BMC Geriatrics

RESEARCH

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Internet use and life satisfaction among empty nesters in rural areas of Yangzhou: based on propensity score matching and mediating effect model

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Abstract

Background Empty nesters represent a unique group that deserves focused attention. Internet usage is becoming increasingly prevalent among older people. This study preliminarily discussed the differences in life satisfaction between empty nesters who used the Internet and those who did not. This study also provided insight into how Internet use interacted with social participation to improve their life satisfaction.

Methods A face-to-face survey was conducted in Yangzhou City, China, from July to August 2022. Covariates related to life satisfaction, such as sociodemographic characteristics and participants' health behaviors, were collected. Propensity Score Matching (PSM) was used to match Internet users with non-Internet users. Binomial logistic regression was employed to analyze the association between Internet use and life satisfaction, and the KHB method was used to examine the mediating effect.

Results 1,177 respondents aged 60 and above were ultimately matched for analysis in this study. The results showed that Internet use was significantly correlated with higher levels of both social participation ($\beta = 0.276$, $P < 0.05$) and life satisfaction ($\beta = 0.433$, $P < 0.05$). Social participation partially mediated the relationship between Internet use and life satisfaction, with a mediating effect of 0.112 accounting for 21% of the total effect. Further analysis of group heterogeneity indicated that the positive association between Internet use and life satisfaction was more prominent among participants who were younger, male, unemployed, had an income, and were in relatively healthy conditions.

Conclusions Internet use was crucial in promoting social participation and enhancing life satisfaction among rural empty nesters. Interventions aimed at improving their life satisfaction should prioritize the creation of inclusive and supportive environments, encouraging social participation, and enhancing digital literacy.

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Keywords Empty nesters, Internet use, Life satisfaction, Social participation

Background

With the acceleration of China's aging process, the problem of empty nesters has become increasingly prominent. According to 2020 population statistics, the number of empty nesters in China was nearly 150 million [1]. Many adult children in rural areas have moved away for education or employment opportunities, exacerbating the empty nester phenomenon in rural regions. According to the "2020 Report on the Current Situation of Rural Old-Care in China," over half of older people in rural areas now live in empty-nest households [2].

Influenced by the values of filial piety in traditional Chinese culture, older people in China, particularly those in rural areas, have historically relied heavily on their families, especially their children, for support in their later years. In traditional multi-generational households, there was an implicit expectation that children would care for their aging parents. However, this long-standing cultural norm has been increasingly challenged by modern society, where many children migrate to urban areas in search of work, leaving their elderly parents behind in rural areas [3, 4].

Liu et al. [5] and He et al. [6] have revealed that empty nesters in China express life satisfaction and quality of life than their counterparts in non-empty nest households. Moreover, due to a prolonged lack of spiritual support and neglect from their children, rural empty nesters are particularly prone to feelings of abandonment, which may lead to psychological problems such as low mood, loneliness, anxiety, and even depression [7]. Compared to their urban counterparts, rural empty nesters faced more significant challenges, including limited economic income, a weaker healthcare system, fewer leisure and entertainment activities, and lower level of social participation. These factors exacerbated both the physical and mental health of rural empty nesters, worsening their overall situation [8]. Research showed that 43.9% of rural empty nesters said they often feel lonely and isolated, which is much higher than that of their urban counterparts [9]. Moreover, the quality and availability of healthcare services in rural areas were often inferior to those in urban areas. Rural regions typically have fewer medical facilities and lack specialized care for older adults. As a result, the overall health status of empty nesters in rural areas was concerning, with a higher incidence of chronic illnesses [4, 10]. A systematic review evaluated that the research on empty nesters in China was mainly focused on urban areas, and further research should be conducted in rural areas to better understand the unique challenges faced by rural empty nesters [6]. Therefore, in the context of the aging population, improving the life satisfaction of empty nesters in rural areas has became a key focus of social concern.

With the rapid development of Internet technology, the Internet has played an increasingly important role in people's daily lives. For the unique group of empty nesters, the widespread adoption and development of the Internet have provided a new way for social interaction and information acquisition. According to the 52nd "Statistical Report on Internet Development in China", by June 2023, the number of rural Internet users in China had reached 301 million, accounting for 27.90% of the total Internet users [11]. Internet use has offered a new way for empty nesters to alleviate many challenges. It has enabled them to stay connected with distant family members [12], access healthcare information [13], and engage in online and offline social activities [14], all of these factors can contribute positively to their life satisfaction. Therefore, we specifically focused on Internet use, as it represents a modern intervention with significant potential to improve the quality of life for empty nesters.

Life satisfaction reflects an individual's sense of contentment or fulfillment across various aspects, including personal relationships, work or career aspirations, physical and mental well-being, personal growth, and overall happiness [15, 16]. In the Internet era, the Internet and digital technologies have proven to be essential channels for improving life satisfaction of older people and other vulnerable social groups [17]. Cho, Hyeonmi, et al. have demonstrated the potential effectiveness of promoting mobile Internet use to enhance life satisfaction among older adults [18]. Research based on the U.S. Health and Retirement Study (HRS) has revealed a positive correlation between increased Internet use and heightened social support among older people, helping to reduce feelings of loneliness, ultimately contributing to enhanced life satisfaction and mental well-being [19].

Many studies have examined the multifaceted factors influencing life satisfaction [20], including sociodemographic characteristics, community engagements, family structures, healthy behavioral lifestyles, etc. For example, older people living with their spouses have been shown to have higher life satisfaction [21]. Sleep problems were highly prevalent among older people. Banerjee S et al. examined the positive association between life satisfaction and sleep quality among older Indian people [22]. Additionally, self-rated health (SRH) has emerged as a significant predictor of life satisfaction among older people, with individuals who rate their health as good reporting higher levels of life satisfaction than those who rate their health as poor [23]. A study in South Korea further revealed that older individuals often derive meaning in

life from high-quality parent-child relationships and consistent interactions with their children [24]. It could be concluded that the factors contributing to life satisfaction among older people were very complex. We attempted to explore the association between Internet use and life satisfaction among rural empty nesters, and whether there were mediating variables in the association.

Social participation, an important part of active aging aimed at fostering the integration of older people into society or their community [25], is crucial for maintaining well-being. For instance, Lv R's study showed a strong association between social participation and life satisfaction among community-dwelling older people [26]. Kobayashi, L.C. et al. discovered that Internet use and social engagement can facilitate the maintenance of health literacy among older people during the aging process [27]. Furthermore, Zhang, K. et al. proposed that social media communication could serve as an intervention to alleviate loneliness among older people by bolstering social support and interaction [28].

Though some studies have explored the relationship between Internet use and life satisfaction among older people, limited studies have been conducted specifically on empty nesters in rural areas, and the potential mediating role of social participation has been less discussed. Therefore, the objective of this study was to investigate the association between Internet use and life satisfaction among rural empty nesters, as well as to explore the potential mediating effect of social participation. Based on previous studies, two hypotheses were proposed: (1) there is a significant positive association between Internet use and life satisfaction among empty nesters, and (2) social participation serves as a mediator in the association between Internet use and life satisfaction among empty nesters.

Methods

Sampling and data collection

A cross-sectional study was conducted in Yangzhou City, located in eastern China, between July and August 2022. Initially, six villages were randomly selected within the rural areas of Yangzhou City, based on considerations of population size and geographical location. Within these villages, households were randomly chosen, and from each, one adult resident aged 55 years or older was invited to participate in the survey. Data collection was carried out through face-to-face interviews, during which each participant was thoroughly informed about the study's objectives and provided their informed consent prior to participation. The questionnaire comprehensively covered the sociodemographic characteristics, behavioral lifestyles, social participation, and life satisfaction of the participants. Prior to the main survey, a pre-survey was conducted to refine the questionnaire, resulting in revisions to several sections to better suit the respondents. Ultimately, 2,192 questionnaires were collected, and among these, the study focused on empty nesters aged 60 years and older. After excluding cases with missing values for key variables, the final sample consisted of 1,224 individuals. Following propensity score matching (PSM), 1,177 respondents were successfully matched for the definitive analysis (as shown in Fig. 1).

Measures

Life satisfaction

The dependent variable in this study was life satisfaction. In the questionnaire, participants were asked, "Are you satisfied with your life?" with five response options ranging from 1 (extremely dissatisfied) to 5 (extremely satisfied). A score of 3 was set as the threshold based on previous studies [29, 30], with scores of 3 or below categorized as "less than satisfied" and scores of 4 or 5 categorized as "satisfied." Thus, life satisfaction was treated as a binary variable, with the two categories being "less than satisfied" and "satisfied."

Internet use

Internet use was measured by the question, "How often do you use the Internet (including TikTok, short videos, WeChat, etc.)?" The answers included "1 = never", "2 = occasionally", "3 = often", and "4 = always". Option 1 was coded as "0 = never use the Internet", and options 2 to 4 were combined and coded as "1 = use the Internet", making it a binary categorical variable.

Social participation

In terms of social participation, consistent with previous studies [31], participants were asked whether they had participated in the following ten activities over the past month, such as visiting friends, playing mahjong, chess, or cards, and offering help to others. Participants who participated in any of these activities were deemed socially engaged. They were awarded one point for participating in each activity. The higher the score, the greater the level of social participation.

Covariates

Based on previous research [31–33], a variety of control variables were taken into consideration, including sociodemographic characteristics (age, gender, marital status, insurance status, profession, and income), behaviors and lifestyle factors (smoking status, drinking status, and sleep quality), health status (self-rated health, chronic condition, and hospitalization within the past year), as well as interactions with children (frequency of meetings with children).

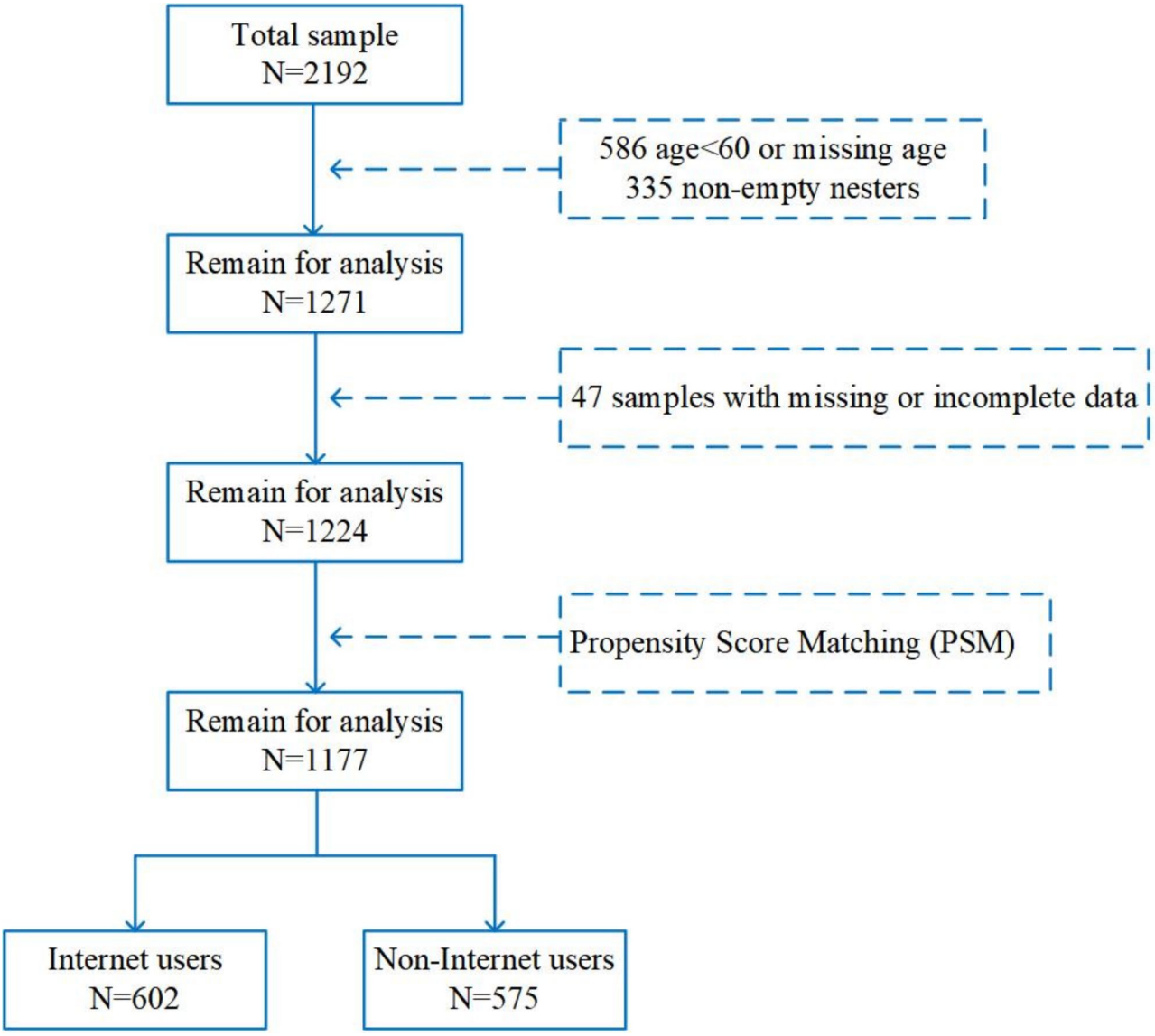

Fig. 1 The flowchart of the sample

Statistical analysis

In this study, the PSM model was used to reduce selection bias and address the issue of endogeneity in estimating the causal impact of Internet use on life satisfaction among empty nesters [34]. By using PSM, we aimed to create a treatment group (those using the Internet) and a control group (those not using the Internet) that were statistically comparable based on a set of covariates. This ensured that the observed differences in life satisfaction could be more confidently attributed to Internet use, rather than confounding factors.

Stata 17.0 was used to analyze the association between Internet use and life satisfaction among empty nesters. The Wilcoxon rank-sum test was employed for continuous variables, while chi-square tests were used for categorical variables to compare sample characteristics between Internet users and non-Internet users.

The binomial logistic regression model was used to test the relationship between Internet use and life satisfaction. The model was constructed as follows:

$$P_Y(Y=1|X_{1,}X_{2,}\ldots X_k)=F(\beta_0+\beta_1X_1+\beta_2X_2\ldots+\beta_kX_k)$$

$$=\frac{1}{1+e^{-(\beta_0+\beta_1X_1+\beta_2X_2\ldots+\beta_kX_k)}} \quad (1)$$

In formula (1), P represented the probability of life satisfaction among empty nesters; Y represented life satisfaction; X_k represented Internet use; β_k was the regression coefficient we focused on, reflecting the direction and degree of Internet use's impact on life satisfaction.

From a theoretical perspective, the engagement of empty nesters in Internet use may be considered as a self-selection behavior, potentially leading to selective bias. We used Rubin's counterfactual framework [35] as the theoretical foundation, dividing the respondents into an treatment group (using the Internet) and a control group (not using the Internet). To assess the robustness and ascertain the net impact of Internet use on life satisfaction, we employed the PSM method to calculate the Average Treatment Effect on the Treated (ATT), thus mitigating the influence of endogeneity. Psmatch2 was employed for covariate identification and propensity score analysis. The specific models were as followed:

$$y_i = (1 - D_i)\, y_{0i} + D_i y_{1i} = y_{0i} + (y_{1i} - y_{0i})\, D_i \quad (2)$$

$$\begin{aligned} ATT &= E\left[y_{1i} - y_{0i} | D_i = 1, P(X)\right] \\ &= E\left[y_{1i} | D_i = 1, P(X)\right] - E\left[y_{0i} | D_i = 1, P(X)\right] \end{aligned} \quad (3)$$

In formulas (2) and (3), the binary processing variable D_i = {0, 1} was used to indicate whether the respondents utilized the Internet. Specifically, D_i = 1 represented the treatment group (those who used the Internet), while D_i = 0 represented the control group (those who did not use the Internet). The variable y_{1i} signified the life satisfaction of empty nesters who engaged in Internet, whereas y_{0i} signified the life satisfaction of empty nesters who did not use the Internet; $y_{1i} - y_{0i}$ represented the processing effect of Internet use among empty nesters. The ATT was calculated as the difference between the life satisfaction of empty nesters who used the Internet and the life satisfaction they would have experienced if they had not used the Internet.

For the mediation analyses, the KHB [36, 37] method was used to examine whether social participation mediated the association between Internet use and life satisfaction. The KHB method decomposed the total effect of the independent variable (X) on the dependent variable (Y) into both direct and indirect effects. The direct effect represented the relationship between X and Y after accounting for the mediator (M), while the indirect effect reflected the extent to which the relationship between X and Y was mediated by M. One key strength of the KHB method was its ability to statistically test the significance of the indirect effect in non-linear settings.

Results

In the final analysis, a total of 1,224 participants were included in the study. Following PSM, we successfully matched 1,177 participants for further examination. Table 1 showed the characteristics of the variables used in this study. The mean age of all empty nesters was 67.1 years. Our study population comprised a higher proportion of females (56.24%) compared to males (43.76%).

Table 1 Characteristics of the sample after PSM (*N* = 1177)

Variables		*N* (%)	Mean ± SD
Dependent variable			
	Life satisfaction		
	1 = Less than satisfied	188 (15.97)	
	2 = Satisfied	989 (84.03)	
Independent variable			
	Internet use		
	0 = No	575 (48.85)	
	1 = Yes	602 (51.15)	
Mediating variable	Social participation		0.981 ± 0.831
Control variables			
	Age		
	1 = 60–65	357 (30.33)	
	2 = 66–70	557 (47.32)	
	3 = Above 70	263 (22.34)	
	Gender		
	1 = Male	515 (43.76)	
	2 = Female	662 (56.24)	
	Marital status		
	1 = Unmarried	107 (9.09)	
	2 = Married	1070 (90.91)	
	Profession		
	1 = No	906 (76.98)	
	2 = Yes	271 (23.02)	
	Income		
	1 = No	227 (19.29)	
	2 = Yes	950 (80.71)	
	Medical insurance		
	1 = No	34 (2.89)	
	2 = Yes	1143 (97.11)	
	Smoke status		
	1 = Still have	329 (27.95)	
	2 = Quit	66 (5.61)	
	3 = No	782 (66.44)	
	Drink status		
	1 = Yes	290 (24.64)	
	2 = No	887 (75.36)	
	Sleep quality		
	1 = Very poor	25 (2.12)	
	2 = Poor	267 (22.68)	
	3 = Good	694 (58.96)	
	4 = Very good	191 (16.23)	
	Self-rated health		
	1 = Very poor	91 (7.73)	
	2 = Poor	267 (22.68)	
	3 = Good	752 (63.89)	
	4 = Very good	67 (5.69)	
	Chronic condition		
	1 = Yes	707 (60.07)	
	2 = No	470 (39.93)	
	Hospitalization within the past year		

Table 1 (continued)

Variables		*N* (%)	Mean ± SD
	1 = Yes	108 (9.18)	
	2 = No	1069 (90.82)	
Meeting with children			
	1 = At least once a week	248 (21.07)	
	2 = At least once a month	238 (20.22)	
	3 = Once a few months	691 (58.71)	

Note: Categorical variables reported the number and percentages, N (%); while continuous variables reported the means and standard deviations, Mean ± SD

Approximately 90.91% of empty nesters were married, with over 20% reporting regular weekly contact with their children. Additionally, approximately 60% of the empty nesters indicated that they had a chronic condition. 602 empty nesters (51.15%) who used the Internet and 575 empty nesters (48.85%) who did not use the Internet were included after PSM.

The PSM results showed that the t-value of ATT was 2.08 (> 1.96), meaning that after controlling for other factors that may affect life satisfaction, Internet users' life satisfaction was 2.08 times higher than that of non-users on average. The *p*-values for all control variables were greater than 0.1, and the biases were all under 10% after matching, indicating no statistically significant differences (see Table 2). All samples successfully passed the balance test, demonstrating no imbalance in control variables. The results indicated that PSM could significantly reduce the error associated with self-selection.

The mean age of Internet users was 65.4 years, younger than that of non-Internet users, who averaged 68.8 years. Statistically significant differences were observed between the two groups of empty nesters in terms of life satisfaction, social participation, age, gender, marital status, income, self-rated health, smoking status, and drinking status (all $P < 0.001$). More than half of the empty nesters who were extremely satisfied with their lives used the Internet. Empty nesters who used the Internet had higher levels of social participation. We could also see that males used the Internet more than females. Among empty nesters with income, 54.42% of them reported using the Internet. Among those with bad self-rated health, only 34 empty nesters (37.36%) said they did not use the Internet. The detailed characteristics of the other variables were presented in Table 3.

The regression results for Internet use, social participation, and life satisfaction were presented in Table 4. Model 1 included Internet use, life satisfaction, and characteristics of empty nesters. The positive coefficients suggested that Internet use was significantly associated with life satisfaction. In model 2, the dependent variable was social participation, where the positive coefficients indicated that Internet use increased social participation. In model 3, the results indicated that social participation gave rise to higher levels of life satisfaction. In model 4, all possible covariates were controlled, and the results indicated that Internet use was significantly associated with life satisfaction, while social participation was significantly associated with life satisfaction. The effect of Internet use on life satisfaction was correspondingly reduced after including social participation, which suggested social participation might have a partial mediating effect.

Figure 2 diagrammatically presented the outcomes of our theoretical model. Path a indicated the direct link between Internet use and social participation; path b showed the connection between social participation and life satisfaction; and path c represented the relationship between Internet use and life satisfaction. Path c' represented the effect of Internet use on life satisfaction, taking into account the mediating role of social participation. Using the KHB method, as shown in Table 5, we found that social participation partially mediated the association between Internet use and life satisfaction. The mediating effect (indirect effect, ab = c - c') of social participation was 0.112, which accounted for 21% of the total effect.

The research presented above demonstrated a significant correlation between Internet use and life satisfaction among empty nesters. However, this relationship varied across different subgroups, as shown in Table 6. Models 5–7 concluded that there was a significant positive correlation between Internet use and life satisfaction among empty nesters under the age of 70. While Internet use positively influenced the life satisfaction of those aged 66 to 70, this impact was relatively weaker compared to those aged 60 to 65. From a gender perspective, among male empty nesters, there was a statistically significant positive correlation between increased Internet use and higher life satisfaction. Males were more likely than females to overuse the Internet for entertainment, which contributed to their higher life satisfaction levels. In the group of empty nesters who were not in the workforce, a significant positive correlation was also found between Internet use and life satisfaction. In terms of income, although both groups displayed significant results, the regression coefficients were larger for the group with income. This suggested a stronger correlation between Internet use and life satisfaction among those with a source of income. Lastly, the association between Internet use and life satisfaction varied significantly among empty nesters with different health conditions. For those without chronic conditions, Internet use was positively associated with their life satisfaction.

Table 2 Sample balance test

Variable	Unmatched	Mean		%bias	T-test		V(T)/V(C)
	Matched	Treated	Control		t	P>| t|	
Age	U	1.603	2.216	-92.5	-16.14	<0.001	1.10
	M	1.645	1.683	-5.8	-1.00	0.319	1.12
Gender	U	1.447	1.648	-41.2	-7.19	<0.001	1.08
	M	1.478	1.447	6.5	1.10	0.272	1.01
Marital status	U	1.002	1.026	-21.0	-3.76	<0.001	0.06*
	M	1.002	1.002	0.0	0.00	1.000	1.00
Profession	U	1.191	1.259	-16.2	-2.84	0.005	0.81*
	M	1.203	1.179	5.6	1.03	0.305	1.01
Income	U	1.868	1.750	30.3	5.33	<0.001	0.61*
	M	1.859	1.874	-3.8	-0.76	0.446	1.10
Medical insurance	U	1.977	1.967	5.7	1.01	0.315	0.72*
	M	1.975	1.985	-6.0	-1.24	0.216	1.65*
Smoke status	U	2.290	2.497	-23.4	-4.08	<0.001	1.18*
	M	2.272	2.243	3.4	0.56	0.579	0.97
Drink status	U	1.689	1.800	-25.5	-4.45	<0.001	1.34*
	M	1.709	1.676	7.7	1.25	0.212	0.94
Sleep quality	U	2.915	2.874	6.0	1.05	0.296	0.96
	M	2.914	2.957	-6.4	-1.09	0.275	0.95
Self-rated health	U	2.753	2.610	20.6	3.62	<0.001	0.69*
	M	2.741	2.736	0.7	0.13	0.894	0.91
Chronic condition	U	1.404	1.393	2.2	0.38	0.705	1.01
	M	1.410	1.365	9.2	1.60	0.110	1.04
Hospitalization within the past year	U	1.894	1.910	-5.4	-0.94	0.350	1.16
	M	1.907	1.897	3.4	0.58	0.561	0.91
Meeting with children	U	2.368	2.397	-3.5	-0.61	0.540	0.99
	M	2.362	2.372	-1.2	-0.21	0.832	0.95

Note: *$P < 0.10$, **$P < 0.05$, ***$P < 0.01$

Discussion

With the aging population continually increasing, life satisfaction among rural empty nesters needs to be explored for further research. Consistent with previous studies [17, 18, 38], the findings of the current study supported our hypotheses: there was a significant positive association between Internet use and life satisfaction, with social participation acting as a mediating factor in this association.

Unlike Western societies that prioritize individualism, China is an ethical society where filial piety and caring for parents are fundamental moral principles and social norms. However, in today's fast-paced, high-pressure, and rapidly changing society, many young people, whether actively or passively, choose to leave their elderly parents behind. Similarly, older adults, in turn, may also actively or passively embrace the "empty-nest" life state [4]. "Empty-nest" reflects the physical separation of living space between two generations, which limits the realization of the traditional filial piety tradition. But at the same time, with the rapid development of information technology, the Internet has undergone significant growth in China. The widespread adoption of the Internet has greatly changed the lifestyle of the empty nesters in rural areas, helping to bridge the gap in social interaction and bring them closer to their families.

The Internet served as a powerful tool for addressing the social and geographical challenges faced by empty nesters [39]. These seniors often experience a decline in physical capabilities, psychological stress, and social difficulties [40]. By utilizing the Internet, they can share experiences online, access vital information, and learn digital skills [41]. This digital engagement enabled them to maintain and strengthen relationships with distant family members and friends through video calls and messaging [12]. These connections can help alleviate feelings of loneliness and isolation, contributing positively to their emotional well-being and overall life satisfaction. Additionally, the Internet provided a wide variety of entertainment and leisure activities that enhanced the quality of life for older adults [42]. Various platforms provided access to movies, music, television shows, and online games, which can contribute to spiritual enjoyment [43]. The benefits of these aspects in enhancing life satisfaction among empty nesters should be considered.

Social participation was positively correlated with life satisfaction among empty nesters. By engaging in community activities, clubs, or organizations, these

Table 3 Descriptive statistics of empty nesters who used and did not use the internet after PSM

Variables		After matching (*N* = 1177)		χ^2/Z	*P*
		Internet users (*N* = 602)	Non-Internet users (*N* = 575)		
Life satisfaction				21.537	< 0.001
	Less than satisfied	67 (35.64)	121 (64.36)		
	Satisfied	535 (54.10)	454 (45.90)		
Social participation		1.171 ± 0.884	0.783 ± 0.720	-7.981	< 0.001
Age				13.514	< 0.001
	60–65	285 (79.83)	72 (20.17)		
	66–70	246 (44.16)	311 (55.83)		
	Above 70	71 (27.00)	192 (73.00)		
Gender				35.366	< 0.001
	Male	314 (60.97)	201 (30.03)		
	Female	288 (43.50)	374 (56.50)		
Marital status				12.929	< 0.001
	Unmarried	37 (34.58)	70 (65.42)		
	Married	565 (52.80)	505 (47.20)		
Profession				5.292	0.022
	No	480 (52.98)	426 (47.02)		
	Yes	122 (45.02)	149 (54.98)		
Income				21.132	< 0.001
	No	85 (37.44)	142 (62.56)		
	Yes	517 (54.42)	433 (45.58)		
Medical insurance				0.692	0.487
	No	15 (44.12)	19 (55.88)		
	Yes	587 (51.36)	556 (48.64)		
Smoke status				22.248	< 0.001
	Still have	198 (60.18)	131 (39.82)		
	Quit	42 (63.63)	24 (36.36)		
	No	362 (46.29)	420 (53.71)		
Drink status				13.029	< 0.001
	Yes	175 (60.34)	115 (39.66)		
	No	427 (48.14)	460 (51.86)		
Sleep quality				1.178	0.757
	Very poor	12 (48.00)	13 (52.00)		
	Poor	130 (48.69)	137 (51.31)		
	Good	358 (51.59)	336 (48.41)		
	Very good	102 (53.40)	89 (46.60)		
Self-rated health				19.833	< 0.001
	Very poor	34 (37.36)	57 (62.64)		
	Poor	118 (44.19)	149 (55.81)		
	Good	420 (55.85)	332 (44.15)		
	Very good	30 (44.78)	37 (55.22)		
Chronic condition				0.619	0.440
	Yes	355 (50.21)	352 (49.79)		
	No	247 (52.55)	223 (47.45)		
Hospitalization within the past year				0.024	0.920
	Yes	56 (51.85)	52 (48.15)		
	No	546 (51.08)	523 (48.92)		
Meeting with children				3.216	0.201
	At least once a week	125 (50.40)	123 (49.60)		
	At least once a month	134 (56.30)	104 (43.70)		
	Once a few months	343 (49.64)	348 (50.36)		

Note: Categorical variables reported the number and percentages, N (%); while continuous variables reported the means and standard deviations, Mean ± SD

* $P < 0.1$, ** $P < 0.05$, *** $P < 0.01$

Table 4 Association between Internet use, social participation, and life satisfaction among empty nesters

Variables	Model 1[a]		Model 2[b]		Model 3[a]		Model 4[a]	
	β	SE	*β*	SE	*β*	SE	*β*	SE
Internet use	0.545***	0.198	0.406***	0.053			0.433**	0.202
Social participation					0.325***	0.117	0.276**	0.120
Age (60–65)								
66–70	-0.227	0.238	-0.014	0.059	-0.374*	0.225	-0.210	0.238
Above 70	-0.171	0.276	-0.001	0.073	-0.372	0.255	-0.142	0.277
Gender (Male)								
Female	0.146	0.277	0.326***	0.077	-0.075	0.276	0.037	0.282
Marital status (Unmarried)								
Married	0.543**	0.258	0.016	0.083	0.585**	0.257	0.560***	0.258
Profession (No)								
Yes	-0.099	0.215	0.333***	0.061	-0.182	0.218	-0.176	0.219
Income (No)								
Yes	0.548***	0.213	0.123*	0.064	0.546**	0.213	0.517**	0.214
Medical insurance (No)								
Yes	-0.208	0.529	0.036	0.139	-0.201	0.532	-0.248	0.533
Smoke status (Still have)								
Quit	-0.274	0.412	-0.063	0.111	-0.264	0.411	-0.287	0.412
No	-0.353	0.285	-0.260***	0.078	-0.232	0.285	-0.275	0.288
Drink status (Yes)								
No	0.545**	0.244	-0.081	0.065	0.572**	0.245	0.599**	0.247
Sleep quality (Very poor)								
Poor	0.439	0.487	0.212	0.170	0.391	0.489	0.378	0.492
Good	0.905*	0.484	0.115	0.167	0.888*	0.485	0.889*	0.488
Very good	1.298**	0.541	0.176	0.175	1.260**	0.542	1.261**	0.545
Self-rated health (Very poor)								
Poor	0.234	0.278	0.030	0.099	0.214	0.280	0.218	0.280
Good	1.487***	0.281	0.063	0.094	1.487***	0.283	1.475***	0.283
Very good	1.869***	0.593	0.210	0.137	1.831***	0.596	1.867***	0.597
Chronic condition (Yes)								
No	0.210	0.187	-0.008	0.048	0.206	0.187	0.210	0.188
Hospitalization within the past year (Yes)								
No	-0.609*	0.313	-0.031	0.082	-0.640**	0.315	-0.611*	0.316
Meeting with children (At least once a week)								
At least once a month	0.115	0.277	0.068	0.072	0.152	0.277	0.115	0.278
Once a few months	-0.046	0.222	0.082	0.060	-0.037	0.221	-0.046	0.222
R^2	0.140		0.105		0.141		0.145	

a: Dependent variable = life satisfaction

b: Dependent variable = social participation

Note: Standard errors in brackets, * $P < 0.1$, ** $P < 0.05$, *** $P < 0.01$

individuals can establish and maintain meaningful connections with others. Such social interactions helped reduce feelings of loneliness and isolation [44], providing emotional support and friendship [45], which in turn enhanced their overall life satisfaction. Additionally, social participation offered opportunities for empty nesters to play active roles in their communities, whether through volunteering or taking part in group activities [46]. This involvement fostered a sense of belonging, which contributed to their self-worth and fulfillment. Furthermore, participating in social activities encouraged both physical and mental engagement, thereby promoting better overall health [47]. Good health was a crucial factor in improving life satisfaction.

We also found that social participation played a mediating role between Internet use and life satisfaction among empty nesters. The findings were consistent with previous research as well [43, 48]. The Internet emerged as a facilitating platform, enabling empty nesters to access a broader range of social activities, which in turn provided them with positive experiences. Specifically, the enhanced opportunities facilitated by online engagement contributed significantly to their social participation. Furthermore, social participation among empty nesters

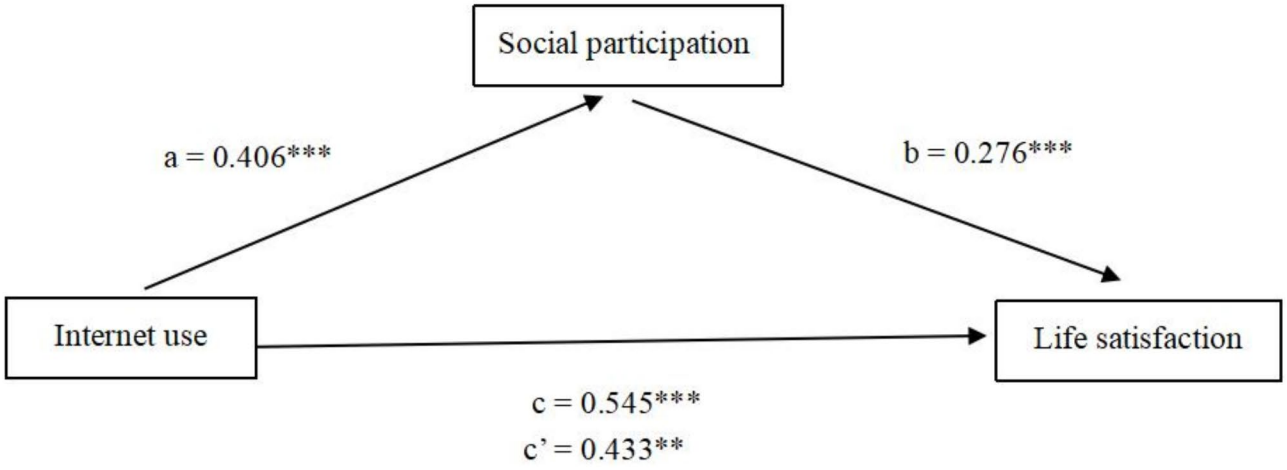

Fig. 2 The mediating effects of social participation on the relation between Internet use and life satisfaction

Table 5 Models of the mediating role of social participation in the relationship between Internet use and life satisfaction

	β	SE	Z	*P*	LLCI	ULCI
Total effect (c)	0.545	0.199	2.74	0.006	0.155	0.936
Direct effect (c')	0.433	0.202	2.14	0.032	0.036	0.830
Indirect effect (ab = c-c')	0.112	0.051	2.20	0.027	0.012	0.212

Table 6 Heterogeneity analysis of the impact of Internet use on life satisfaction

Variables	By age			
	Model 5 Age = 60–65	Model 6 Age = 66–70	Model 7 Age = Above 70	
Internet	0.929**	0.607**	-0.181	
	(0.508)	(0.263)	(0.549)	
Control variables	Yes	Yes	Yes	
N	357	557	263	
R^2	0.245	0.100	0.246	
Variables	By gender		By profession	
	Model 8 Male	Model 9 Female	Model 10 No	Model 11 Yes
Internet	0.649**	0.341	0.560**	0.347
	(0.284)	(0.288)	(0.232)	(0.412)
Control variables	Yes	Yes	Yes	Yes
N	515	662	906	271
R^2	0.140	0.164	0.134	0.193
Variables	By income		By chronic condition	
	Model 12 No	Model 13 Yes	Model 14 No	Model 15 Yes
Internet	0.438*	0.752*	0.538**	0.676
	(0.229)	(0.428)	(0.247)	(0.349)
Control variables	Yes	Yes	Yes	Yes
N	227	950	470	707
R^2	0.119	0.201	0.137	0.160

Note: * $P<0.10$, ** $P<0.05$, *** $P<0.01$; standard errors are reported in parentheses

was instrumental in maintaining their physical and mental well-being, as well as enhancing their overall quality of life. By fostering social interactions and engagement, these activities provided a sense of belonging and purpose, which were crucial for their health and happiness. Consequently, social participation acted as a crucial link between their Internet use and overall life satisfaction.

Internet use was more strongly associated with life satisfaction among middle-aged and younger empty nesters compared to their older counterparts. Younger empty nesters tended to exhibit better cognitive function and showed a greater willingness to embrace new technologies. They made use of the Internet's information accessibility to meet various needs, which positively impacted their overall life satisfaction. In contrast, older empty nesters may face more barriers to Internet usage [31]. Regarding gender differences, males typically had more exposure to technology and related activities, making it easier for them to accept and use the Internet as they age [49]. Moreover, older males may have more leisure time available to use the Internet, while older females often shoulder greater household responsibilities, leading to reduced Internet usage. Non-employed empty nesters may increasingly rely on the Internet for information due to a lack of daily work and social activities. In contrast, those who were employed may have limited time to engage with the Internet [50]. For empty nesters with an income, the use of the Internet had a stronger correlation with their life satisfaction, which may be because the Internet provided information acquisition, social interaction, entertainment, and other functions to meet

some of their needs. Conversely, empty nesters without an income may not access the Internet as frequently or fully due to economic constraints, thus weakening the potential impact of Internet use on life satisfaction [51]. Additionally, empty nesters with chronic conditions may be influenced by various other factors, such as psychological stress and the increased economic burden associated with their conditions, which can obscure the positive relationship between Internet use and life satisfaction [52].

Our findings significantly contributed to both practice and policy in addressing the unique challenges faced by empty nesters in this vulnerable population. The implications of our research for practice suggested that interventions promoting Internet access and digital literacy among rural empty nesters could positively impact their overall well-being. For example, community-based organizations and social service providers could develop targeted programs that meet the specific needs of this group. These programs could include training and support for using digital technologies, establishing online social networks, and providing access to mental health resources. Additionally, our research highlighted the importance of fostering social support networks to encourage social interactions and reduce feelings of isolation and loneliness among rural empty nesters. These networks can offer both practical assistance and emotional support, significantly enhancing life satisfaction. In terms of policy implications, the study emphasized the need for comprehensive and targeted policies to address the challenges faced by rural empty nesters in Yangzhou and similar rural areas. Policymakers must address the digital divide between rural and urban areas, particularly the gap affecting the elderly. This included initiatives aimed at expanding Internet access and digital literacy within this population, such as investing in infrastructure to improve broadband coverage in rural areas and providing subsidies or discounts for Internet services to older people. Additionally, policymakers should prioritize the development of accessible mental health resources and services, as mental health issues were often a significant challenge for this demographic.

This study has several limitations. Firstly, the participants were selected from a survey focused on residents' health status. They were relatively young and may not be representative of the whole sample. Secondly, although we adjusted for as many covariates as possible and used PSM to make the results as robust as possible, the factors influencing life satisfaction were complex, and some biases may remain unobserved. Thirdly, our measurement of life satisfaction is rudimentary, we plan to use well-established scales to conduct research in the future. Finally, the surveys were only conducted on rural empty nesters in Yangzhou City, eastern China, studies of urban empty nesters and other areas need to be added to ensure our findings were nationally representative.

Conclusions

Our results confirmed a significant positive association between Internet use and life satisfaction among rural empty nesters, highlighting the mediating role of social participation. Increased Internet use led to improved social participation, which in turn enhanced life satisfaction. The government should evaluate and adjust policies to ensure that empty nesters have equal access to the Internet. Additionally, tailored Internet services and resources, such as health information, online courses and social networking platforms, should be provided according to their specific needs and interests.

Abbreviations

PSM	Propensity Score Matching
ATT	Average Treatment Effect on the Treated
HRS	Health and Retirement Study
SRH	Self-rated health

Acknowledgements

The authors of this article would like to thank all people who participated in this study, we are very grateful to the anonymous reviewers for their valuable comments on the manuscript revision.

Author contributions

Y.T. carried out the study, and holds the main responsibility for writing the manuscript. Y.N., Z.Y., and W.K. contributed to data collection and conducted the statistical analysis. G.Y., Y.X., and M.M. drafted parts of the paper and revised the manuscript. Y.Q. and R.J. helped perform the analysis with constructive discussions. Y.T. and Y.N. contributed equally to this work. All authors provided input during the preparation of the manuscript and approved the final.

Funding

This work was supported by grants from National Social Science Foundation (Number: 23BSH151), Nantong Science and Technology Program (Number: MS2023084), and Jiangsu Province Elderly Health Scientific Research Project (Number: LKM2023041). The granting agencies did not have roles in the design, collection, analysis, and interpretation of data or in writing the manuscript.

Data availability

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate

Ethical Approval was obtained from the ethics committee of Nantong University (protocol code: 2021014; date of approval: 26/2/2021). All participants provided written informed consent. All methods were carried out in accordance with relevant guidelines and regulation, as mentioned in World Medical Association Declaration of Helsinki.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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Received: 11 June 2024 / Accepted: 12 February 2025
Published online: 25 February 2025

References

1. Tao T, Jin G, Guo Y. Empty nesters households in China: Trends and patterns. Popul Res. 2023;47(01):58–71. (in Chinese).
2. Zheng X, Wu Z. Filial but cannot and care each other: a study on the problems of mutual-support for the empty Nest Elderly in Rural Areas. Inner Mongolia Social Sci. 2022;43(02):147–154. (in Chinese).
3. Liu X, Yu HJ, Zhang MZ, et al. The transition of eldercare responsibility and traditional filial piety concepts and its urban-rural differences in China: an age-period-cohort analysis from 2006 to 2017. BMC Public Health. 2024;24(1):1669.
4. Li XD, Cao HJ, Xie SY, et al. Urban-rural differences in the effect of empty-nest on mental health and behaviors of Chinese older population. Psychol Health Med. 2022;27(6):1334–1346.
5. Liu L, Guo Q. Life satisfaction in a sample of empty nesters: a Survey in the rural area of a Mountainous County in China. Qual Life Res. 2008;17(6):823–830.
6. He W, Jiang L, Ge X, et al. Quality of life of empty nesters in China: a systematic review and meta-analysis. Psychol Health Med. 2020;25(2):131–147.
7. He L, Wang J, Wang F, et al. Depression symptoms and quality of life in empty nesters among Chengdu: a cross-sectional study. Front Psychiatry. 2022;13:1003261.
8. Li B, Chen S. The Elderly Care Dilemma and optimization path of empty Nest Elderly in Rural areas from the perspective of Social Support——Taking M Village in Huizhou City, Guangdong Province as an Example. J Hebei Youth Administrative Cadres Coll. 2024;36(03):45–53. (in Chinese).
9. Liu J, Bi C. Dilemma and improvement strategies on spiritual well-being of rural empty nesters under the goal of common prosperity. J Wuhan Polytechnic. 2023;22(06):90–95. (in Chinese).
10. Zheng J, Zhang X, On the Availability of Medical Care Based on Health Needs Situation of Rural Empty Nesters. J Liaoning Univ (Philosophy Social Science). 2024;52(04):40–52. (in Chinese).
11. China Internet Network Information Center. The 52nd Statistical Report on China's Internet Development. https://www.cnnic.net.cn/n4/2023/0828/c88-10829.html. 2023. 2023-12-7.
12. Stockwell S, Stubbs B, Jackson SE, et al. Internet use, social isolation and loneliness in older adults. Aging Soc. 2021;41(12):2723–2746.
13. Merkel S, Hess M. The Use of Internet-Based Health and Care services by Elderly people in Europe and the importance of the Country context: Multilevel Study. Jmir Aging. 2020;3(1):e15491.
14. Kim J, Hearn G, Hall A, IMPACT OF DIGITAL, AND SOCIAL ENGAGEMENT ON QUALITY OF LIFE AMONG RURAL OLDER ADULTS. Innov Aging. 2023;7(Supplement1):846.
15. Mei Y, Zhang Y, Yu J, et al. Healthy lifestyle mediates the association between health locus of control and life satisfaction among college students in Hubei, China: during the normalization stage of COVID-19 epidemic prevention and control. Arch Public Health. 2023;81(1):136.
16. Park JH, Min S, Eoh Y, et al. The elderly living in single-person households in South Korea: a latent profile analysis of self-esteem, life satisfaction, and depression. Qual Life Res. 2021;30(4):1083–1092.
17. Lissitsa S, Chachashvili-Bolotin S. Life satisfaction in the internet age–changes in the past decade. Comput Hum Behav. 2016;54:197–206.
18. Cho H, Choi M, Lee H. Mobile internet use and life satisfaction among older adults: the moderating effect of living alone. J Appl Gerontol. 2023;1–9.
19. Heo J, Chun S, Lee S, et al. Internet use and well-being in older adults. Cyberpsychology Behav Social Netw. 2015;18(5):268.
20. Massey B, Edwards AV, Musikanski L. Life satisfaction, affect, and belonging in older adults. Appl Res Qual Life. 2021;16(3):1205–1219.
21. Nagargoje VP, James KS, Muhammad T. Moderation of marital status and living arrangements in the relationship between social participation and life satisfaction among older Indian adults. Sci Rep-Uk. 2022;12(1):20604.
22. Banerjee S, Boro B. Analysing the role of sleep quality, functional limitation and depressive symptoms in determining life satisfaction among the older Population in India: a moderated mediation approach. BMC Public Health. 2022;22(1):1933.
23. Hu X, Chen Q. The Effect of Social Participation on the life satisfaction in older adults living alone based on the Mediating Role of Depression. Chin Health Service Manage. 2024;41(09):1048–1051. (in Chinese).
24. Chai HW, Jun HJ. Relationship between ties with adult children and life satisfaction among the Middle-Aged, the Young-Old, and the oldest-old Korean adults. Int J Aging Hum Dev. 2017;85(4):354–376.
25. Johnson KJ, Mutchler JE. The emergence of a positive gerontology: from disengagement to social involvement. Gerontologist. 2014;54(1):93–100.
26. Lv R, Yang L, Li J, et al. Relationship between social participation and life satisfaction in community-dwelling older adults: multiple mediating roles of depression and cognitive function. Arch Gerontol Geriat. 2024;117:105233.
27. Kobayashi LC, Wardle J, von Wagner C. Internet use, social engagement and health literacy decline during ageing in a longitudinal cohort of older English adults. J Epidemiol Commun H. 2015;69(3):6.
28. Zhang K, Kim K, Silverstein NM, et al. Social Media Communication and Loneliness among older adults: the mediating roles of Social Support and Social Contact. Gerontologist. 2021;61(6):9.
29. Zhang Y, Zhang X, Cao B, et al. Life satisfaction of the elderly living alone and its influencing factors. Chin Rural Health Service Adm. 2022;42(11):813–818. (in Chinese).
30. Li C, Chi I, Zhang X et al. Urban and rural factors associated with life satisfaction among older Chinese adults. 2015.
31. Yang H, Zhang S, Cheng S, et al. A study on the impact of internet use on depression among Chinese older people under the perspective of social participation. Bmc Geriatr. 2022;22(1):1–701.
32. Liao Z, Zhou H, He Z. The mediating role of psychological resilience between social participation and life satisfaction among older adults in China. Bmc Geriatr. 2022;22(1):948.
33. Cheng X, Ge T, Cosco TD. Internet use and life satisfaction among Chinese older adults: the mediating effects of social interaction. Curr Psychol. 2023;1–8.
34. Rosenbaum PR, Rubin DB. Constructing a Control Group using Multivariate Matched Sampling methods that incorporate the Propensity score. Am Stat. 1985;39(1):33.
35. Rubin DB. Reflections stimulated by the comments of Shadish (2010) and West and Thoemmes (2010). Psychol Methods. 2010;15(1):38–46.
36. Karlson KB, Holm A, Breen R. Comparing regression coefficients between same-sample nested models using Logit and Probit: a New Method. Sociol Methodol. 2012;42(1):286–313.
37. Kohler U, Bernt Karlson K, Holm A. Comparing coefficients of nested nonlinear probability models. Stata J. 2011;11(3):420–438.
38. Lee S, Lee J, Choi I. Life satisfaction in later life: the interplay of Marital Condition and Income among Elderly koreans. Sustainability-Basel. 2020;12(8):8.
39. Ang S. Internet use and cohort change in social connectedness among older adults. Adv Life Course Res. 2022;54:10.
40. Sarkar M, Kasemi N, Majumder M, et al. Physical and mental health among older parents: does offspring migration and living arrangement matter? Findings from Longitudinal Aging Survey in India (2017-18). Ssm - Popul Health. 2023;24:101503.
41. Sun X, Yan W, Zhou H, et al. Internet use and need for digital health technology among the elderly: a cross-sectional survey in China. BMC Public Health. 2020;20(1):1386.
42. Lifshitz R, Nimrod G, Bachner YG. Internet use and well-being in later life: a functional approach. Aging Ment Health. 2018;22(1):85–91.
43. Hou B, Li Y, Wang H. Internet use and health status among older adults: the mediating role of social participation. Front Public Health. 2022;10:1072398.
44. Meehan DE, Grunseit A, Condie J, et al. Social-ecological factors influencing loneliness and social isolation in older people: a scoping review. Bmc Geriatr. 2023;23(1):726.
45. Nagao-Sato S, Akamatsu R, Karasawa M, et al. Associations between patterns of participation in community activities and social support, self-efficacy, self-rated health among community-dwelling older adults. J Psychiatr Res. 2023;157:82–87.
46. Lim S, Cox NJ, Tan QY, et al. Volunteer-led physical activity interventions to improve health outcomes for community-dwelling older people: a systematic review. Aging Clin Exp Res. 2021;33(4):843–853.
47. Beier ME, Torres WJ, Gilberto JM. Activities Matter: Personality and Resource Determinants of Activities and their Effect on Mental and Physical Well-being and Retirement Expectations. Work, Aging and Retirement. 2018;4(1):67-78.

48. Sghaier S, Asiamah N, Danquah E, et al. Information technology ability mediates the association between older adults' subjective age and social activity: a STROBE-compliant cross-sectional analysis. Arch Gerontol Geriat. 2022;103:104790.
49. Yoon H, Jang Y, Kim S, et al. Trends in Internet Use among older adults in the United States, 2011–2016. J Appl Gerontol. 2021;40(5):466–470.
50. Shao Q. Does less working time improve life satisfaction? Evidence from European Social Survey. Health Econ Rev. 2022;12(1):1–18.
51. Jiang Y, Xie Y, Shao Q. How did internet usage affect life satisfaction before and after COVID-19? Mediating effects and heterogeneity analysis. Socio-Econ Plan Sci. 2024;95:102007.
52. Phulkerd S, Thapsuwan S, Chamratrithirong A, et al. Influence of healthy lifestyle behaviors on life satisfaction in the aging population of Thailand: a national population-based survey. BMC Public Health. 2021;21(1):43.

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