacy Questionnaire (HLS-SF12)[61], which evaluates three dimensions: health care, disease prevention, and health promotion. Each item is scored on 4-point Likert scales (1 = very difficult, 2 = difficult, 3 = easy, and 4 = very easy). The health literacy index (HL index) was standardized using the formula: [index = (mean − 1) × (50/3)] , where the “mean” represents the average score for each individual. The resulting health literacy scores ranged from 0 to 50, with scores of 0 to 25 classified as insufficient, 26 to 33 as probably insufficient, 34 to 42 as adequate, and 43 to 50 as very adequate[62].

Physical exercise were measured based on weekly total exercise time, including activities such as fitness exercises (e.g., dumbbell lifting), walking, swimming, cycling, using sports equipment (e.g., treadmills), and other forms of aerobic exercise (e.g., running, table tennis). The total exercise time (in minutes) was calculated by summing the duration of all activities, with ≥150 minutes per week considered a healthy level of physical activity[63].

Moderating Variable

The moderating variable selected for this study was the education level of older adults. Education level was assessed using the questionnaire item, “Your highest level of education,” with responses categorized into the following groups: junior high school or below, high school or junior college, and bachelor’s degree or higher. These categories were determined based on the characteristics of the sample population and the available data.

Statistical Methods

Descriptive statistics were calculated to analyze data from 1,147 participants, using means, standard deviations, and minimum and maximum values to summarize the key variables. Multiple linear regression was applied to explore the relationship between Internet use and self-rated health. The mediating effects were assessed using the Bootstrap method, specifically through chain mediation model and chain mediation model with moderation from the PROCESS 4.0 macro developed by Andrew F. Hayes. The analysis involved 1,000 repeated samples, and the significance of the mediation effect was determined by examining the confidence interval (CI). A mediation effect was considered statistically significant if the CI did not include zero, and the effect size was estimated based on the point estimate. All statistical analyses were performed using SPSS version 25.0, with two-sided tests and a significance level set at $p < 0.05$.

Research Results

Descriptive Analysis

The characteristics of the participants are shown in Table 2. The mean self-rated health score of older adults was 73.899, suggesting that older adults have relatively good overall health. The average internet use was 0.724, indicating a high

level of internet penetration among older adults, with the internet playing an increasingly important role in their daily lives. The gender distribution in the study population was balanced (mean value = 0.507), and urban residents slightly outnumbered rural residents (mean value = 0.570). The majority of participants had medical insurance coverage (mean value = 0.887). The mean self-efficacy score was 28.099, reflecting a relatively high level of *self-efficacy* among older adults.

Table 2. Descriptive Statistical Results of Each Variable.

Variables	N	Mean	SD	Min	Max
Self-rated Health	1147	73.899	19.614	0	100
Internet Use	1147	0.724	0.447	0	1
Age	1147	1.646	0.646	1	3
Gender	1147	0.507	0.500	0	1
Education Level	1147	1.541	0.784	1	3
Marital Status	1147	1.591	1.148	1	4
Residence	1147	0.570	0.495	0	1
Per capita monthly household income	1147	1.825	0.785	1	3
Political Affiliation	1147	0.217	0.412	0	1
Nationality	1147	0.940	0.238	0	1
Living Alone	1147	0.119	0.323	0	1
Medical Insurance	1147	0.887	0.317	0	1
Number of Chronic Diseases	1147	1.401	0.744	1	4
Self-efficacy	1147	28.099	5.340	8	40
Health Literacy	1147	1.985	0.854	1	4
Physical Exercise	1147	2.473	0.679	1	3

The Relationship Between Internet Use and Self-Rated Health

This section analyzes self-rated health as the explained variable and internet use as the explanatory variable, incorporating control variables within a multiple linear regression model. Multicollinearity diagnostics are then performed. The results, presented in Table 3, show that the variance inflation factor (VIF) values for all variables in both models (A and B) are below 10, indicating no significant multicollinearity among the variables.

Table 3. Results of Multiple Linear Regression Analysis.

Variables	Model A[a](Self-rated Health)			Model B[b](Self-rated Health)		
	B	*P* value	VIF	B	*P* value	VIF
Internet Use	4.109	.003	1.248	-0.929	.492	1.374
Age	-0.626	.484	1.103	-0.566	.500	1.105
Gender	0.992	.384	1.068	-9.23E-05	1.000	1.086
Education Level	2.577	.003	1.481	1.421	.078	1.505
Marital Status	-1.311	.020	1.376	-0.973	.065	1.380
Residence	1.089	.378	1.232	-0.610	.602	1.258
Per capita monthly household income	-0.323	.696	1.387	-0.612	.431	1.398
Political Affiliation	0.258	.861	1.219	-1.605	.248	1.236
Nationality	6.594	.005	1.023	6.638	.003	1.025
Living Alone	4.674	.016	1.299	4.359	.017	1.302
Medical Insurance	6.505	□.001	1.039	3.675	.028	1.062
Number of Chronic Diseases	-5.238	□.001	1.044	-4.523	□.001	1.056
Self-efficacy	N/A[c]	N/A	N/A	0.537	□.001	1.218
Health Literacy	N/A	N/A	N/A	5.658	□.001	1.340
Physical Exercise	N/A	N/A	N/A	3.898	□.001	1.268
Constant	64.304	□.001	N/A	37.046	□.001	N/A

[a] R^2=0.105, F=11.041, P□.001.
[b] R^2=0.219, F=21.104, P□.001.
[c] N/A: not applicable.

A comparison of the two models reveals that Model B includes three additional control variables, *self-efficacy*, *health literacy*, and *physical exercise*, compared to Model A. As indicated by Model A, internet use has a significant positive effect on self-rated health in older adults (B = 4.109, *P* = .003), suggesting that internet use contributes to improved self-rated health. Model B further shows that *self-efficacy*, *health literacy*, and *physical exercise* each have a significant positive impact on self-rated health (*P* < .001). Importantly, when these control variables are included in the model, the effect of internet use on self-rated health disappears. This suggests that *self-efficacy*, *health literacy*, and *physical exercise* may play a mediating role in the relationship between internet use and self-rated health among older adults.

Chain Mediation Analysis

To explore further the mediating roles of *self-efficacy*, *health literacy*, and *physical exercise* in the relationship between internet use and self-rated health in older adults, this section employs chain mediation analysis using the PROCESS 4.0 program for SPSS 25, based on the framework established by Hayes et al.[64]. In this chain mediation analysis, *self-efficacy* is treated as a continuous variable, while the other variables are categorical, so the *self-efficacy* variable is standardized before inclusion in the analysis.

Table 4. Regression results of the relationship among internet use, self-efficacy, health literacy, physical exercise and self-rated health.

Variables	Model 1[a] (Self-rated Health)		Model 2[b] (Self-efficacy)		Model 3[c] (Health Literacy)		Model 4[d] (Physical Exercise)		Model 5[e] (Self-rated Health)	
	B	*P* value	B	*P* value	B	*P* value	B	*P* value	B	*P* value
Internet Use	4.109	.003	2.189	<.001	0.344	<.001	0.290	<.001	-0.929	.492
Self-efficacy	N/A [f]	N/A	N/A	N/A	0.049	<.001	0.005	.144	0.537	<.001
Health Literacy	N/A	N/A	N/A	N/A	N/A	N/A	0.078	.001	5.658	<.001
Physical Exercise	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3.898	<.001
Age	-0.626	.484	0.272	.270	-0.032	.371	-0.026	.378	-.566	.500
Gender	0.992	.384	0.201	.522	0.034	.449	0.158	<.001	0.000	1.000
Education Level	2.577	.003	0.340	.149	0.093	.007	0.081	.004	1.421	.078
Marital Status	-1.311	.020	-0.186	.231	-0.034	.134	0.005	.769	-0.973	.065
Residence	1.089	.378	0.269	.429	0.149	.003	0.149	<.001	-0.610	.602
Per capita monthly household income	-0.323	.696	-0.175	.442	0.025	.455	0.074	.006	-0.612	.431
Political Affiliation	0.258	.861	1.482	<.001	0.063	.288	0.059	.222	-1.605	.248
Nationality	6.594	.005	0.111	.864	0.047	.618	-0.107	.161	6.638	.003
Living Alone	4.674	.016	-0.412	.441	0.057	.460	0.083	.191	4.359	.017
Medical Insurance	6.505	<.001	1.440	.003	0.135	.058	0.206	<.001	3.675	.028
Number of Chronic Diseases	-5.238	<.001	0.011	.957	-0.093	.002	-.043	.081	-4.523	<.001
Constant	64.304	<.001	-3.865	<.001	1.499	<.001	1.674	<.001	52.124	<.001

[a] R^2=0.105, *F*=11.041, *P*<.001.
[b] R^2=0.084, *F*=8.704, *P*<.001.
[c] R^2=0.247, *F*=28.584, *P*<.001.
[d] R^2=0.211, *F*=21.666, *P*<.001.
[e] R^2=0.219, *F*=21.104, *P*<.001.
[f] N/A: not applicable.

The results of the chain mediation analysis for internet use and self-rated health are presented in Table 4. According to Model 1, internet use significantly predicts self-rated health (B = 4.109, *P*= .003), thus Hypothesis 1 is supported, indicating that internet use positively affects older adults' self-rated health. Models 2, 3, and 4 show that internet use significantly predicts *self-efficacy* (B = 2.189, *P* < .001), *health literacy* (B = 0.344, *P* < .001), and *physical exercise* (B = 0.290, *P* < .001).

When internet use, *self-efficacy*, *health literacy*, and *physical exercise* are all included in the regression equation (Model 5), the coefficients of the variables change. Comparing Model 5 with Model 1, the positive prediction of internet use on self-rated health becomes non-significant, while the positive predictions of *self-efficacy, health literacy,* and *physical exercise* remain significant, which is consistent with the results of the multiple linear regression analysis.

Figure 2 and Table 5 together illustrate the results of the chain mediation analysis. The path coefficients are shown in Figure 2, where solid arrows represent significant effects, and dashed arrows indicate no significant effect. Table 5 presents the results of the Bootstrap test.

Figure 2. Chain mediation analysis of the association between internet use and self-rated health.*** *P* < .001; ** *P* < .01; * *P* < .05; + *P* < .1.

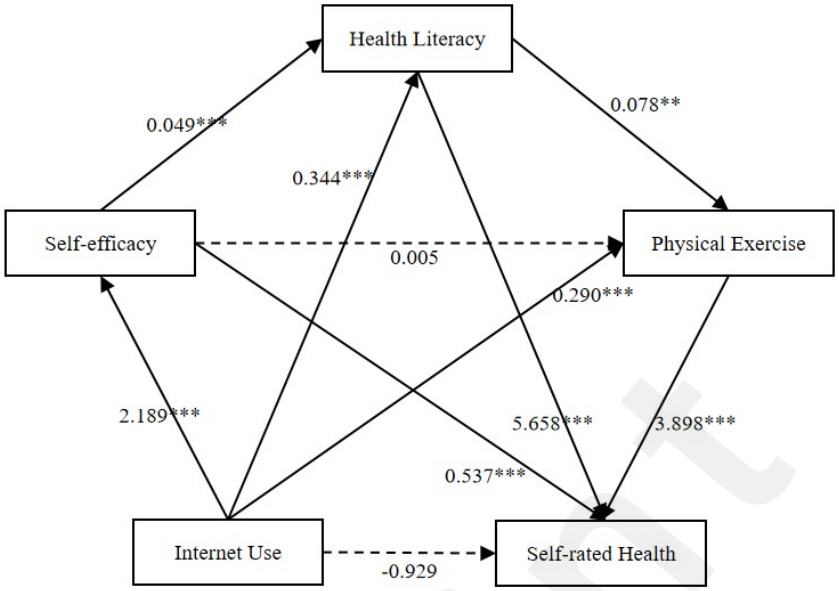


Table 5. Results of chain mediation analysis.

Number	Effect Path	B	SE	95%CI	Proportion of Effect
1	Total effect	4.109	1.376	1.41~6.809	N/A [a]
2	Direct effect	-0.929	1.35	-3.579~1.721	N/A
3	Total indirect effect	5.039	0.689	3.822~6.576	100%
4	Internet Use→Self-efficacy→Self-rated Health	1.174	0.376	0.535~1.993	23.30%
5	Internet Use→Health Literacy→Self-rated Health	1.947	0.397	1.270~2.798	38.64%
6	Internet Use→Physical Exercise→Self-rated Health	1.129	0.323	0.585~1.822	22.41%
7	Internet Use→Self-efficacy→Health Literacy→Self-rated Health	0.605	0.143	0.351~0.901	12.01%
8	Internet Use→Self-efficacy→Physical Exercise→Self-rated Health	0.046	0.039	-0.023~0.133	0.91%
9	Internet Use→Health Literacy→Physical Exercise→Self-rated Health	0.104	0.045	0.033~0.206	2.06%
10	Internet Use→Self-efficacy→Health Literacy→Physical Exercise→Self-rated Health	0.032	0.014	0.010~0.063	0.64%

[a] N/A: not applicable.

Combining Figure 2 and Table 5, it can be seen that the total effect of internet use on self-rated health is 4.109, with the confidence interval not including 0, which is consistent with the result from Model 1. This indicates that internet use has a positive impact on older adults' self-rated health, with a total effect of 4.109. The direct effect is -0.929, with the confidence interval including 0, suggesting that after controlling for the three mediating variables, internet use itself does not have a significant direct effect on older adults' self-rated health. Instead, internet use exerts its positive influence on self-rated health entirely through the mediating roles of *self-efficacy, health literacy,* and *physical exercise*. The total indirect effect is 5.039, indicating that *self-efficacy, health literacy,* and *physical exercise* have a positive overall mediating effect on the relationship between internet use and self-rated health.

According to the study hypotheses, there are seven indirect paths in the chain mediation model, as shown in Table 5. The analysis results for paths 4 to 6 indicate that the mediating effects of *self-efficacy, health literacy,* and *physical exercise* on the relationship between internet use and self-rated health are significant, thus Hypotheses 2, 3, and 4 are supported. At the 95% confidence interval, the mediation effects are 1.174, 1.947, and 1.129, accounting for 23.30%, 38.64%, and 22.41% of the total indirect effect, respectively. The results of the chain mediation analysis are shown in paths 7 to 10, where, except for path 8, paths 7, 9, and 10 are statistically significant. Hypothesis 6 is not supported, while Hypotheses 5, 7, and 8 are supported.

Moderated Chain Mediation Analysis

The moderating effect of *education level* was tested in Table 6. The results reveal that education level moderates the relationships between internet use, *self-efficacy*, and *physical exercise* (Model 6, Model 8). However, it does not moderate the relationships between *internet use*, *health literacy*, and *self-rated health* (Model 7, Model 9).

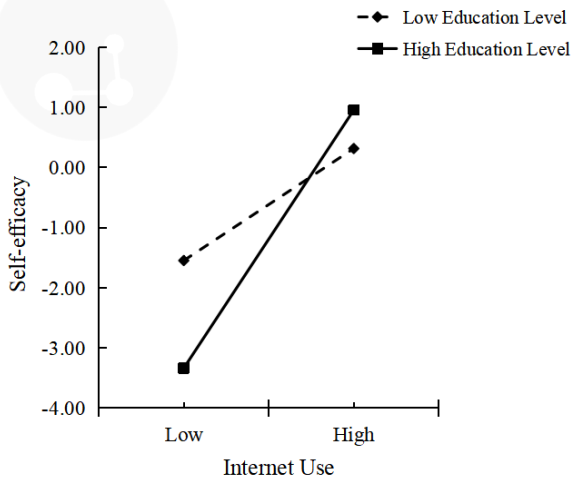
Table 6. Moderated chain mediation test of internet use on self-rated health.

Variables	Model 6[a] (Self-efficacy)		Model 7[b] (Health Literacy)		Model 8[c] (Physical Exercise)		Model 9[d] (Self-rated Health)	
	B	*P* value	B	*P* value	B	*P* value	B	*P* value
Internet Use	0.028	.976	0.526	□.001	0.085	.447	-4.714	.145
Self-efficacy	N/A [e]	N/A	0.049	□.001	0.005	.197	0.525	□.001
Health Literacy	N/A	N/A	N/A	N/A	0.080	.001	5.702	□.001
Physical Exercise	N/A	N/A	N/A	N/A	N/A	N/A	3.833	□.001
Education Level	-1.351	.060	0.236	.024	-0.080	.349	-1.558	.525
Internet Use×Education Level	1.834	.013	-0.156	.147	0.174	.046	3.237	.198
Age	0.282	.252	-0.033	.357	-0.025	.398	-0.547	.514
Gender	0.244	.437	0.031	.500	0.162	□.001	0.087	.936
Marital Status	-0.175	.259	-0.035	.124	0.006	.727	-0.954	.071
Residence	0.341	.317	0.143	.004	0.156	□.001	-0.477	.684
Per capita monthly household income	-0.158	.486	0.023	.479	0.076	.005	-0.581	.455
Political Affiliation	1.456	□.001	0.065	.277	0.057	.236	-1.635	.240
Nationality	0.080	.901	0.049	.598	-0.110	.149	6.576	.003
Living Alone	-0.419	.433	0.058	.453	0.082	.196	4.346	.017
Medical Insurance	1.500	.002	0.129	.070	0.212	□.001	3.802	.024
Number of Chronic Diseases	0.012	.954	-0.093	.002	-0.043	.083	-4.521	□.001
Constant	-2.098	.091	1.351	□.001	1.836	□.001	55.257	□.001

[a] R^2=0.089, F=8.552, P□.001.
[b] R^2=0.248, F=26.719, P□.001.
[c] R^2=0.214, F=20.541, P□.001.
[d] R^2=0.220, F=19.900, P□.001.
[e] N/A: not applicable.

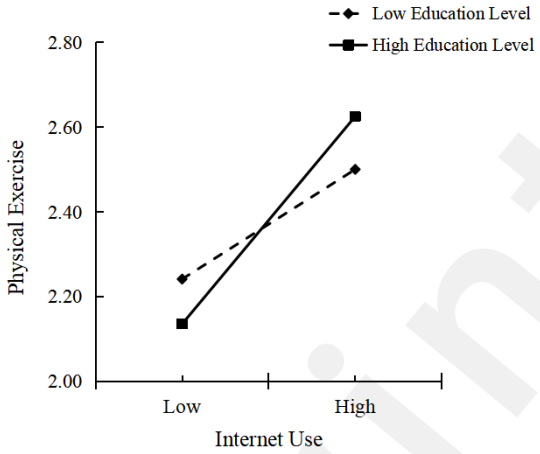
The interaction term between *internet use* and *education level* (B = 1.834, P = .013) significantly predicts *self-efficacy*. Education level positively moderates the relationship between internet use and self-efficacy, as shown in Figure 3. At higher education levels, the effect of internet use on self-efficacy is stronger (B = 4.293, P < .001), whereas at lower education levels, the effect is weaker (B = 1.863, P < .001). The slope for individuals with higher education is significantly steeper than that for those with lower education, indicating that among older adults with higher education, internet use has a more pronounced influence on self-efficacy.

Figure 3. Education level as a moderator in the relationship between internet use and self-efficacy.



Similarly, the interaction term between *internet use* and *education level* (B = 0.174, *P* = .046) is a predictor of *physical exercise*. Education level positively moderates the relationship between internet use and physical exercise, as shown in Figure 4. The results indicate that, at higher education levels, the effect of internet use on physical exercise is stronger (B = 0.490, *P* < .001), whereas at lower education levels, the effect is weaker (B = 0.259, *P* < .001). The slope for individuals with higher education is steeper than for those with lower education, indicating that internet use has a greater impact on physical exercise among older adults with higher education levels.

Figure 4. Education level as a moderator in the relationship between internet use and physical exercise.



Furthermore, this study examined the moderating role of *education level* on the indirect pathway between internet use and self-rated health in older adults, with the results presented in Table 7.

Table 7. Results of Moderated Chain Mediation Analysis.

Number	Indirect Effect Path	Moderating effect	B	SE	95%CI Lower	95%CI Upper
1	Internet Use→Self-efficacy→Self-rated Health	Low level of edu[a]	0.979	0.328	0.441	1.761
		High level of edu	2.256	0.889	0.829	4.168
		Index of Moderated Mediation	0.964	0.582	0.030	2.238
2	Internet Use→Health Literacy→Self-rated Health	Low level of edu	2.114	0.407	1.377	2.981
		High level of edu	0.939	0.576	-0.235	2.110
		Index of Moderated Mediation	-0.887	0.469	-1.961	-0.032
3	Internet Use→Physical Exercise→Self-rated Health	Low level of edu	0.994	0.311	0.427	1.639
		High level of edu	1.877	0.635	0.704	3.203
		Index of Moderated Mediation	0.667	0.393	-0.004	1.536
4	Internet Use→Self-efficacy→Health Literacy→Self-rated Health	Low level of edu	0.524	0.136	0.294	0.813
		High level of edu	1.208	0.390	0.541	2.108
		Index of Moderated Mediation	0.516	0.282	0.015	1.144
5	Internet Use→Self-efficacy→Physical Exercise→Self-rated Health	Low level of edu	0.034	0.031	-0.021	0.100
		High level of edu	0.079	0.075	-0.046	0.254
		Index of Moderated Mediation	0.034	0.037	-0.021	0.127
6	Internet Use→Health Literacy→Physical Exercise→Self-rated Health	Low level of edu	0.113	0.049	0.030	0.233
		High level of edu	0.050	0.039	-0.011	0.145
		Index of Moderated Mediation	-0.047	0.031	-0.115	-0.001

Number	Indirect Effect Path	Moderating effect	B	SE	95%CI Lower	95%CI Upper
7	Internet Use→Self-efficacy→Health Literacy→Physical Exercise→Self-rated Health	Low level of edu	0.028	0.013	0.007	0.057
		High level of edu	0.065	0.034	0.014	0.147
		Index of Moderated Mediation	0.028	0.020	0.001	0.079

[a] edu: education

As shown in Table 7, *education level* moderates the mediation effects of indirect paths 1, 2, 4, 6, and 7, thereby influencing the relationship between internet use and self-rated health. However, no moderating effect was found for paths 3 and 5. Education level positively moderates the mediation effects of paths 1, 4, and 7 (moderated mediation indices: 0.964, 0.516, and 0.028, respectively), meaning that the indirect effects of these paths are stronger at higher education levels and weaker at lower education levels. For paths 2 and 6, education level has a negative moderating effect on the mediation paths (moderated mediation indices: -0.887 and -0.047, respectively). This negative effect occurs because the positive moderating influence of education is only significant at lower education levels, while no significant positive effect is observed at higher levels. Consequently, education level negatively moderates the indirect effects of paths 4 and 6. Overall, Hypothesis 9 is supported. Our moderated mediation analysis demonstrates that education level modulates the strength of the association between internet use and self-rated health among older adults, with self-efficacy, health literacy, self-efficacy → health literacy, health literacy → physical exercise, and self-efficacy → health literacy → physical exercise acting as mediating pathways.

Discussion

Principal Findings

Utilizing 2021 PBICR survey data, this study initiates an in-depth exploration of the impact of internet use on the self-rated health of older adults from the perspectives of self-efficacy, health literacy, and physical exercise. It investigates the chain mediating effects of these three variables and examines the moderating role of education level in the influence mechanism. The findings indicate that internet use significantly enhances the self-rated health of older adults, with this facilitation entirely mediated through the three factors. Self-efficacy, health literacy, and physical exercise are independent mediators and form a continuous chain of mediating influence. Education Level exhibits a moderating effect between internet use and self-efficacy, physical exercise.

On the one hand, internet use is identified as a positive factor influencing the self-rated health of older adults, aligning with the findings of Fjell A et al[65, 66]. Internet use can improve the self-rated health of older adults. According to media effects theory, internet use, as a new medium, extensively covers older adults' engagement with media such as WeChat (a social networking and instant messaging application created by the Chinese technology company Tencent) , TikTok (a popular and controversial social media platform owned by ByteDance), and Taobao (a Chinese e-commerce platform owned by Alibaba Group) . It enables them to access more scientific health knowledge and obtain stable social network support, thereby altering their health levels. For instance, the internet allows people to consult health experts at any time and place[67], effectively alleviating the difficulties older adults face in seeking medical care. This timely access to medical services improves their health conditions[68]. Additionally, the internet increases social interaction among older adults, helping them maintain close ties with society and promoting their health[69].

On the other hand, the chain mediating analysis reveals that self-efficacy, health literacy, and physical exercise fully mediate between internet use and the self-rated health of older adults. The direct effect is insignificant, with indirect effects reaching 100%. The positive impact of internet use on older adults' self-rated health is entirely manifested through these three mediating factors. Merely accessing the internet does not enhance their health; it is the additional benefits of self-efficacy, health literacy, and physical exercise during internet use that improve older adults' self-rated health.

Firstly, internet use affects the self-efficacy of older adults. The study finds a positive correlation between self-efficacy and the frequency of media exposure, such as smartphones. Higher media exposure leads to higher self-efficacy[70]. After engaging with various media platforms, individuals can enhance their self-efficacy through self-motivation and self-regulation[71], as well as by increasing their perception of social support[72]. Additionally, the internet offers new learning environments and opportunities through online courses, aiding individuals in gaining confidence and a sense of achievement from learning and mastering new skills, thereby further boosting self-efficacy[73].

Secondly, the enhancement of self-efficacy lays a solid foundation for the improvement of health literacy among older adults. On one hand, the internet reduces information asymmetry and broadens access to various types of information. It enables older adults to learn about fitness and health knowledge online, significantly improving their health literacy and, consequently, their health levels[74]. On the other hand, within the HBM, self-efficacy plays a crucial role in influencing behavior. It empowers older adults to believe that they can improve their health through a series of actions, encouraging them to actively learn health knowledge, enhance health literacy, and attempt health behavior changes. As self-efficacy

increases, older adults become more proactive in engaging in health-related social activities and adopting healthier lifestyles, behaviors that contribute to the enhancement of health literacy[50].

Thirdly, the improvement of health literacy can further enhance the physical exercise of older adults, thereby promoting overall health improvements. Existing research confirms the positive role of the internet in enhancing physical exercise. Older adults can watch sports broadcasts, share exercise experiences, and participate in online sports communities, gaining a wealth of sports-related information and knowledge[75]. This information aids in the formulation of exercise plans[76] and the enhancement of exercise awareness[77], thereby encouraging participation in physical activities. Additionally, the increase in cognitive abilities paves the way for behavioral change. Enhanced health literacy strengthens the ability to seek and understand health information, facilitating the decision-making process for engaging in physical exercise[78].However, the chain mediating role of "self-efficacy→physical exercise" between internet use and self-rated health was not observed among older adults.

Fourthly, education level moderates the mediating effects of internet use on the self-rated health of older adults. Internet use impacts the physical and mental health of older adults through the mediating roles of self-efficacy, health literacy, and physical exercise, with the first part of these mediating paths moderated by educational level. Education level adjusts the mediating effects of multiple indirect paths in the association between internet use and self-rated health among older adults. Education level can influence literacy, cognitive levels, flexibility in searching for information, and technology acceptance[79], enabling older adults with higher education to more readily grasp internet-related knowledge and skills, thereby enhancing their self-efficacy. They are more likely to find suitable health resources and support services online, such as fitness classes and nutritional advice, helping to form and maintain healthy behaviors. Furthermore, individuals with higher education levels are more likely to engage in online health interventions, which benefits their self-efficacy and physical exercise[80]. Additionally, those with higher education often have greater autonomy and control, indicating a strong and stable self-efficacy[11], and they may be more proactive in using internet resources to understand and change unhealthy habits, fostering a healthy lifestyle.

Finally, this study offers suggestions from dimensions such as internet use and self-efficacy to enhance the health of older adults in the digital age: (1) To enhance internet use among older adults, policies should be developed to encourage internet companies to create age-appropriate internet products, such as fitness applications tailored for older adults. Additionally, internet education and training for older adults should be strengthened, with community-level internet training courses organized and community workers and family members encouraged to guide older adults in using the internet. (2) Enhance older adults' connection with society by encouraging participation in volunteer services, to boost their sense of self-efficacy through task completion. (3) Strengthening health education can improve the health literacy of older adults. Encourage medical institutions or family doctor teams to provide professional health education services, and popularize health knowledge for older adults through lectures, videos, and other ways. (4) It is suggested to use mobile applications to establish online exercise communities at the community level, creating an elderly friendly and supportive social environment that promotes physical exercise, thereby motivating older adults to engage more actively in physical exercise.

Limitations and Future Research

This study also has its limitations, necessitating improvements in future research. Firstly, it utilized only the cross-sectional data from the 2021 PBICR survey, precluding complete inference of causal relationships between variables. Secondly, the outcome variable was based on self-rated health, introducing the potential for reporting biases and affecting the accuracy and reliability of the data collected. Subsequent research should further investigate the mechanisms affecting the physical and mental health of participants. Thirdly, this study focused solely on the mediating effects of self-efficacy, health literacy, and physical exercise. The relationship between internet use and self-rated health may involve other mediators, such as social capital, which future studies will aim to explore more broadly.

Conclusion

This paper uses the 2021 PBICR data, based on media effects theory and the HBM. Through multiple linear regression and Bootstrap tests, it verifies the correlation between internet use and self-rated health among older adults. The study indicates that internet use can impact the health of older adults through individual and chained mediating effects of self-efficacy, health literacy, and physical exercise, with education level moderating several mediating paths. The research holds theoretical and practical value for exploring positive aging from the perspective of internet use. Firstly, it offers a new research perspective for proactive aging and the construction of digital elderly care systems. Secondly, previous studies most have only discussed individual mediating effects, neglecting the chained impact of multiple mediators. Moreover, the study considers the moderating role of education level on mediating paths, providing a new perspective for understanding the influence of cultural capital on health. Finally, the paper proposes recommendations to promote internet use among older adults from both macro-social and micro-individual levels, offering practical support for improving the health status of older adults in the digital era.

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Data Availability

The Psychology and Behavior Investigation of Chinese Residents (PBICR) is an open-access, large-sample, nationwide representative study. It regularly collects high-quality microdata from representative Chinese populations, including the general population, special groups, and patients with specific diseases, in order to analyze psychological and behavioral issues among Chinese residents. The study currently provides access to data from 2020 and 2021, which can be requested through the PBICR website [81].

Authors' Contributions

CYM and WZL contributed to the study's conception and design. WZL contributed to data cleaning, data analysis, and the drafting of the paper; CYM focused on revising and enhancing the paper; XQL and ZWS collaborated on revising the manuscript and formatting it.

Conflicts of Interest

None declared.

Multimedia Appendix 1

Selected Questionnaire Questions from PBICR 2021.

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Abbreviations

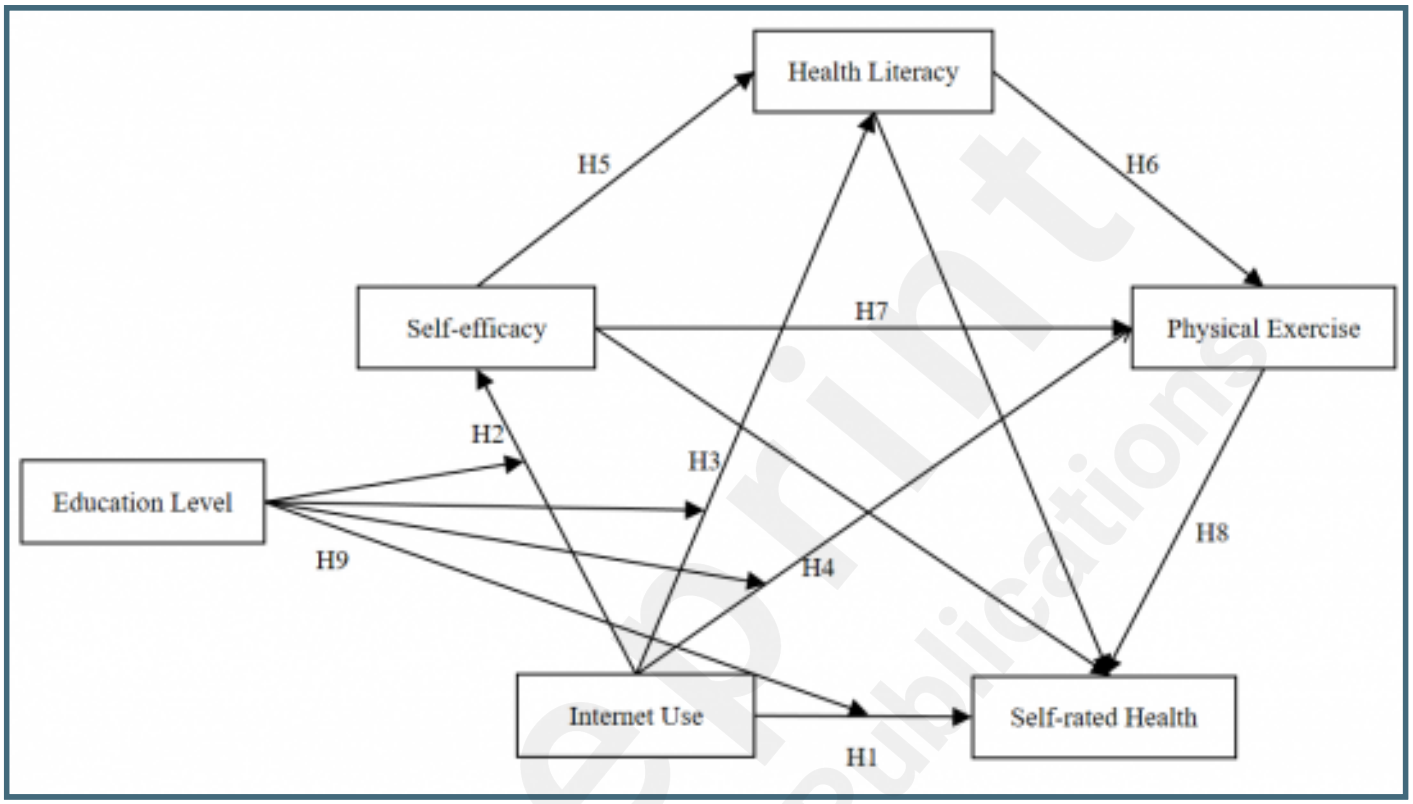
PBICR: Psychology and Behavior Investigation of Chinese Residents

HBM: Health Belief Model
ICT: Information and Communication Technology
CHARLS: China Health and Retirement Longitudinal Study
NGSES: New General Self-Efficacy Scale
HLS-SF12: 12-item Short-Form Health Literacy Questionnaire
HL index: health literacy index
CI: confidence interval
VIF: variance inflation factor

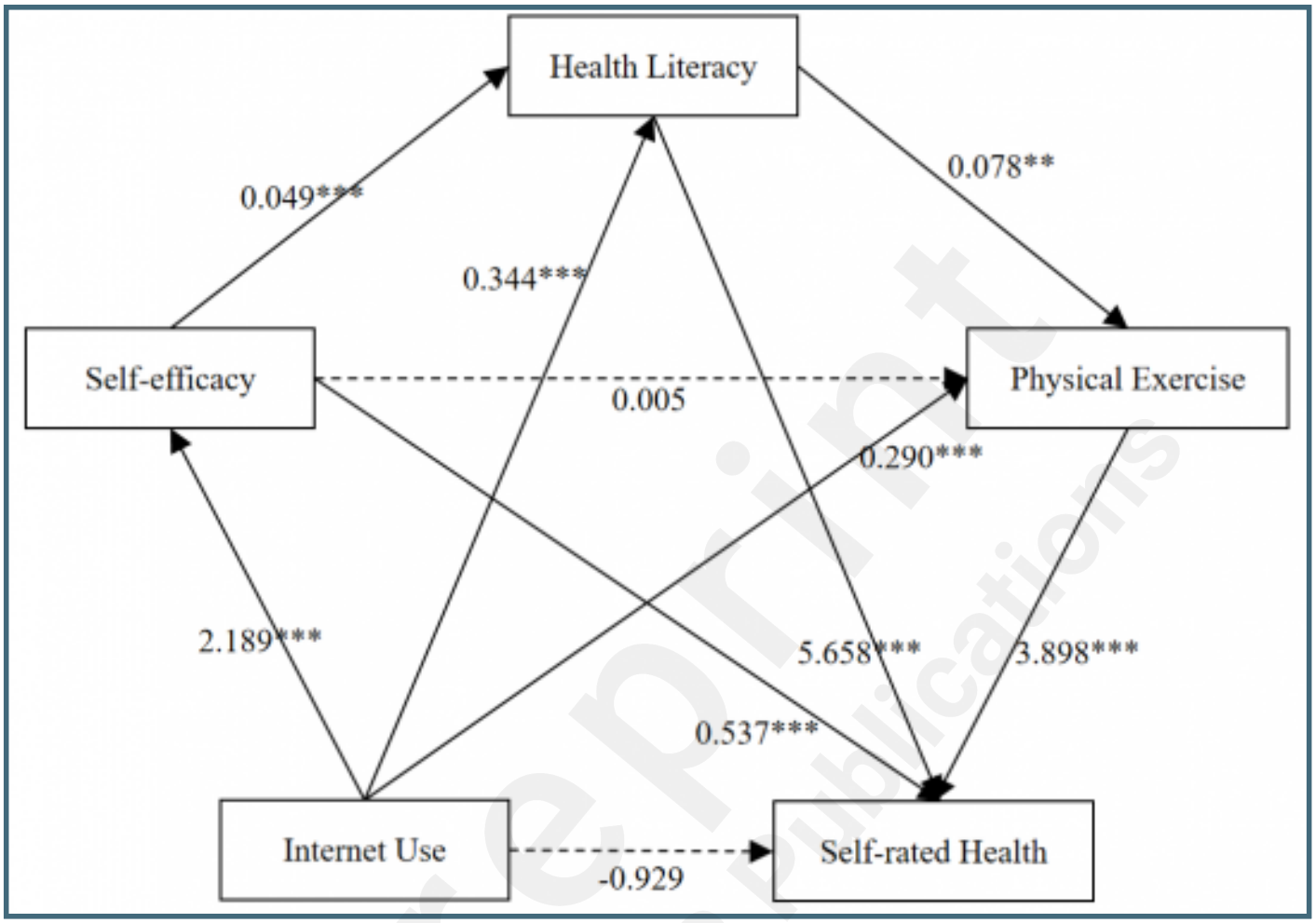
Supplementary Files

Figures

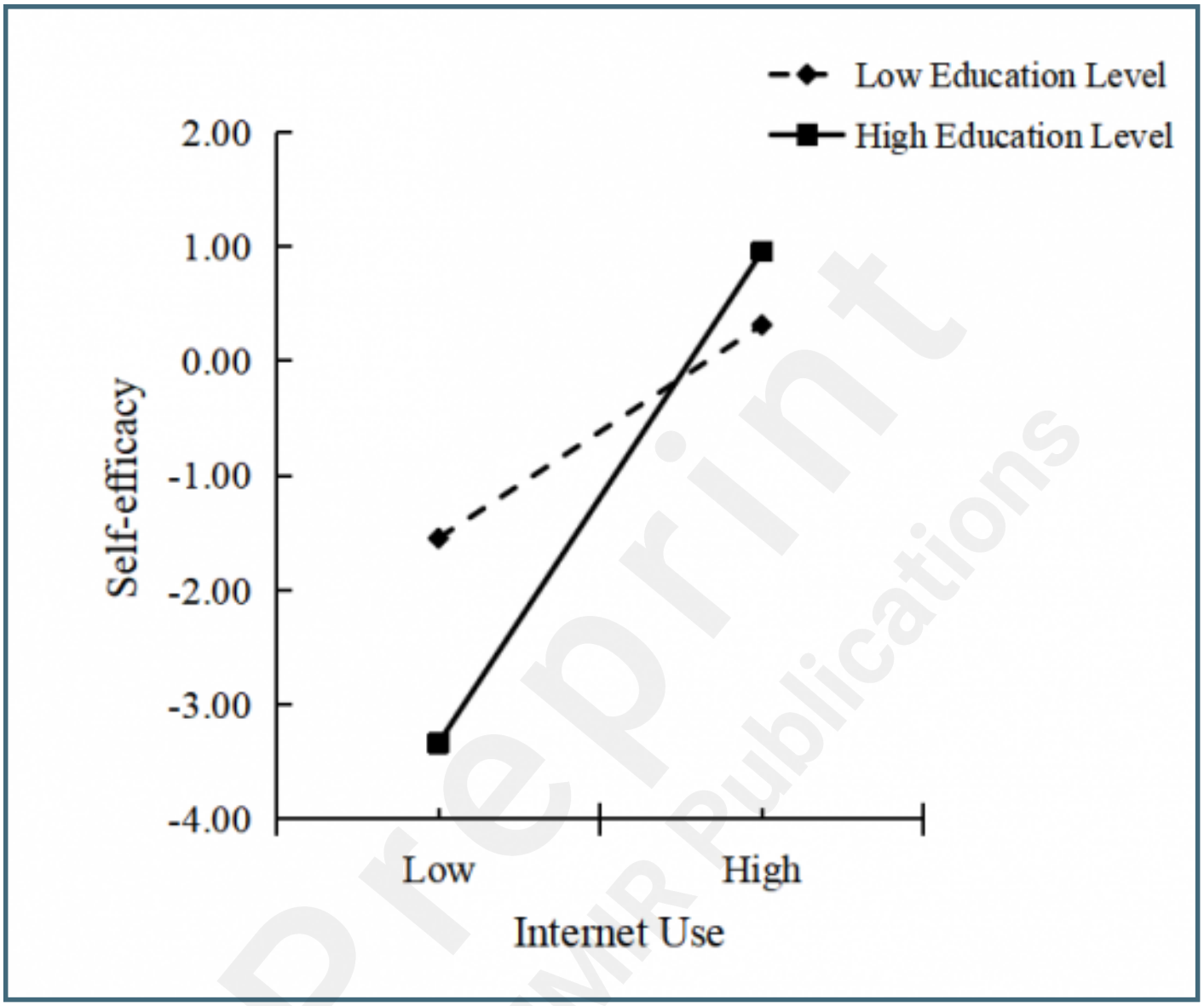
Hypothesis model. H: hypothesis. H1?Internet Use?Self-rated Health; H2?Internet Use?Self-efficacy?Self-rated Health; H3?Internet Use?Health Literacy?Self-rated Health; H4?Internet Use?Physical Exercise?Self-rated Health; H5?Internet Use?Self-efficacy?Health Literacy?Self-rated Health; H6?Internet Use?Self-efficacy?Physical Exercise?Self-rated Health; H7?Internet Use?Health Literacy?Physical Exercise?Self-rated Health; H8?Internet Use?Self-efficacy?Health Literacy?Physical Exercise?Self-rated Health; H9?Adjustment of Education Level :“Internet Use?Self-rated Health”.



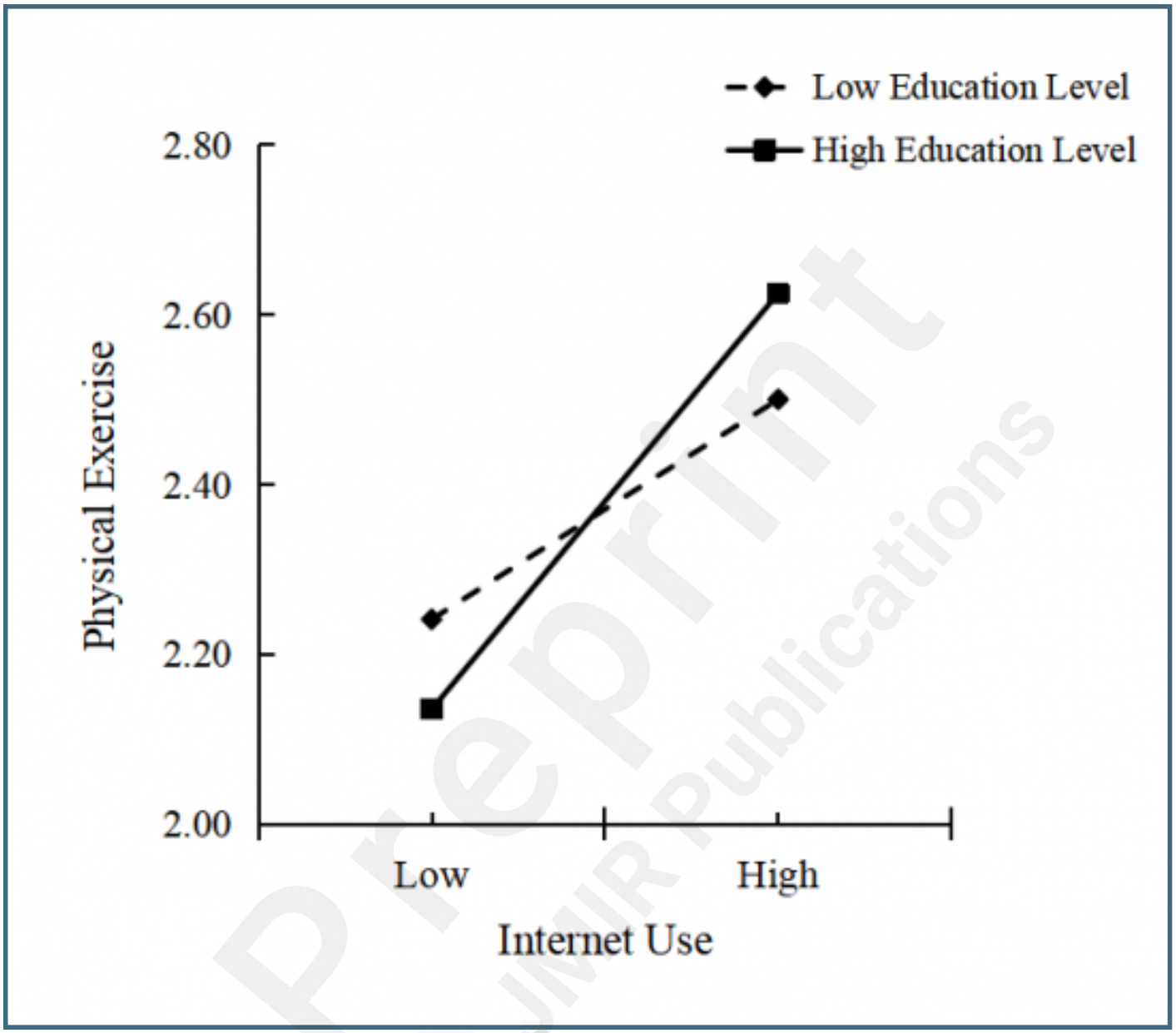
Chain mediation analysis of the association between internet use and self-rated health.*** P < .001; ** P < .01; * P < .05; + P < .1.



Education level as a moderator in the relationship between internet use and self-efficacy.



Education level as a moderator in the relationship between internet use and physical exercise.



Multimedia Appendixes

Selected Questionnaire Questions from PBICR 2021.
URL: http://asset.jmir.pub/assets/9477196af0e287df1f1d68208f66c2a1.doc