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The mediation effect of social participation in the relationship between Internet use and health behaviors among middle-aged and older individuals

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Abstract

Objectives: The increasing popularity and influence of the Internet in modern society have greatly impacted individuals' lives. This population-based study elucidated the dynamic linkage between Internet use (IU) and health behaviors (HBs), particularly emphasizing the intermediary function of social participation (SP) in middle-aged and older adults (MOA) in China.

Methods: Data were obtained from the China Health and Retirement Longitudinal Study in 2020. This study employed binary logistic regression to investigate the influence of IU on the HBs of MOA in China. Additionally, binary logistic and multiple linear regressions were used to test whether SP regulates the relationship between IU and HBs (i.e. nonsmoking, non-drinking, physical activity, and physical examination). Furthermore, the Karlson-Holm-Breen method was employed to assess the mediating role of SP.

Results: IU had a positive effect on nonsmoking (OR: 1.113, $p < 0.05$), physical activity (OR: 1.775, $p < 0.001$), and physical examination (OR: 1.226, $p < 0.001$). However, this study revealed that IU had a significant negative effect on non-drinking (OR: 0.775, $p < 0.001$). Moreover, the mediating effect analysis demonstrated that SP played a mediating role in the relationship between IU and the HBs.

Conclusion: Active engagement in social activities is an effective method for enhancing the positive impact of IU on the adoption of physical activity and physical examinations. In order to meet individuals' needs, it is essential to design and promote Internet health services and social activities tailored to their age group and cultural background. Furthermore, greater efforts should be employed to implement public policy initiatives aimed at providing care for MOA.

Keywords

Internet use, health behaviors, social participation, middle-aged and older adults, mediation effect

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Introduction

As the global demographic structure changes, the aging population has demonstrated an obvious growth trend. Globally, the proportion of individuals aged 60 and older will reach 1.4 billion by 2030.[1] By the end of 2030, the number of older adults in China is estimated to exceed 345 million.[2] Consequently, aging has emerged as a global health priority, necessitating comprehensive strategies to mitigate its associated complications. For a long time, the Chinese government has prioritized aging-related health concerns as a major strategic goal.[3] The measure to achieve this goal is to provide better services to the older adult

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population to improve their sense of contentment, security, and happiness. However, due to the increasing aging population, China continues to face rising healthcare costs, pension strains, and public service demands.[4,5]

Common issues associated with aging include hypofunction and cognitive decline.[6] Previous studies have identified health behaviors (HBs) as a crucial determinant of health status among middle-aged and older adults (MOA). HBs, such as smoking abstinence, avoiding excessive drinking, engaging in moderate physical exercise, and participating in regular physical examinations, can significantly reduce the number of multiple chronic diseases and improve the health of MOA.[7–9] In addition, existing literature suggests that HBs play a key role in enabling people to gain, maintain, or improve control over their health.[10] Therefore, HBs should be considered to improve the overall health of MOA.

By June 2021, the proportion of China's netizens had reached 1.011 billion, and the percentage of individuals aged 50 years and above rose from 26.3% in December 2020 to 28.1% by June 2021.[11] As the Internet penetration rate soars, the breadth of Internet utilization among MOA progressively widens. However, acknowledging the prevalent notion that information and communication technologies (ICTs) pose greater learning hurdles for older individuals,[12] it is necessary to focus on the effects of Internet use (IU) on the health of MOA.

According to healthy lifestyle theory, living a healthy lifestyle is influenced by a person's social environment.[13] Social participation (SP) represents a pivotal avenue for older adults to access the community, fostering interpersonal exchanges and sustaining vital social ties.[14] Studies have demonstrated that SP is a key factor affecting the physical and mental health of MOA.[15–17] Additionally, it is an essential part of a healthy aging strategy because it enhances social connections and reduces social isolation and loneliness.[18] Therefore, examining the health effects of SP among MOA is warranted. Hence, a meticulous examination of the health ramifications associated with social engagement among MOA is justified. This study explored the influence of IU on the HBs of MOA and analyzed the mediating effect mechanism of SP.

Literature review

Effect of Internet usage on health behavior

Many scholars have studied the influence of IU on HBs and have consistently found that Internet access facilitates health knowledge acquisition, thereby enhancing an individual's capacity for effective self-management. Specifically, Neter et al. reported that IU was prospectively associated with knowledge and preventive behaviors related to Alzheimer's disease.[19] Nam et al. focused on older couples' HBs and found that IU was related to a higher likelihood of receiving a flu shot among wives and prostate examinations for husbands.[20] Kalichman demonstrated that IU of people living with HIV/AIDS significantly improved knowledge of HIV disease and confidence in their ability to adhere to medication.[21] Li et al. pointed out that IU has a positive impact on the self-treatment of common diseases.[22] Lee et al. found that Hispanics who actively sought health-related information online demonstrated a higher propensity for increased consumption of fruits and vegetables and greater engagement in physical activities.[23] Luo et al. showed that watching short videos enhanced the frequency of exercise among older adults.[24] De Santis et al. proved that the utilization of health apps for physical activity promotion has increased significantly.[25] Turan et al. found that the emergence of online appointment registration services, telemedicine, and online consultations enables people to enjoy medical services.[26] However, IU has also exhibited a pronounced detrimental influence on individuals' lives, underscoring the dual-edged nature of this technological advancement, such as poor sleep quality,[27] social isolation,[28] and health deterioration due to addiction.[29] For example, Zhou et al. summarized that the use of Internet may cause irregular rest.[30] Oksanen et al. used a nationwide sample of Finnish workers and found that social media use increased the risk of drinking.[31] Duplaga similarly found that Polish older adults who use the Internet a few times a week were associated with more frequent alcohol consumption and less fruit and vegetables than nonusers.[32] Wang et al. found that IU frequency increased the probability of smoking in young Chinese adults.[33] Finally, Li et al. found that using the Internet reduced the duration and frequency of physical exercise among Chinese rural residents aged 40 and above.[34] Guo et al. revealed that "playing games" via the Internet had no impact on physical exercise.[3]

The mediating role of social participation

Maslow's hierarchy of needs theory emphasizes that people have social needs.[35] SP plays an important role in reducing loneliness, meeting social needs, and improving the health of MOA,[36] and emerges as an efficacious strategy for middle-aged and older individuals to bridge the gap into society, fostering interpersonal interactions, maintaining social connections, and promoting active and healthy aging.[15] Previous research has demonstrated that older adults are more likely to participate in social activities if they use the Internet.[37,38] This indicates that in the digital era, the Internet can overcome the limitations of time and space and affect individuals' SP.[14,37]

Moreover, researchers regard SP as a research topic and analyze the relationship between SP and HBs. For instance, using a survey of the adult population in Finland, Nieminen et al. reported that SP was associated with HBs.[39] Wang et al. demonstrated that SP could promote Chinese MOA to do physical exercise and participate in physical

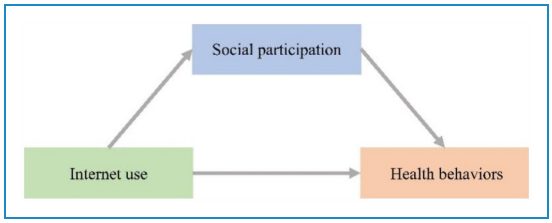

Figure 1. Logic framework diagram.

examinations.[40] These studies demonstrate that SP is an important part of healthy aging, prompting MOA to become healthy.

Meanwhile, some scholars have explored whether SP plays an intermediary role between IU and HBs. A study on older adults in China found that SP may facilitate the utilization of medical services when using the Internet.[41] Chinese researchers also found that social support through the Internet contributed to smoking cessation.[42] Nevertheless, another study revealed that IU occupied the leisure time of rural residents, thereby reducing their physical exercise.[34]

Although some studies have investigated the effects of IU on HBs, few have explored how SP mediates the relationship between IU and HBs among MOA. Based on the China Health and Retirement Longitudinal Study (CHARLS), this study not only analyzed the relationship between IU and HBs of MOA in China but also analyzed the mediating effects of SP on the association between IU and HBs (Figure 1). Using data from the 2020 CHARLS could be beneficial for reflecting on the impact of the Internet because, after the COVID-19 pandemic, individuals' IU has become more frequent.[43] Additionally, such an analysis may allow a more nuanced understanding of the relationship between IU and HBs and provide a realistic basis for better guidance on IU to improve the quality of life of MOA.

Methods

Data source and sample

The data used in this study were obtained from the CHARLS, which is a nationally representative survey. As a national stratified probability survey, CHARLS covers 450 villages across 28 provinces, including municipalities and autonomous regions. The CHARLS aims to collect a set of microdata representing households and individuals aged 45 years and above in China. Information on demographic characteristics, health status and functioning, and healthcare and insurance was collected. All interviewees signed an informed consent form. This study utilized the 2020 CHARLS data, the latest dataset available, which time duration from July to August 2020. The nature of this study is a nationwide, cross-sectional study. Based on the research objectives, this study retained survey responses from adults aged 45 and older and eliminated those with missing values, resulting in a final sample of 17,248 individuals. The detailed study population screening process is illustrated in Figure 2.

Variables

Dependent variable. According to the previous studies,[40,44,45] HBs were assessed using questions from the questionnaire, including the following four specific dimensions:

In terms of smoking status, the question selected was, "Do you still smoke, or have you quit smoking?" The options were "still smokes," "quit," and "never smoked," with "still smokes" recorded as "smoking." Meanwhile, "quit" and "never smoked" were combined and recorded as "nonsmoking."[40]

For alcohol consumption, we chose the question, "Did you drink any alcoholic beverages, such as beer, wine, or liquor in the past year?" The response options were "drink more than once a month" and "drink but less than once a month," which were combined into the "drinking" group. "None of these" was redefined as "non-drinking."[46]

For physical activity behavior, we selected three questions: "Do you usually do vigorous exercise for at least 10 min continuously per week," "Do you usually do moderate exercise for at least 10 min per week," "Do you usually do light exercise for at least 10 min per week?" These options were combined and respondents who participated in any activity were recorded as 1. Respondents who did not engage in any activities were recorded as having a 0.[40]

Regarding physical examination, we chose the question, "When was the last time you had a routine medical examination since your last visit?" According to the self-reported participation frequency, participants who participated a physical examination in the past two years were classified as positive cases (code 1), while non-participants constituted the reference group (coded 0).[40]

Independent variable. IU was elicited by asking respondents to answer the following question: "Have you used the Internet in the last month, including to chat, watch the news, watch videos, play games, for financial management, and others." We redefined "no" as "non-Internet use" and assigned a value of 0, and "yes" was redefined as "Internet use" and assigned a value of 1.[22]

Mediator variable. SP was the mediating variable in this study. Participants were asked whether they had engaged in eight different activities during the previous period, such as interacting with friends, playing Mahjong, and participating in a community-related organization. If an individual participated in an activity, it was recorded as 1; nonparticipation was recorded as 0. The total score ranges from 0 to 8 points. The higher the level of social activity, the higher the level of SP.

Covariates. Based on the contextual and individual characteristics of the Andersen model,[44,47] we included eight

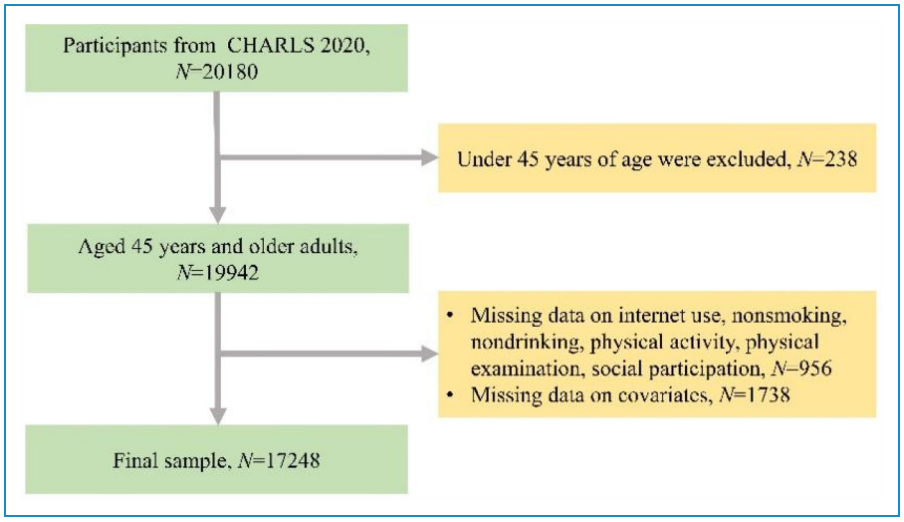

Figure 2. Flowchart of participants inclusion.

covariates. The individual predisposing variables encompassed age, gender, marital status,[48] education level,[49] and residence.47 The enabling variable was health insurance.[2] The need variables were represented by self-reported health status, which was measured by the question, "Would you say your health is very good, good, fair, poor, or very poor?" The results were combined "very good" and "good" into the group of "good," and "very poor" and "poor" into the group of "poor." Diagnosis of a chronic disease[50] also consisted of the need variable and was represented by the answer to "Have you been diagnosed with conditions listed below by a doctor?" The 2020 CHARLS asked about 15 types of chronic diseases, including hypertension and dyslipidemia, as diagnosed by doctors. Table 1 gives a detailed explanation of the assignment of each covariant.

Statistical analysis

Data analysis included five main steps. First, descriptive analyses were conducted to describe the characteristics of the participants through the mean (standard deviation [SD]) for continuous variables and percentages for categorical variables. Second, as the dependent variable was dichotomous, we used binary logistic regression to analyze the correlation between IU and HBs, including nonsmoking, non-drinking, physical activity, and physical examination. Third, to examine whether SP mediated the association between IU and HBs, we applied binary logistic regression and multiple linear regression. The primary regression models were as follows:

$$\boldsymbol{Y} = \boldsymbol{\alpha_i} + \boldsymbol{\beta_i X} + \boldsymbol{\delta_i C} + \boldsymbol{\varepsilon} \quad (1)$$

$$\boldsymbol{Y} = \boldsymbol{\alpha_j} + \boldsymbol{\beta_j X} + \boldsymbol{\gamma_j M} + \boldsymbol{\delta_j C} + \boldsymbol{\varepsilon} \quad (2)$$

where Y is the dependent variable representing nonsmoking, non-drinking, physical examination, and SP. X represents IU, M represents SP, and C represents the control variables. The constant terms and coefficients of the independent variables and control variables before the addition of mediating variables are denoted as α_i, β_i, and δ_i, respectively (see equation (1)). α_j, β_j, γ_j, and δ_j represent the coefficients of the constant term, independent variable, mediator variable, and control variable, respectively, after mediating (see equation (2)). ε is the error term. The multicollinearity test was checked by using the correlation coefficients and the variance inflation factor (VIF) between variables. Upon analyzing correlation and VIF, we found that the variables correlate weakly with each other (see Table S1). In addition, since all VIFs are less than 10, they share no clear multicollinearity (see Table S2). Extreme outliers were checked using box plots.

Fourth, the Karlson-Holm-Breen (KHB) method was used to evaluate mediating effects.[51] Finally, there may be an endogeneity problem with the influence of IU on HBs among middle-aged and older individuals. As the choice to use the Internet is their own, this selection is non-random and is influenced by other factors, which may lead to self-selection bias. Therefore, this study used propensity score matching (PSM) to examine the effects of IU.[52] All analyses were performed using Stata version 17 (StataCorp., College Station, TX, USA), and a p-value < 0.05 was considered statistically significant.

Results

Participants characteristics

Table 2 illustrates the descriptive statistics, including a total of 17,248 respondents. The average age was 61.32 years old, and the majority were females (53.08%) and spouses (84.78%). Notably, 42.49% of respondents lacked formal education, lived in rural areas (60.67%), had health insurance (95.51%), or had chronic diseases (80.97%). Nearly

Table 1. Coding of variables.

Variables	Coding
Internet use	1 for use, 0 for no use
Nonsmoking	1 for yes, 0 for no
Non-drinking	1 for yes, 0 for no
Physical activity	1 for participation, 0 for non-participation
Physical examination	1 for yes, 0 for no
Social participation	Levels of social participation (score ranges from 0 to 8), with higher scores representing greater social participation
Gender	1 for male, 0 for female
Age	Respondent's age
Marital status	The value of with a spouse is 1, and the value of without a spouse is 0
Education level	1 for no formal education, 2 for elementary school, 3 for Junior high school, 4 for Senior high school and above
Health insurance	1 for yes, 0 for no insurance
Residence	1 for rural, 0 for urban
Self-reported health status	1 for poor, 2 for fair, 3 for good
Chronic diseases	1 for the presence of chronic diseases, 0 for the absence of chronic diseases

25% of the individuals identified their health condition as poor, whereas 24.61% reported good health status.

Additionally, the number of people using the Internet was 7133 (41.36%), with an average age of 56.29 years. Of these, 3519 (49.33%) were female, 6530 (91.55%) were married, 1473 (20.25%) had no formal education, and approximately 50% lived in rural areas. Only 2.76% of participants who used the Internet were uninsured, 19.07% rated their health status as poor, and most (78.20%) did not have a chronic disease.

Results of binary logistics regression analysis

The regression results are illustrated in Table 3 and indicate that IU is related to the HBs of MOA in China. After controlling the variables, Models 1, 3, and 4 demonstrated that IU was associated with nonsmoking (OR: 1.113, $p < 0.05$), physical activity (OR: 1.775, $p < 0.001$), and physical examination (OR: 1.226, $p < 0.001$). However, as seen in Model 2, after controlling for other variables, there was a significant negative correlation between IU and not drinking (OR: 0.712, $p < 0.001$).

Analysis of the mediating effect

We used multiple linear regression analyses to examine whether SP mediates the association between IU and HBs. The relationships between the dependent and mediating variables were analyzed using binary logistic regression. Before controlling for mediating variables, IU was significantly associated with HBs, as illustrated in Table 3. Model 9 (Table 4) also illustrates that IU was significantly correlated with SP.

We verified the mediating effect of SP again using the KHB method. In terms of nonsmoking, the total, direct, and indirect effects are 0.108, 0.147, and −0.038, respectively, and the estimation results are significant in Table 5. The mediating effects of SP were significant for the dependent variable.

PSM analysis of internet usage and health behavior

Table 6 reports that after controlling for the heterogeneity of samples between the two groups, the effects of IU on nonsmoking, non-drinking, physical activity, and physical examination were still significant.

To ensure the reliability of the estimated results, a balance test was illustrated in Table 7. After matching, the SD of all covariates was < 5%. The differences between the control and treatment groups were not significant after matching. This indicates that PSM significantly reduced the difference by passing the balance test.

Discussion

Propagating health knowledge via the Internet helps cultivate health consciousness and HBs among MOA. HBs have significant implications for quality of life. This reflects the importance of active aging strategies in China. Based on a national sample of Chinese MOA from the 2020 CHARLS dataset, this study examined the mechanism by which IU significantly affects HBs, including non-drinking, nonsmoking, physical activities, and physical examination. This study further explored the mediating role of SP.

Internet usage and health behavior

Our findings confirmed that IU positively influenced nonsmoking, consistent with previous studies. For example, Peng and Chan demonstrated that IU influences smoking

Table 2. Descriptive statistics of the sample.

Variables	Total sample ($N = 17248$)	Internet use ($N = 7133$)	Non-Internet use ($N = 10115$)
Nonsmoking, *N* (%)			
Yes	12798 (74.20)	5198 (72.87)	7600 (75.14)
No	4450 (25.80)	1935 (27.13)	2515 (24.86)
Non-drinking, *N* (%)			
Yes	10926 (63.56)	3933 (55.14)	7029 (69.49)
No	6286 (36.44)	3200 (44.86)	3086 (30.51)
Physical activity, N (%)			
Yes	15543 (90.11)	6770 (94.91)	8773 (86.73)
No	1705 (9.89)	363 (5.09)	1342 (13.27)
Physical examination, *N* (%)			
Yes	7785 (45.14)	3140 (44.02)	4645 (45.92)
No	9463 (54.86)	3993 (55.98)	5470 (54.08)
Social participation, mean (SD)	0.80 (1.03)	1.12 (1.20)	0.58 (0.82)
Gender, *N* (%)			
Male	8092 (46.92)	3614 (50.67)	4478 (44.27)
Female	9156 (53.08)	3519 (49.33)	5637 (55.73)
Age, mean (SD)	61.32 (9.33)	56.29 (7.25)	64.86 (9.00)
Marital status, *N* (%)			
With a spouse	14623 (84.78)	6530 (91.55)	8093 (80.01)
Without a spouse	2625 (15.22)	603 (8.45)	2022 (19.99)
Education level, *N* (%)			
No formal education	7328 (42.49)	1473 (20.25)	5855 (57.88)
Elementary school	3835 (22.23)	1569 (22.00)	2266 (22.40)
Junior high school	3878 (22.48)	2401 (33.66)	1477 (14.60)
Senior high school and above	2207 (12.80)	1690 (23.69)	517 (5.11)
Residence, *N* (%)			
Rural	10464 (60.67)	3615 (50.68)	6849 (67.71)
Urban	6784 (39.33)	3518 (49.32)	3266 (32.29)

(continued)

Table 2. Continued.

Variables	Total sample (*N* = 17248)	Internet use (*N* = 7133)	Non-Internet use (*N* = 10115)
Health insurance, *N* (%)			
Yes	16474 (95.51)	6936 (97.24)	9538 (94.30)
No	447 (4.49)	197 (2.76)	577 (5.70)
Self-reported health status, *N* (%)			
Poor	4311 (24.99)	1360 (19.07)	2951 (29.17)
Fair	8692 (50.39)	3777 (52.95)	4915 (48.59)
Good	4245 (24.61)	1996 (27.98)	2249 (22.23)
Chronic diseases, *N* (%)			
Yes	13966 (80.97)	5578 (78.20)	8388 (82.93)
No	3282 (19.03)	1555 (21.80)	1777 (17.07)

abstinence.[53] Liu et al. identified the Broadband China Policy as having a negative correlation with smoking behavior and smoking amount.[54] Nevertheless, Cui et al. observed overuse of the Internet in MOA impaired physiological functions, reducing energy reserves and hindering HB adoption.[55] However, there are several reasons for these contrasting findings. First, IU facilitates health knowledge dissemination through digital platforms, aligning with the Knowledge-Attitude-Practice (KAP) framework's behavioral modification principles. Second, researchers have found that greater advertising exposure is associated with a higher likelihood of cigarette use. However, according to the "Administrative Measures for Internet Advertising,"[56] China has banned online cigarette advertisements. Therefore, people in China are unlikely to be influenced by tobacco advertisements when using the Internet. Third, China has stipulated that it is not permitted to buy tobacco through the Internet, based on the "Regulation on the Implementation of the Law of the People's Republic of China on Tobacco Monopoly"[57] and the "Tobacco Monopoly Licensing Management Regulations."[56]

This study revealed that IU significantly and negatively affected non-drinking, consistent with previous findings. Finnish research found a positive correlation between participating in social media and the risk of alcohol consumption.[31] Parallel findings emerged from Belgium's alcohol-tolerant context, where alcohol exposure frequency on social media predicts self-identification as alcohol consumers.[58] There are several possible explanations for this. First, there is conflicting evidence regarding low-moderate alcohol consumption's health impacts despite established risks.[59–61] Amid varying levels of health literacy, this may result in some people choosing to consume alcohol. Furthermore, as people's health literacy varies, they may not know whether the health information they are exposed to is of good quality.[62] In addition, contrasting with tobacco restrictions, older adults encounter unimpeded online alcohol marketing and purchasing channels. Additionally, this study found that MOA who use the Internet are more inclined to engage in physical activity, which is consistent with other studies. Guo et al. reported that "watching news," "chatting," and "watching videos" via the Internet were positively related to physical activity.[3] Wang et al. revealed that the effect of IU intensity influenced physical activity among older adults.[33] As presented on WeChat, Tik Tok or YouTube, home workouts and instructional videos by social media fitness influencers are free, easy to access online, and often do not require any equipment. This can motivate IUs to engage with this type of physical activity.[63] However, by contrast, Li et al. found that IU significantly reduced the duration and frequency of physical exercise among rural residents aged 40 and above.[34]

In addition, IU was significantly and positively associated with physical examinations, aligning with existing studies. For example, Nakagomi et al. highlighted the role of the Internet in promoting health screening.[64] Xavier et al. also reported that IU contributed to participation in a cancer screening program.[65] In other words, IU has a positive impact on physical activity and physical examinations. A possible reason for this may be that information on the Internet is more abundant, which helps older adults enrich their lives. Thus, MOA can obtain exercise guidance and

Table 3. Binary logistics regression results for the Internet use and health behaviors.

Variables	Model 1 nonsmoking OR (95%CI)	Model 2 non-drinking OR (95%CI)	Model 3 physical activity OR (95%CI)	Model 4 physical examination OR (95%CI)
Internet use	1.113* (1.008, 1.229)	0.712*** (0.654, 0.775)	1.775*** (1.542, 2.043)	1.226*** (1.135, 1.324)
Gender	0.035*** (0.031, 0.039)	0.143*** (0.132, 0.154)	0.921 (0.826, 1.028)	0.890*** (0.833, 0.950)
Age	1.023*** (1.017, 1.028)	1.020*** (1.016, 1.025)	0.979*** (0.973, 0.985)	1.049*** (1.045, 1.053)
Marital status	1.431*** (1.254, 1.632)	1.104 (0.990, 1.230)	1.360*** (1.193, 1.551)	1.201*** (1.096, 1.316)
Education level (ref.= no formal education)				
Elementary school	1.186** (1.061, 1.327)	1.047 (0.952, 1.152)	1.279*** (1.116, 1.465)	1.086 (0.998, 1.181)
Junior high school	1.178** (1.049, 1.321)	0.890* (0.806, 0.982)	1.365*** (1.168, 1.597)	1.088 (0.994, 1.190)
Senior high school and above	1.593*** (1.384, 1.832)	0.806** (0.714, 0.910)	1.834*** (1.458, 2.307)	1.464*** (1.310, 1.637)
Residence	0.924 (0.847, 1.008)	1.097* (1.017, 1.183)	0.782*** (0.697, 0.877)	0.796*** (0.745, 0.850)
Health insurance	1.220 (0.991, 1.503)	1.044 (0.876, 1.245)	1.653*** (1.360, 2.010)	1.474*** (1.263, 1.721)
Self-reported health status (ref.= poor)				
Fair	0.796*** (0.716, 0.885)	0.619*** (0.565, 0.677)	1.574*** (1.397, 1.774)	0.950 (0.880, 1.025)
Good	0.904 (0.798, 1.023)	0.577*** (0.518, 0.642)	1.400*** (1.209, 1.622)	1.025 (0.934, 1.124)
Chronic diseases	1.360*** (1.223, 1.513)	1.049 (0.957, 1.150)	1.222** (1.062, 1.405)	1.556*** (1.428, 1.695)
Constant	3.231*** (2.067, 5.051)	2.100*** (1.434, 3.076)	9.328*** (5.551, 15.675)	0.019*** (0.013, 0.027)

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

medical checkup information through IU, strengthening their motivation to engage in health-related activities.

Social participation as a mediating role

In this study, we found that SP negatively mediated the link between IU and nonsmoking, indicating a masking mechanism. Smoking often accompanies the gathering of people with friends and colleagues, which is seen as a way of relaxing and socializing. For example, many middle-aged Japanese men may smoke in social contexts to gain peer acceptance and social connections.[66] Offering and sharing cigarettes, is considered as a good way to make friends.[67] Based on these considerations, refusing a cigarette that another person offers can be seen as impolite and not conforming to social norms.[68] Another study found that, among previous and current smokers who had attempted to quit smoking, 90% reported that their friends had tried to

Table 4. Mediating effect regression results.

Variables	Model 5 Nonsmoking OR (95%CI)	Model 6 Non-drinking OR (95%CI)	Model 7 Physical activity OR (95%CI)	Model 8 Physical examination OR (95%CI)	Model 9 Social participation Coefficients (SE)
Internet use	1.158**	0.768***	1.547***	1.147**	0.371***
	(1.047, 1.280)	(0.704, 0.837)	(1.343, 1.783)	(1.061, 1.240)	(0.018)
Social participation	0.902***	0.815***	1.671***	1.197***	
	(0.867, 0.940)	(0.786, 0.844)	(1.550, 1.802)	(1.159, 1.235)	
Gender	0.035***	0.139***	0.934	0.892**	−0.020
	(0.031, 0.039)	(0.129, 0.151)	(0.836, 1.042)	(0.835, 0.953)	(0.016)
Age	1.022***	1.019***	0.980***	1.050***	−0.005***
	(1.017, 1.027)	(1.015, 1.024)	(0.974, 0.986)	(1.046, 1.054)	(0.001)
Marital status	1.425***	1.096	1.388***	1.210***	−0.031
	(1.249, 1.626)	(0.983, 1.222)	(1.216, 1.584)	(1.104, 1.326)	(0.022)
Education level (ref.= no formal education)					
Elementary school	1.195**	1.062	1.251**	1.076	0.054**
	(1.069, 1.337)	(0.965, 1.169)	(1.091, 1.434)	(0.988, 1.171)	(0.020)
Junior high school	1.199**	0.919	1.298**	1.06	0.147***
	(1.068, 1.346)	(0.832, 1.015)	(1.110, 1.519)	(0.969, 1.160)	(0.022)
Senior high school and above	1.654***	0.870*	1.655***	1.373***	0.378***
	(1.436, 1.905)	(0.769, 0.984)	(1.316, 2.083)	(1.227, 1.537)	(0.027)
Residence	0.910*	1.068	0.812***	0.813***	−0.126***
	(0.834, 0.993)	(0.990, 1.152)	(0.724, 0.911)	(0.760, 0.869)	(0.016)
Health insurance	1.234*	1.069	1.592***	1.447***	0.112**
	(1.002, 1.520)	(0.896, 1.276)	(1.308, 1.938)	(1.239, 1.690)	(0.036)
Self-reported health status (ref.= poor)					
Fair	0.800***	0.626***	1.537***	0.937	0.078***
	(0.720, 0.890)	(0.572, 0.686)	(1.363, 1.733)	(0.867, 1.011)	(0.019)
Good	0.918	0.594***	1.348***	0.996	0.162***
	(0.810, 1.040)	(0.533, 0.661)	(1.163, 1.563)	(0.907, 1.093)	(0.023)
Chronic diseases	1.376***	1.069	1.193*	1.535***	0.096***

(continued)

Table 4. Continued.

Variables	Model 5 Nonsmoking OR (95%CI)	Model 6 Non-drinking OR (95%CI)	Model 7 Physical activity OR (95%CI)	Model 8 Physical examination OR (95%CI)	Model 9 Social participation Coefficients (SE)
	(1.237, 1.531)	(0.974, 1.173)	(1.036, 1.373)	(1.408, 1.672)	(0.020)
Constant	3.521***	2.448***	7.052***	0.016***	0.695***
	(2.248, 5.514)	(1.667, 3.595)	(4.182, 11.894)	(0.011, 0.023)	(0.081)

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

Table 5. KHB test for social participation.

Effect	β	SE	P	95% CI Lower	95% CI Upper	Mediation (%)
Internet use–social participation–nonsmoking						
Total effect	0.108	0.051	0.033	0.009	0.208	
Direct effect	0.147	0.051	0.004	0.046	0.247	
Indirect effect	−0.038	0.008	<0.001	−0.054	−0.023	−35.21
Internet use–social participation–non-drinking						
Total effect	−0.340	0.044	<0.001	−0.426	−0.255	
Direct effect	−0.264	0.044	<0.001	−0.351	−0.178	
Indirect effect	−0.076	0.008	<0.001	−0.091	−0.061	22.34
Internet use–social participation–physical activity						
Total effect	0.627	0.072	<0.001	0.486	0.769	
Direct effect	0.436	0.072	<0.001	0.295	0.578	
Indirect effect	0.191	0.017	<0.001	0.157	0.224	30.40
Internet use–social participation–physical examination						
Total effect	0.204	0.039	<0.001	0.127	0.281	
Direct effect	0.137	0.040	0.001	0.059	0.215	
Indirect effect	0.067	0.007	<0.001	0.053	0.080	32.71

prevent them from quitting by tempting them with cigarettes.[69] These social activities make nonsmoking and smoking cessation difficult. For these reasons, many countries have implemented strict smoking bans in indoor public places, such as Australia.[70] The Chinese government has also instituted smoking bans in public places; however, smoking is commonly observed in some public places that are supposed to be smoke-free, such as spaces dedicated to mahjong, chess, and poker.[68] For instance, playing mahjong is a favorite pastime of many rural people in China, while smoking is commonly undertaken among male players. It can be speculated that playing mahjong is

Table 6. Effect of Internet use on health behavior based on PSM.

Dependent variable	Matching method	ATT	SE	*T* value
Nonsmoking	K-nearest neighbor ($n = 3$)	0.027	0.014	2.00
	Caliper matching	0.029	0.012	2.34
	Kernel matching	0.034	0.011	3.06
Non-drinking	K-nearest neighbor ($n = 3$)	−0.070	0.015	−4.79
	Caliper matching	−0.063	0.013	−4.72
	Kernel matching	−0.068	0.012	−5.74
Physical activity	K-nearest neighbor ($n = 3$)	0.034	0.009	3.61
	Caliper matching	0.035	0.009	3.91
	Kernel matching	0.039	0.008	4.94
Physical examination	K-nearest neighbor ($n = 3$)	0.059	0.015	3.85
	Caliper matching	0.055	0.014	3.85
	Kernel matching	0.065	0.013	5.15

an obstacle to smoking cessation, with the probability of smoking increases in places where many people smoke.[71] These results indicate that engaging in certain social activities is likely to increase the likelihood of smoking.

SP was found to mediate the relationship between IU and non-drinking. Specifically, IU promotes the beneficial effect of SP, thereby increasing the overall effect of IU on the probability of alcohol consumption among MOA. One study demonstrated that IU could stimulate older adults in China to participate in more social activities.[72] The main finding from a nationally representative sample of Swedish older adults was that higher levels of social activity were related to increased alcohol consumption frequency.[73] The reason for this may be that although there are significant risks associated with alcohol consumption,[74] alcohol consumption frequently occurs within a social context, especially in cultures that normalize such habits.[40] The Munich Oktoberfest, recognized as the world's largest Volksfest (popular festival),[75] serves as a significant cultural event wherein participants dress up in traditional attire and engage in alcohol consumption practices. These activities not only strengthen interpersonal bonds but also reinforce social solidarity and communal identity. Similarly, as a cultural symbol, wine is integral within familial reunion, conveys auspicious blessings, and represents aspirations for the future, thereby constituting a significant element in terms of expressing traditional family values and sociocultural etiquette practices.[76] As MOA engage in social events, such as dining with friends or family members, their chances of consuming alcohol also rise.

Furthermore, the mediating effect test results demonstrated that IU affected the physical activities of MOA by promoting social interaction, leisure, and entertainment. This is consistent with the results of previous studies.[77,78] For example, square dancing is a typical social activity organized by ordinary people and carried out in public spaces.[79] It is popular among MOA in China due to its simple and interesting movements and distinctive rhythms. Dance music and movements are key points in square dancing. Currently, people can easily find their favorite dance videos via the Internet, which has fostered interest in dancing.[80] Square dancing is a nightly activity in China, conducted in housing units, squares, parks, or courtyards.[81] Finding a good dancer, especially a good friend, can offer further encouragement and help to share knowledge of the relevant movement skills involved in square dancing. This type of engagement enables MOA to find a comfortable and suitable way to engage in this activity, thereby developing regular exercise habits.

In this study, we also found that SP mediated the relationship between IU and physical examination. With the proliferation of the Internet, individuals can access health knowledge more easily. Chinese MOA tend to watch videos related to longevity and health preservation, which can lead to the development of health consciousness.[82] Studies have found that the Internet has prompted older adults to monitor their health status, engage in health maintenance, and adopt preventive HBs.[20,83] Engagement in social events can furnish MOA with more social support and information resources.[40] Social platforms, such as senior colleges or community clubs, also provide opportunities to share information about community public health services. For example, Chinese adults aged 65 and older can attend free medical checkups at a community center. In addition, using the Internet can help MOA communicate better with friends or children. Therefore, the affection of family and friends could support and motivate MOA to carry out healthcare activities and cultivate a HBs, including regular medical checkups.

Based on our results, this study proposes the following recommendations: First, governments should take active measures to reduce the negative effects of IU.[84] Internet regulations should be strengthened to avoid negative and inaccurate information being presented.[85] In addition, governments should create a culture of aging-friendliness by strengthening influential infrastructure such as the Internet, parks, and activity centers.[86] Public policymakers should improve the digital literacy of MOA in various ways, and then help them to cross the "digital divide" in order to better integrate into the digital society.[87] Second, healthcare professionals should develop the physical exercise methods suitable for MOA, utilize the Internet to transmit more scientifically based fitness knowledge, and encourage active engagement in physical activity.[3] Third, communities and family members should provide sufficient help, guidance, and encouragement for MOA to use the Internet. Communities should provide Internet safety and usage

Table 7. Covariates balance testing for PSM.

		Mean				T-test	
Variable	Sample	Treated	Control	Bias (%)	Reduct |bias| (%)	*t*	*P*>*t*
Social participation	U	1.119	0.581	52.4		35.01	<0.001
	M	1.091	1.123	−3.1	94.1	−1.54	0.124
Gender	U	0.507	0.443	12.8		8.30	<0.001
	M	0.507	0.523	−3.2	75.1	−1.90	0.058
Age	U	56.287	64.864	−105.0		−66.68	<0.001
	M	56.347	56.300	0.6	99.4	0.40	0.690
Marital status	U	0.915	0.800	33.5		21.04	<0.001
	M	0.915	0.914	0.4	98.8	0.30	0.764
Education level	U	2.604	1.669	94.7		62.12	<0.001
	M	2.592	2.571	2.1	97.7	1.19	0.232
Residence	U	0.507	0.677	−35.2		−22.89	<0.001
	M	0.511	0.516	−1.0	97.1	−0.59	0.555
Health insurance	U	0.972	0.943	14.7		9.21	<0.001
	M	0.972	0.972	0.0	100.0	0.00	0.996
Self-reported health status	U	2.089	1.931	22.7		14.65	<0.001
	M	2.086	2.079	1.0	95.7	0.59	0.552
Chronic diseases	U	0.782	0.829	−12.0		−7.80	<0.001
	M	0.781	0.783	−0.3	97.6	−0.16	0.872

training, as well as Internet operation guidance, so that MOA can master basic Internet skills. Communities could collaborate with public welfare organizations, schools, or businesses to carry out digital literacy projects through utilizing the equipment and teaching resources of such institutions to organize targeted digital literacy classes for older adults.[88,89] For individuals with more limited learning abilities or special needs, one-on-one tutoring could be used, such as young people helping older adults. In addition, the content of digital literacy projects could include the use of common digital tools and applications, such as WeChat or TikTok. MOA could use these applications to communicate with family and friends and watch health science videos. Family members should be patient and guide their parents or grandparents on how to use relevant application via the Internet and on how to resolve difficulties when engaged in IU, which is likely to improve the confidence of MOA.[38] Fourth, local communities should utilize the Internet to publicize health information, which is likely to help stimulate the interest of MOA. Community workers should organize various fitness exercises, provide health education lectures on the hazards of tobacco and excessive alcohol consumption, and encourage voluntary participation and leisure activities to enrich the lives of MOA.[90]

Limitations

This study has some limitations. First, the data used were cross-sectional. Although associations among IU, SP, and HBs were identified, causal relationships could not be conclusively established. In future studies, we will consider collecting longitudinal data. Second, IU was measured as a binary variable that failed to capture the complex dimensions of IU. It overlooked other factors, such as the frequency, type, duration, and content of IU. Therefore, future studies should select multiple indicators to define IU. Third, the effect of IU on HBs may also be influenced by other mediating variables. However, this study examined only the mediating role of SP. We plan to explore the possibility of other mediating variables, such as social status,

social equity, and intergenerational relationships. Finally, according to the Andersen model, the covariates were preselected for this study. Although the factors affecting HBs are complex, some unobserved or unexplained deviations still exist. Further studies should consider adding other factors such as diverse geographic and demographic contexts.

Conclusion

This study found that IU directly affects the HBs of MOA and that SP plays an intermediary role between IU and HBs. Therefore, age- and culturally appropriate Internet health services and social activities should be designed and promoted. Public policies for caring for the middle-aged and elderly populations, including digital inclusion, community education training, and community cultural engagement, should also be robustly implemented. In conclusion, this study provides evidence for the relationship between IU and HBs of MOA in China and investigates the mediating role of SP, thus contributing to the current scientific literature. Moreover, these findings may have positive implications and valuable insights for policymakers, health promotion workers, and Internet product developers, suggesting that encouraging MOA to actively use the Internet and participate in social activities may facilitate their health.

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Ethical considerations

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Author contributions

XY: conceptualization, data curation, writing—original draft. YC: supervision, writing—review & editing. QT: methodology. XZ: supervision, writing—review & editing.

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The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Data availability statement

Data and documentation of CHARLS are available at http://charls.pku.edu.cn/. We have obtained permission to use the data in the study from the source (CHARLS).

Supplemental material

Supplemental material for this article is available online.

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