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Research Report

Effect of Internet Use on Cognitive Function of Middle-Aged and Elderly Adults in China: Evidence from China Family Panel Studies

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Abstract.
Background: The development and popularization of the Internet provides an important opportunity to advance national strategies for healthy aging, particularly the impact of the Internet on cognitive function in middle-aged and older adults.
Objective: This study aimed to quantify the impact of Internet use on the cognitive health of middle-aged and older adults (aged $\geq$ 45 years).
Methods: We used data from the Chinese Family Panel Study (CFPS) survey, tested the robustness of the baseline findings by variable substitution and instrumental variables methods, and analyzed heterogeneity. Subsequently, five purposes of Internet use that affect cognitive function were analyzed in depth.
Results: Internet use may improve cognitive function in middle-aged and older adults. The effect of Internet use on cognitive function was more pronounced in the lower age group (45–59 years), among males, in rural areas, and among middle-aged and older adults with higher levels of education. Cognitive functioning of middle-aged and older adults varied according to how often they used the Internet for entertainment, socialization, study, work, and business activities.
Conclusions: The use of the Internet may be considered a practical non-pharmacological intervention to slow cognitive decline in middle-aged and older adults.

Keywords: Alzheimer's disease, cognitive function, Internet use, heterogeneity analysis, instrumental variable

INTRODUCTION

Population aging is a global issue. China has the largest and fastest-growing number of people with cognitive disorders [1]. The respective incidence, mortality, and disability-adjusted life year (DALY) rates of dementia in China increased from

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43.32/100,000, 7.88/100,000, and 155.95/100,000 in 1990 to 126.57/100,000, 22.55/100,000, and 420.22/100,000 in 2019. In 2019, the standardized incidence, mortality, and DALY rates of dementia in China were higher than those globally [2]. Dementia substantially burdens society, families, and individuals [3, 4]. Early cognitive decline may evolve into dementia [5]. Unfortunately, there is no effective cure for dementia. *The Lancet* [6] published 12 risk factors that may lead to the onset of dementia cases, including low education, hearing loss, hypertension, obesity, smoking, alcohol intake, depression, lack of exercise, social isolation, diabetes and air pollution. These variables cause 40% of dementia in China, 41% in India, and 56% in Latin America [7]. Neurology researchers have revealed that cognitive therapies for middle-aged and older adults can remodel nerves like the cerebral cortex and hippocampus, which are critical for learning, memory, and cognition [8].

Moreover, the Internet use scale among the middle-aged and elderly rapidly expands. The number of netizens in China has reached 106.7 billion, with an internet penetration rate of 75.6%, nearly 280 million "silver-haired Internet users" over 50 years [9]. The Internet continues to penetrate the daily lives of middle-aged and elderly people. Much prior research has shown [10–13] that Internet manipulation stimulates the brain's central nervous system, inducing neurological connectivity changes and, thus, brain function recovery. A 10-year study found that Internet use reduced the incidence of cognitive impairment in Brazilian older adults [14]. According to many studies, computers and other technologies may improve memory and orientation in older people [15–17]. Therefore, using the Internet may be considered an advantageous tool to prevent/improve cognitive decline.

Previous studies have mostly focused on the relationship between various risk factors and cognitive disorders [18, 19] or explored the effects of various nonpharmacological interventions [20]. Regarding Internet use, the main studies have been related to mental health [21, 22], life satisfaction [23], well-being of the elderly [24], and support from family caregivers for dementia patients [25]. However, there is limited research on the relationship between internet use and cognitive function. Furthermore, Internet use has not been studied in detail in the existing literature [26]. Most previous cognitive level tests are too crude, yet cognitive measurements encompass numerous dimensions, and using individual items may be less accurate [27]. The causal relationship between the two has not been addressed [27, 28]. Considering this, this study further confirms the impact of internet use on cognitive function in middle-aged and elderly people. Second, the robustness of the results was examined using instrumental variable and the substitution of dependent variables method. Finally, we explored the differential effects of the five purposes of Internet use on cognitive functioning and analyzed the potential reasons. This will complement and expand the evidence on the cognitive impact of Internet use on middle-aged and older adults in the Chinese context.

METHODS

Sample and data processing

The 2010 China Family Panel Study (CFPS) baseline sample covers 25 provinces, municipalities, or autonomous regions, representing 95% of the Chinese population. The researchers who conducted the 2010 baseline survey interviewed a total of 14,960 households and 42,590 individuals. Furthermore, they initiated a long-term follow-up survey of individual samples. The data for the present study were from CFPS survey data collected in 2014 (wave 3), 2016 (wave 4), and 2018 (wave 5), which numbered a total of 111,393 samples. These survey data were obtained using the same cognitive test questions, and the Internet use module was tested. This study used the wave 3 data as the baseline data and used waves 4 and 5 data as follow-up data. Furthermore, the following samples were excluded: (1) samples < 45 years old and the unreasonable ($n = 53{,}705$); (2) samples that only appeared once ($n = 5{,}169$) (samples that had been followed-up at least once were retained); (3) samples with missing control variables ($n = 9{,}946$); (4) samples with missing standardized core variable values (cognitive total, vocabulary test, and figure test scores were standardized based on year and age) ($n = 25$). Eventually, this study included a total of 42,548 benchmark analysis samples. Figure 1 illustrates the exclusion criteria and the respondent screening process.

Description of variables

The dependent variable was cognitive function. The three cognitive function measurement indicators were obtained from the CFPS vocabulary and figure test scores and the total score of the vocabulary

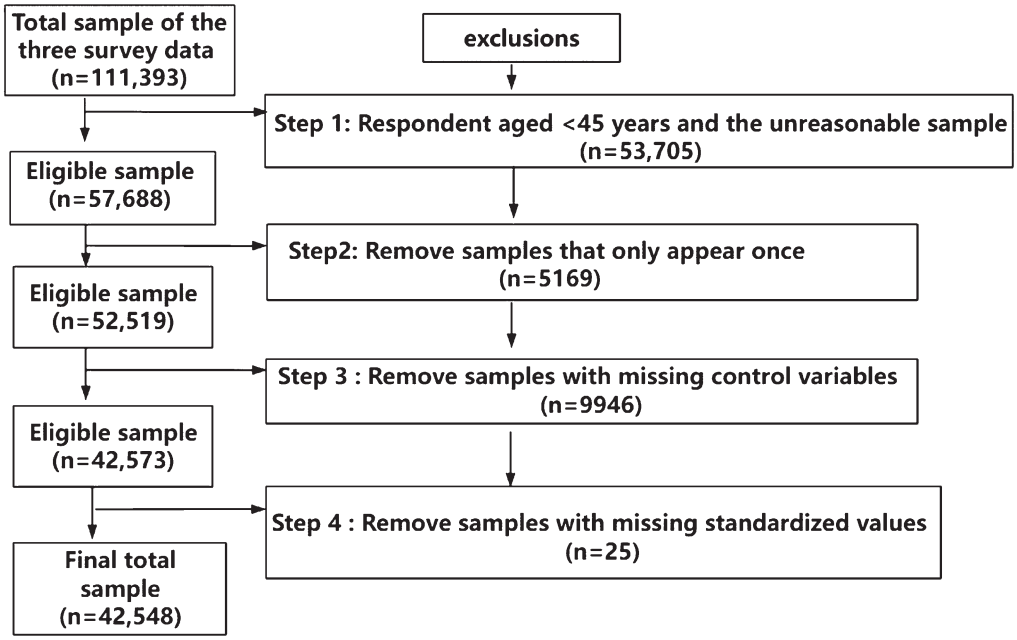

Fig. 1. Flowchart showing respondent screening.

and figure tests. The vocabulary test involved literacy and memory tests, while the figure test involved calculation and sequence tests. In the literacy and calculation tests, the interviewer showed the respondents 34 Chinese characters and 24 figure questions that progressed from easy to difficult. The test was ended if the respondent answered three consecutive questions incorrectly. The respondent's correct answer to the most difficult question determined their score based on the sequence position. The comparability of scores across different years was ensured using the comparability-adjusted scores provided by CFPS [29].

Independent variables: internet use. In this study, we examined internet use from the following two aspects: Internet use: This is confirmed by asking either "mobile access" or "computer access. If one of the two questions is positive, the answer is "yes," and if both are "no," the answer is "no." Frequency of using the Internet for various purposes: Frequency of Internet use for five purposes: entertainment, socializing, studying, working, and business. For example, the question on the frequency of using the Internet for entertainment: "In general, how often do you use the Internet for entertainment (watching videos and downloading songs)?" The other four uses are the same and will not be repeated. In this study, the variable was simplified and logically related according to the distribution of the data characteristics: the seven inverse variables (7 = Almost every day; 6 = 3–4 times a week; 5 = 1–2 times a week; 4 = 2–3 times a month; 3 = once a month; 2 = once a few months; 1 = never) were combined and coded into the following five ordinal variables (1 = never; 2 = rarely used; 3 = generally used; 4 = frequently used; and 5 = always used).

Control variables. Previous studies [30] have linked Internet use and cognitive ability to gender, age, urban/rural, education level, health status, chronic disease status, marital status, retirement status, family income, cohabitation of children with parents, and social security (health insurance and pension insurance). Therefore, all these variables were included in the control variables to minimize their confounding effects on Internet use. Most control variables were re-coded as the questionnaire options were excessively granular (Table 1).

Data analysis

Table 1 presents the basic characteristics of the study sample. The participants' characteristics were summarized using the mean for variables. How Internet use affected the respondents' cognitive function was determined using the following measurement model:

Table 1
Definitions of variables and descriptive statistics

Variables	Description	Mean	SD	Min.	Max.
Cognitive function	Cognitive total scores	0.00	1.00	–2.88	3.40
Vocabulary test scores	0.00	1.00	–3.17	4.02	
Figure test scores	0.00	1.00	–3.82	4.48	
Internet use	Internet access (0 = no; 1 = yes)	0.15	0.36	0.00	1.00
Personal factors					
Gender	0 = female; 1 = male	0.49	0.50	0.00	1.00
Age	years	59.58	9.68	45.00	94.00
Urban/rural residence	0 = rural; 1 = urban	0.46	0.50	0.00	1.00
Educational level	The highest educational level (1 = illiterate/semi-illiterate; 2 = primary school; 3 = junior high school; 4 = high school/vocational school/technical school/vocational high school; 5 = junior college; 6 = bachelor's degree; 7 = master's degree; 8 = doctoral degree)	2.16	1.18	1.00	7.00
Employment status	Currently working (0 = no; 1 = yes)	0.43	0.50	0.00	1.00
Health status	Self-rated health status (1 = very healthy; 2 = healthy; 3 = relatively healthy; 4 = average; 5 = unhealthy)	3.37	1.23	1.00	5.00
Chronic diseases	Any chronic disease within six months (0 = no; 1 = yes)	0.25	0.43	0.00	1.00
Family factors					
Partner	Unpartnered (unmarried, divorced, and widowed) or partnered (married or cohabiting) (0 = no; 1 = yes)	0.87	0.33	0.00	1.00
Cohabitation with children	Are you currently cohabiting with your children (0 = no, 1 = yes)	0.54	0.50	0.00	1.00
Per capita net household income	Total income of all family members divided by the number of family members	1.52	2.11	0.00	148.40
Social security					
Medical insurance	0 = No; 1 = yes	0.77	0.42	0.00	1.00
Endowment insurance	0 = No; 1 = yes	0.94	0.24	0.00	1.00

The three scores were standardized by year to yield standard variables with a mean of 0 and a variance of 1 each year to render the data comparable.

$$\text{Congn}_{\text{ijt}} = \delta + \beta\ \text{Internet}_{\text{ijt}} + \gamma\ \text{Control}_{\text{ijt}} + \mu_j + \tau_t + \varepsilon_{\text{ijt}}$$

where Congn_{ijt} is the cognitive function test score of the middle-aged and elderly adults i in province j in year t, which involved three dimensions: cognitive total score, vocabulary test score, and figure test score. Internet_{ijt} is the Internet use of middle-aged and elderly adults i in year t. β is the coefficient of interest, representing the influence of Internet use on the cognitive function of middle-aged and elderly adults. To compensate for the issue of missing variables as much as possible, Control_{ijt} refers a series of control variables that include three aspects: (1) personal factors (gender, age, urban and rural classification, education level, retirement, health status, and chronic diseases); (2) family factors (marital status, partnered or unpartnered, cohabitation or non-cohabitation with children, and per capita family income); (3) social security (whether contributing to medical and endowment insurance). μ_j and τ_t refer to the province fixed effect and year fixed effect, respectively. ε_{ij} is the stochastic error term. All analyses were performed using STATA.

RESULTS

Analysis of the effect of Internet use on middle-aged and elderly adults' cognitive function

Baseline results. The basic analysis results are shown in Table 2. Internet use positively affected the respondents' vocabulary, figure, and total test scores and significantly influenced the vocabulary and total test scores. The cognitive function of respondents was related to gender ($p < 0.01$). The respondents' cognitive function differed significantly between the genders, where the men had better cognitive function than the women. The cognitive function of respondents was related to age ($p < 0.01$), where their cognition function declined with age. The cognitive function of respondents was related to residence ($p < 0.01$), where city dwellers had better cognition than rural dwellers. Respondents with higher education levels had higher cognitive function ($p < 0.01$). The cognitive function of respondents was related to retirement ($p < 0.01$), whereas employed respondents had a better cognitive function. The respondents' health status significantly negatively affected the

Table 2
Baseline analysis of the effect of Internet use on the respondents' cognitive function

Variable	Cognitive total score	Vocabulary test score	Figure test score
Internet use	0.115*** (0.014)	0.245*** (0.012)	0.017 (0.015)
Gender	0.096*** (0.009)	0.167*** (0.008)	0.066*** (0.009)
Age	0.007*** (0.001)	0.010*** (0.001)	0.006*** (0.001)
Urban/rural	0.074*** (0.010)	0.119*** (0.009)	0.025** (0.010)
Education level	0.313*** (0.005)	0.390*** (0.004)	0.311*** (0.005)
Retirement status	0.094*** (0.011)	0.128*** (0.010)	0.071*** (0.011)
Health condition	0.001 (0.004)	–0.018*** (0.012)	0.005 (0.004)
Partner	0.017 (0.014)	0.081*** (0.012)	–0.009 (0.014)
Number of children cohabiting	–0.002 (0.009)	0.014* (0.008)	–0.000 (0.009)
Per capita annual income	0.014*** (0.004)	0.016*** (0.004)	0.010** (0.004)
Endowment insurance	0.105*** (0.011)	0.035*** (0.010)	0.106*** (0.011)
Medical insurance	0.030 (0.019)	0.105*** (0.017)	–0.002 (0.019)
R^2	0.186	0.345	0.149
Observations	42548	42548	42548

*$p<0.1$, **$p<0.05$, ***$p<0.01$. All columns in the table present robust standard error regression results, which controlled for three factors: personal, family, and social security. Standard errors are presented in parentheses. Standardized coefficients are in square bracket.

Table 3
Instrumental variable results of the effect of Internet use on cognition

	Stage 1	Stage 2		
Variable		Vocabulary test score	Figure test score	Total test score
Internet use		0.492***	–0.053	0.136***
		(0.032)	(0.036)	(0.036)
Instrumental variable	0.826***			
F value	1732			
R^2	0.363	0.326	0.148	0.183
Observations	42548	42548	42548	42548

*$p<0.1$, **$p<0.05$, ***$p<0.01$. Average Internet usage level among middle-aged and elderly people in the community as an instrumental variable.

vocabulary test score but not the figure and total test scores ($p<0.01$). Endowment insurance affected the vocabulary, figure, and total test scores, while medical insurance only affected the vocabulary test scores ($p<0.01$).

Endogenous analysis. Due to certain unobservable factors that can simultaneously affect the Internet usage and cognitive function of middle-aged and elderly people, the regression residuals and independent variables generated by missing these factors did not meet the independent conditions, resulting in endogeneity issues of omission bias. This study alleviated the endogeneity issues mentioned above by using the respondents' community average level of Internet usage (excluding the respondents' web use per se) as the instrumental variable. Given the similar political, economic, cultural, and social development situations in the same community, the average level of Internet use in the community and Internet use by middle-aged and elderly people were potentially correlated. Additionally, excluding the Internet usage of middle-aged and elderly people also satisfies the exogeneity hypothesis somewhat. Many studies used this method to construct instrumental variables and effectively solve the synchronization endogeneity issue between the explanatory variable and dependent variable caused by measurement errors and omitted variables, which are jointly determined by a certain factor [31, 32].

Table 3 depicts the regression results. The first-stage regression findings have F values > 10, indicating that the instrumental variable was plausible. The second-stage regression results demonstrated that Internet use significantly influenced the respondents' vocabulary scores and total test scores after considering the reverse causality, while Internet use had no significant effect on the figure test scores. Based on the above discussion, it is believed that endogeneity issues did not seriously affect the earlier results. Therefore, the study conclusion was relatively reliable.

Robustness testing. Cognitive function can be divided into mobile intelligence and fixed intelligence, which both decrease by the year with age

Table 4
Robustness analysis of the influence of Internet use on cognitive ability

Variable	Intelligence level		Recent memory	
	Control personal factors	Control all factors	Control personal factors	Control all factors
Internet use	0.089*** (0.018)	0.078*** (0.018)	0.083*** (0.019)	0.079*** (0.019)
R^2	0.116	0.118	0.028	0.028
Observations	42,544	42,544	42,456	42,456

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$.

Table 5
Analysis of age heterogeneity

Variable	Vocabulary test		Figure test	
	45∼59 years old	≥ 60 years old	45∼59 years old	≥ 60 years old
Internet use	0.219***	0.224***	–0.024	0.071**
	(0.014)	(0.024)	(0.015)	(0.034)
R^2	0.352	0.345	0.168	0.133
Observations	22,241	20,307	22,241	20,307

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$.

Table 6
Analysis of gender heterogeneity

Variable	Vocabulary test		Figure test	
	Male	Female	Male	Female
Internet use	0.235***	0.204***	0.041**	–0.032
	(0.016)	(0.018)	(0.020)	(0.021)
R^2	0.268	0.377	0.141	0.138
Observations	20,871	21,677	20,871	21,677

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$.

[33]. Mobile intelligence is related to thinking ability and memory, which begins to decline in a person's twenties, while fixed intelligence gradually increases and then begins to decline after the age of 60 or 70 years. Nevertheless, overall cognitive function decreases with age. Given brain nerve plasticity towards environmental needs and stimuli, cognitive training can significantly activate specific brain network activities, enhancing mobile intelligence [30, 34]. Increasing cognitive reserve in later years can improve elderly people's cognitive function [35].

This study selected the intelligence level and recent memory indicators in the CFPS questionnaire to replace the dependent variables for the robustness test. Table 4 presents the robustness test results, where Columns 1 and 3 demonstrate that Internet use significantly improved intelligence and recent memory resilience test outcomes, respectively, after controlling personal characteristics. The results remained significant after controlling the individual, family, and social security factors (Table 4, Columns 2 and 4), indirectly indicating that Internet use improved the respondents' cognitive function.

Heterogeneity analysis of the influence of Internet use on middle-aged and elderly adults' cognition

Internet use improves the cognitive performance of middle-aged and elderly Chinese adults, but the effect may vary depending on their background. Therefore, this study analyzed the influence of Internet use on the respondents' cognitive function from four perspectives: age, gender, urban/rural area, and education level. The sample was separated into the younger age group (45–59 years old, i.e., middle-age group) and the old age group (≥60 years old, i.e., old age group) (Table 5). Internet use positively affected the vocabulary test scores of both groups ($p < 0.01$) and had a promoting effect on the figure test scores of the older group ($p < 0.05$).

The respondents were also divided into two subsamples (male and female) to analyze the gender differences in the cognitive effect of Internet use on middle-aged and elderly people (Table 6). The results demonstrated that Internet use improved both male and female respondents' vocabulary test scores ($p < 0.01$). Internet use was positively associated with

Table 7
Analysis of urban–rural heterogeneity

Variable	Vocabulary test		Figure test	
	Urban	Rural	Urban	Rural
Internet use	0.226*** (0.015)	0.261*** (0.019)	0.002 (0.019)	0.019 (0.021)
R^2	0.329	0.300	0.159	0.116
Observations	19,427	23,121	19,427	23,121

*$p<0.1$, **$p<0.05$, ***$p<0.01$.

Table 8
Analysis of education level heterogeneity

Variable	Vocabulary test			Figure test		
	Illiterate	Primary and junior high school	High school and above	Illiterate	Primary and junior high school	High school and above
Internet use	0.341*** (0.040)	0.299*** (0.015)	0.151*** (0.021)	–0.009 (0.036)	0.341*** (0.040)	0.298*** (0.015)
R^2	0.099	0.124	0.087	0.021	0.099	0.124
Observations	16,802	19,832	5914	16,802	16,802	19,832

*$p<0.1$, **$p<0.05$, ***$p<0.01$.

the men's figure test scores ($p<0.05$). Furthermore, the respondents were divided into urban and rural sub-samples to analyze the urban–rural differences in the cognitive effect of Internet use on middle-aged and elderly adults (Table 7). The results demonstrated that Internet use was positively associated with the vocabulary test scores of both groups ($p<0.01$) but did not affect their figure test scores.

Table 8 demonstrates that the respondents were separated into three sub-samples according to education level (illiterate, primary school and junior high school, high school and above) to assess the health effects of Internet use on middle-aged and elderly people. The result demonstrated that Internet use had a promoting effect on the vocabulary and figure test scores of respondents with other educational levels, except for the insignificant impact on the figure test scores of illiterate respondents.

The effect of different Internet use purposes on middle-aged and elderly adults' cognitive function

The frequency of Internet use for five purposes (entertainment, social, learning, work, and business activities) was summarized based on the literature review and CFPS questionnaire analysis. The data analysis results demonstrated that the respondents with higher frequencies of engaging in learning, work, social, entertainment, and business activities through the Internet had significantly higher vocabulary test scores ($p<0.01$). The high scores increased the possibility of alleviating cognitive decline somewhat. The five Internet use purposes exerted inconsistent effects on the figure test scores, where a significant effect was recorded only for the respondents who used the Internet for learning and business activities (Fig. 2).

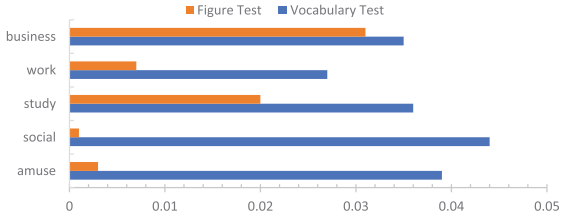

Fig. 2. The effect of five Internet use purposes on the respondents' cognitive function.

DISCUSSION

Principal findings

China faces extraordinary opportunities and challenges due to population aging and Internet development. This national survey indicated that middle-aged and older Internet users had higher cognitive abilities than non-users, which was consistent with international research [36]. The stability of the results was verified using the average Internet usage level among middle-aged and elderly people in the community as the instrumental variable. This finding suggested that Internet use may positively affect the cognitive function of middle-aged and older adults. The effect demonstrated some heterogeneity regard-

ing gender, age, urban/rural type, and literacy level, which was similar to the findings of Chen Ping [37].

The influence of the five Internet use purposes on the cognitive function of middle-aged and elderly people should be discussed in-depth. Activity theory [38] states that older adults need new social participation and social relationships to adapt to the disruption of old ones. Using the Internet for socialization and entertainment can be a means of social participation to satisfy these adults' emotional needs. From the perspective of brain evolution, the individual's need for emotion directly or indirectly contributes to generating a particular neuronal network and improves cognition [39]. Additionally, broad social networks in later life may aid cognitive reserve creation [36] and minimize dementia risk [40, 41]. Social networks can act as cognitive stimulation for elderly people. Middle-aged and elderly people can choose personalized entertainment from various options online to enrich their later lives. Furthermore, online gaming aids the moderation of cognitive decline [13].

Negative emotions are risk factors for cognitive functioning in older adults [6]. Internet intervention can reduce social isolation, anxiety, and depression by increasing communication with friends and family [42], specifically for activity-restricted or empty-nesting elderly people. It is particularly important to establish and maintain close relationships with family members through social networks [43]. This study determined that using the Internet for entertainment and expanding social interactions improved the respondents' vocabulary test scores.

Studying or working using the Internet broadens the channels of obtaining resources. Middle-aged and elderly people can study or work with various applications (apps) and software, which allows them to cultivate their hobbies, exercise their learning ability and memory, and satisfy their needs for self-realization after retirement. Moreover, browsing the Internet to obtain information on health maintenance and health care improves health literacy, positively affecting cognitive decline [44]. Brain nerves have a certain degree of plasticity to environmental demands and stimuli, particularly for learning new knowledge and skills [35]. Frequent Internet use as a cognitively stimulating activity might prevent cognitive decline by thickening the associated cortex in the frontotemporal lobe [45]. Among older adults (55∼76 years) who use the Internet, Internet searches stimulate more neural circuits in the brain compared to reading text [46]. Relying on learning and using cognitive strategies can slightly compensate for the decline in memory capacity due to aging and aid the alleviation of cognitive decline [47]. This study determined that using the Internet for study and work improved the respondents' vocabulary test scores.

Compared to entertainment, socialization, and work activities, the respondents' Internet use for learning and business activities positively influenced their figure test scores. The effect might have been due to the fact that using computing ability, concentration, and reasoning in online learning and business activities increases cognitive stimulation in the brain [12]. Thus, the respondents' more frequent Internet use to engage in commercial activities and study exerted a greater positive effect on their vocabulary and figure test scores.

In summary, the findings support the premise that Internet use is greatly relevant for enhancing cognitive functioning in middle-aged and older adults, especially in the cognitive decline group, and can be used as a practical non-pharmacological intervention.

Strengths and limitations

Cognitive function involves multiple dimensions, and the assessment is relatively complex. Previous studies mainly used individual items to measure cognitive function, which might not be the optimal method. This study ensures better reliability and validity using the three measurement indicators of cognitive ability obtained from the vocabulary and figure test scores in CFPS and the total scores of the two tests and used model replacement methods (intelligence and recent memory levels). Utilizing multiple replacement variables, the results confirmed the link between Internet use and cognitive function in middle-aged and older Chinese people.

To the best of our knowledge, this study is among the few studies to use the average Internet usage level among middle-aged and elderly people in the community as the instrumental variable to alleviate endogeneity issues. Redefining the purposes of Internet usage refined the broad definition of the Internet. The differential effects of the five Internet use purposes on mitigating cognitive decline were explored, and the underlying reasons were explained. The Internet might be an important non-pharmacological intervention to improve cognitive function. The findings provided theoretical support and suggestions for future intervention studies.

This study has three limitations. Thus, the results should be interpreted with caution. First, the observational study limited the authors' capacity to analyze

Internet use and cognitive deterioration causally. Second, whether social isolation and emotions are possible influencing factors was not verified. The relationship between the three requires further investigation. Finally, given the newness of the Internet, middle-aged and elderly people are actively or passively marginalized and face the digital divide dilemma. The relationship between intergenerational family support, Internet use, and cognitive function must also be explored.

Conclusions

Based on 2014, 2026, and 2018 CFPS data, this study empirically demonstrated that Internet use improved middle-aged and older Chinese adults' cognitive function and that this result was relatively robust. Second, compared to the older female respondents living in urban areas and those with high levels of education or illiteracy, Internet use contributed more to the cognitive functions of younger male respondents living in rural areas and those with primary and junior high school education. Third, Internet use affected the respondents' cognitive processes via entertainment, socialization, study, employment, and business activities. To further exert the positive effect of the Internet on the cognition of middle-aged and elderly people, it is asserted that attention should be focused on the background differences between different middle-aged and elderly groups, accurately grasp their differing usage needs, and create a good aging-appropriate network access environment to enhance their Internet use practically.

AUTHOR CONTRIBUTIONS

Xuefei Xia (Data curation; Methodology; Project administration; Resources; Writing – original draft; Writing – review & editing); Peng Cai (Project administration; Resources; Supervision; Visualization); Pingqiao Yuan (Formal analysis; Methodology; Supervision; Writing – original draft); Xue Zhao (Methodology; Software); Fangrong Jia (Resources; Supervision; Visualization); Bangyang Li (Methodology; Software).

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CONFLICT OF INTEREST

The authors have no conflict of interest to report.

DATA AVAILABILITY

The data for this article came from the following public resource: http://www.isss.pku.edu.cn/cfps/.

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