Journal of Gerontological Social Work

ISSN: 0163-4372 (Print) 1540-4048 (Online) Journal homepage: www.tandfonline.com/journals/wger20

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To cite this article: Xinyi Zhao, Xiao Han, Vivian W. Q. Lou & Zhiyue Zhang (2025) Influence of New Internet Usage on Depressive Symptoms Among Older Adults: Does the Effect Vary in People with Different Economic Status?, Journal of Gerontological Social Work, 68:1, 37-52, DOI: 10.1080/01634372.2024.2428254

To link to this article: https://doi.org/10.1080/01634372.2024.2428254

JOURNAL OF GERONTOLOGICAL SOCIAL WORK
2025, VOL. 68, NO. 1, 37–52
https://doi.org/10.1080/01634372.2024.2428254

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Influence of New Internet Usage on Depressive Symptoms Among Older Adults: Does the Effect Vary in People with Different Economic Status?

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ABSTRACT

This study investigated the longitudinal effect of new internet usage on depressive symptoms and whether economic status modified this association. Data were from the China Health and Retirement Longitudinal Study, involving 5,259 participants who were 60 +, did not use the internet in 2015, and were followed up in 2018. Linear regression with standard errors clustered at the city level was employed. We found that new internet usage was associated with less depressive symptoms, and the association was more profound among the poor participants. It implies that bridging the digital divide requires special attention to those with disadvantaged economic status.

ARTICLE HISTORY
Received 16 March 2023
Accepted 7 November 2024

KEYWORDS
New internet usage; depressive symptoms; economic status; older adults

Introduction

With the rapid development of information and communication technology (ICT), internet use has become increasingly omnipresent in daily life. Despite the growing pervasiveness of internet use among older adults, the so-called gray digital divide, defined as "the low internet use of older adults and their exclusion from this medium" (Alexopoulou et al., 2022, p. 5), persistently exists, especially in developing countries (Mubarak, 2018). Prior research has demonstrated that advantageous socioeconomic status (SES) is associated with higher odds of internet use among older adults (Huxhold et al., 2020), and it has also been found that internet use could benefit old people's psychological well-being (Lifshitz et al., 2018; Sims et al., 2017). However, whether the outcomes of internet use would differ among older adults by economic status is still unclear. Therefore, it is meaningful to explore the associations among internet usage, older people's psychological well-being, and their economic status, and whether any moderating relationships exist.

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Supplemental data for this article can be accessed online at https://doi.org/10.1080/01634372.2024.2428254

A growing number of studies have examined the association between internet use and psychological well-being among older adults. However, their conclusions are inconsistent. The majority of studies revealed a significant association between internet use and better mental health (Heo et al., 2015; Quittschalle et al., 2020; Song et al., 2019; Wallinheimo & Evans, 2022; Yuan, 2021). In contrast, several studies have shown that internet use was linked with an elevated level of depressive symptoms or a reduced level of life satisfaction among older people in studies from different regions (Hamilton, 2021; Xie et al., 2021). The disparate findings might be attributed to different study designs, such as their regional coverage and the sample representativeness (Y. Wang et al., 2019).

Moreover, most of the existing studies (Heo et al., 2015; Mohan & Lyons, 2022; Quittschalle et al., 2020; Yuan, 2021) have adopted cross-sectional designs. For instance, Heo et al. (2015) utilized data from the 2008 health and Retirement Study (HRS) in the United States and found that higher levels of internet use were related to higher life satisfaction. Another cross-sectional study involving people aged 75 and over in Germany indicated that internet use was associated with lower levels of depressive symptoms (Quittschalle et al., 2020). In addition, other cross-sectional studies used data from a particular city or province in China. For example, Sun et al. (2020) research in Heilongjiang province found that older people with higher levels of quality of life were more likely to use the internet, while Yuan (2021) research in Shanghai revealed that older adults who used the internet more frequently were less likely to report mental health problems. However, the lack of representativeness and the randomness of the sample might have affected the accuracy of the results (Ma & Sheng, 2023).

In recent years, there have been some studies with longitudinal designs. However, most of them used data from high-income regions, such as the United States (K. Yu et al., 2021), England (Lam et al., 2020; B. C-P. Liu, 2020), and New Zealand (Szabo et al., 2019). For example, a study based on the English Longitudinal Study on Ageing (ELSA) identified that regular use of the internet by older adults predicted lower levels of loneliness 2 years later (B. C-P. Liu, 2020). Lam et al. (2020) utilized data from the 6–8 waves of ELSA and found that internet use for communication was associated with decreased levels of depressive symptoms, whereas internet use for information was associated with lower life satisfaction. Szabo et al. (2019) revealed that internet use for social purposes was related to reduced loneliness among older adults in New Zealand over time. From what we have seen, longitudinal studies using national samples from developing countries, such as China, are far from adequate. Among a limited number of studies, D. Yu and Fiebig (2020) used data from the China Health and Retirement Longitudinal Study (CHARLS) and determined that internet use was a protective factor against cognitive decline among middle-aged and older adults. In general,

a lack of longitudinal evidence about psychological outcomes from developing regions is evident.

There are three levels of the digital divide: access, use, and outcomes (Lythreatis et al., 2022; van Deursen & Helsper, 2015). The first level refers to the gap of physical access to the internet (such as affordability of a computer or an internet subscription) between the haves and the have-nots (L. Yu, 2006). The second level involves the inequalities in knowledge, skills, and other aspects of digital literacy (Aissaoui, 2021; Hargittai, 2002), which determine the actual use of the internet (van Dijk, 2005). The third level involves the differences in the outcomes from internet use among those who have similar access to the internet and usage profiles (Cheshmehzangi et al., 2022; van Deursen & Helsper, 2015). Studies on the third level of the digital divide typically attempt to identify who benefits from internet use in what ways (van Deursen & Helsper, 2015). Empirical research on the first level of the digital divide (Atkinson et al., 2008; Lentz & Oden, 2001; van Deursen & van Dijk, 2019) and the second (Gallistl et al., 2020; Heponiemi et al., 2022; Huxhold et al., 2020; B. C-P. Liu, 2020; van Deursen et al., 2011; van Dijk, 2012) has captured inequalities of access to and use of ITCs by examining sociodemographic diversities (such as age, gender, income), showing that people with a less privileged SES were less likely to access and use the internet.

In recent years, research focus has shifted from access to ICT (i.e., first-level digital divide) and use of ICT (i.e., second-level digital divide) to who benefits from ICT (i.e., third-level digital divide). Some studies have observed that people with a better SES benefited more from internet use (Blank & Lutz, 2018; Heponiemi et al., 2020; van Deursen & Helsper, 2015). For example, a study in the United Kingdom demonstrated that individuals with better education perceived more economic, social, and health-related benefits from internet use (Blank & Lutz, 2018). Another study in Finland found that people who had experienced economic hardship reported fewer health and economic benefits from digital use (Heponiemi et al., 2020). In contrast, other studies drew different conclusions. Using data from the HRS, Byrne et al. (2021) identified that rural older people who used the internet less frequently reported greater loneliness than their urban counterparts. Similarly, a study based on the CHARLS found that rural people benefited more from internet use than their urban counterparts in terms of mental health outcomes (Liao et al., 2020). Yuan's (2021) research on older adults in Shanghai determined that internet users with low income reported fewer psychological problems than those with high income. However, research related to the third-level digital divide, which aims to determine disparities in the returns from internet use among older adults is lacking, and the majority of studies have employed cross-sectional data and been restricted to local areas.

China, a country with more than 264 million people aged 60 and above, according to the latest national census in 2020 (National Bureau of Statistics of China, 2021), has the largest elderly population in the world. The gray digital

divide is a great concern in China. According to the China Internet Network Information Center (2019), only 6.6% of internet users were people aged 60 and above in 2018. However, studies on the gray digital divide have been limited. Using data from the CHARLS, the current study focused on the third level of the digital divide and aimed to explore the differences in the psychological outcomes of internet use by economic status. Following previous research, the following hypotheses were assessed:

Hypothesis 1: Compared with nonusers, older adults who transitioned from nonusers to new users of the internet would report a lower degree of depressive symptoms.

Hypothesis 2: Older adults with lower economic status would benefit more from starting internet use.

Methods

Design and setting

This study used the 2015 and 2018 waves of the CHARLS. The CHARLS collected physical, psychological, demographic, and socioeconomic information on community-dwelling Chinese aged 45 and above. It is nationally representative due to the use of probability proportional to size (PPS) sampling. At the county level, 150 units were selected from nationwide counties after stratification. For each county-level unit, three primary sampling units (neighborhood-level PSUs) were drawn after stratification. After the two-level PPS, households were selected randomly in each PSU. More details can be found in prior research (Zhao et al., 2014). After the baseline survey in 2011, three follow-ups were conducted in 2013, 2015, and 2018. The present study explored the changes in internet use in the latest two waves. Among the original 21,097 participants, we first dropped 10,844 individuals aged below 60 years old. We further excluded 1,065 observations who reported using the internet in 2015 and 3,929 observations with missing data. Finally, 5,259 participants (i.e., potential internet users) remained for analysis.

Measures

New internet usage

In the 2015 and 2018 wave of the CHARLS, participants were asked if they had used the internet during the previous month. There were 5,259 participants who did not use the internet in 2015. Following previous research (Berner et al., 2016, 2019), the participants who did not use the internet at baseline but started using the internet in 2018 were defined as new users of the internet,

and those who still did not use it in 2018 were defined as nonusers of the internet.

Economic status

Following previous research (Y. Liu et al., 2022; Zhai et al., 2022), family income per capita (PCI) was adopted to reflect the participants' economic status. Household income was the sum of individual wages, household net income (e.g., agricultural income, businesses), and transfers in the past year (Smith et al., 2013). PCI was sorted and classified into four quartiles in this study.

Depressive symptoms

Depressive symptoms were assessed by the 10-item Center for Epidemiological Survey Depression (CES-D) questionnaire (Andresen et al., 1994). The 10-item CES-D had comparable accuracy to the original CES-D in identifying cases with depressive symptoms (Boey, 1999). The answers to the 10 questions were encoded on a 4-point scale (0–3), and higher scores indicated higher levels of depressive symptoms. The total score ranged from 0 to 30. According to previous studies (Boey, 1999; Cheng & Chan, 2005; Lei, Sun, Strauss, Zhao et al., 2014), the 10-item CES-D had good reliability and validity in the Chinese older population. In this study, Cronbach's α was 0.80 in 2015 and 0.79 in 2018.

Covariates

Covariates encompassed sociodemographic features, self-rated health, self-reported memory, the proportion of internet users to all residents in the province where the participants lived (i.e., netizen ratio in a participant's province), and CES-D at baseline. Sociodemographic features included age (a continuous variable), sex (female or male), marital status (1 = married, 0 = widowed, divorced, separated or never married), education (1 = finished primary school or above, 0 = less than primary school), and living arrangement (living alone or not). Self-reported health and memory were measured using a 5-point Likert scale from 1 (very poor) to 5 (very good). The variables of self-rated health and self-reported memory were used to reflect participants' general health condition and cognitive condition. We conducted a multicollinearity test and the variance inflation factor (VIF) was less than five, indicating that the potential for multicollinearity is negligible. The netizen ratios of all provinces were obtained from the CINIC (2015).

Analytic strategy

Descriptive statistics were used to analyze the characteristics of the participants. The differences between new users and nonusers were tested by the chi-squared test or t-test. To determine the associations among new internet usage, economic status, and CES-D, linear regression with standard errors clustered at the city level was employed, with CES-D at follow-up being calculated based on internet use transition groups after controlling for a range of baseline covariates (Model 1). To evaluate whether the association of internet use and depressive symptoms would be moderated by economic status, interaction terms for internet use transition groups × PCI were added (Model 2). In the robustness analysis, we repeated the regression models by using family expenditure per capita (PCE) to measure economic status, as PCE has also been considered as a proxy indicator to reflect older peoples' economic status in developing countries (Fang et al., 2022; Lei, Sun, Strauss, Zhang, et al., 2014). All analyses were conducted in Stata 16 (StataCorp LLC, College Station, TX, USA).

Results

Sample characteristics

Table 1 shows the descriptive statistics of all participants grouped by their start of internet usage in 2018. A total of 5,259 participants aged 60 and above were included. The average age of the participants was 66.783 (SD = 5.599). Overall, approximately 48.8% of the participants were female, two-thirds (63.5%) lived in rural areas, and 8.92% were living alone. The majority (83.4%) were married. Less than half (48.6%) had finished primary education. Participants rated their health as fair (3.029) and their memory as poor (1.814) on average. The average CES-D scores (8.954, SD = 6.676) in 2018 were higher than those (8.192, SD = 6.388) in 2015. Of the 5,259 participants who did not use the internet in 2015, 193 (3.7%) reported starting internet use by 2018. Compared with those who did not use the internet, internet users were predominantly male, younger, married, living in urban areas, dwelling in provinces with a higher netizen ratio, with higher educational attainment and family income per capita, and with better self-rated health and memory. CES-D scores in 2015 and 2018 across different economic status by internet use group are shown in Supplementary Table S1.

Association between new internet usage and depressive symptoms

Table 2 presents the association of internet use and depressive symptoms using a regression model with standard errors clustered at the city level. The first column of Table 2 (Model 1) shows that after controlling for covariates, the

Table 1. Descriptive statistics of variables.

	All ($N = 5259$)				No use ($N = 5066$)				New use ($N = 193$)				
	Mean	SD	N	%	Mean	SD	N	%	Mean	SD	N	%	p value
CESD (in 2018)	8.954	6.676			9.077	6.687			5.731	5.468			<.001***
CESD (in 2015)	8.192	6.388			8.289	6.404			5.637	5.389			<.001***
Primary school			2558	48.6			2394	47.3			164	85.0	<.001***
Female			2568	48.8			2492	49.2			76	39.4	.007**
Urban residence			1921	36.5			1783	35.2			138	71.5	<.001***
Living alone			469	8.92			458	9.04			11	5.70	.110
Age (years)	66.782	5.599					66.858	5.625			64.777	4.446	<.001***
Married			4386	83.4			4213	83.2			173	89.6	.018*
Self-reported health	3.029	0.949			3.021	0.950			3.233	0.897			.002**
Self-rated memory	1.814	0.798			1.801	0.790			2.166	0.903			<.001***
PCI	2.420	1.033			2.394	1.024			3.124	1.013			<.001***
1^{st} quartile			1174	22.3			1154	22.8			20	10.4	<.001***
2^{nd} quartile			1689	32.1			1661	32.8			28	14.5	<.001***
3^{rd} quartile			1407	26.8			1354	26.7			53	27.5	.821
4^{th} quartile (richest)			989	18.8			897	17.7			92	47.7	<.001***
Netizen ratio (province)	0.477	0.098			0.476	0.098			0.503	0.109			<.001***

SD = standard deviation; CESD = Center for Epidemiological Survey – Depression; PCI = family income per capita; *$p < .05$, **$p < .01$, ***$p < .001$.

beginning of internet use significantly reduced the CES-D score in 2018 by 0.922 points (B = −0.922, $p < .05$). Hence, Hypothesis 1 was supported.

Moderating effect of economic status

The second column of Table 2 (Model 2) presents the moderating role of PCI in the association between new internet usage and CES-D scores. First, after controlling for all covariates, the start of internet use significantly reduced the CES-D score in 2018 by 3.070 points ($p < .001$). In addition, the effect of new internet usage was significantly smaller among participants in the second highest (B = 2.370, $p < .05$) and the highest quartile (B = 2.732, $p < .01$) of PCI than among those with a lower PCI. Therefore, the protective effect of the start of internet use on depressive symptoms was more evident among those with a poor family economic status (Figure 1). Hence, Hypothesis 2 was supported.

Robustness analyses

First, we conducted a sensitivity analysis by excluding economic status (i.e., PCI) as a confounder (Model 1 of Supplementary Table S2) in the statistical model. The result was similar to that in Model 2 of Supplementary Table S2 (including economic status as a confounder), both in terms of the coefficients and the significance. This implied that regarding economic status as a confounder had little impact on the correlation between internet use and depressive symptoms; economic status as a moderator could serve to explain the associations of internet use and depressive symptoms across people of different economic statuses.

Second, for a robustness check, we used an alternative definition of economic status, namely PCE, instead of PCI. All analyses were repeated, and the results are shown in Supplementary Table S3. The results were consistent with those in the main analyses. After controlling for covariates, the beginning of internet use significantly reduced the CES-D score in 2018 by 0.943 points ($p < .05$). The effect of internet use on depressive symptoms was significantly smaller among participants in the second highest (B = 2.308, $p < .05$) and the highest quartile (B = 1.983, $p < .05$) of PCE (see supplementary Table S3).

Moreover, we conducted another robustness analysis by logit link and binomial distribution with a clinical threshold of CES-D (i.e., CES-D scores of 10 or higher were defined as depressed, otherwise nondepressed). The distribution of participants, whether depressed or not, is presented in Supplementary Table S4. The results of logit regression are presented in Supplementary Table S5. The interaction effect was not significant ($p > .05$) in the logit regression model. This might be because transforming CES-D

Table 2. Coefficients of linear regression of new internet usage and PCI for subsequent CESD.

	Model 1			Model 2		
	B	SE		B	SE	
New internet usage	−0.922	0.444	*	−3.070	0.845	***
PCI						
1st quartile	0.000	.		0.000	.	
2nd quartile	−0.410	0.215		−0.436	0.221	
3rd quartile	−0.433	0.228		−0.481	0.233	*
4th quartile (richest)	−0.671	0.268	*	−0.769	0.278	**
PCI*Internet use						
1st quartile*new use				0.000	.	
2nd quartile*new use				1.495	1.428	
3rd quartile*new use				2.370	1.097	*
4th quartile*new use				2.723	0.984	**
CESD (2015)	0.453	0.016	***	0.452	0.016	***
Primary school or over	−0.986	0.182		−0.974	0.182	***
Female	1.046	0.160	***	1.048	0.160	***
Urban residence	−0.715	0.191	***	−0.710	0.191	***
Living alone	0.302	0.363		0.315	0.362	
Age	0.015	0.013		0.015	0.013	
Married	−0.098	0.238		−0.095	0.238	
Self-reported health	−0.735	0.096	***	−0.738	0.096	***
Self-rated memory	−0.239	0.103	*	−0.236	0.103	*
Netizen ratio (province)	−2.629	0.936	**	−2.620	0.939	**
Constant	8.874	1.109	***	8.893	1.111	***
N	5259			5259		

Standard errors in parentheses, clustered at city level; CESD = Center for Epidemiological Survey – Depression; PCI = Family income per capita. *$p < .05$, **$p < .01$, ***$p < .001$.

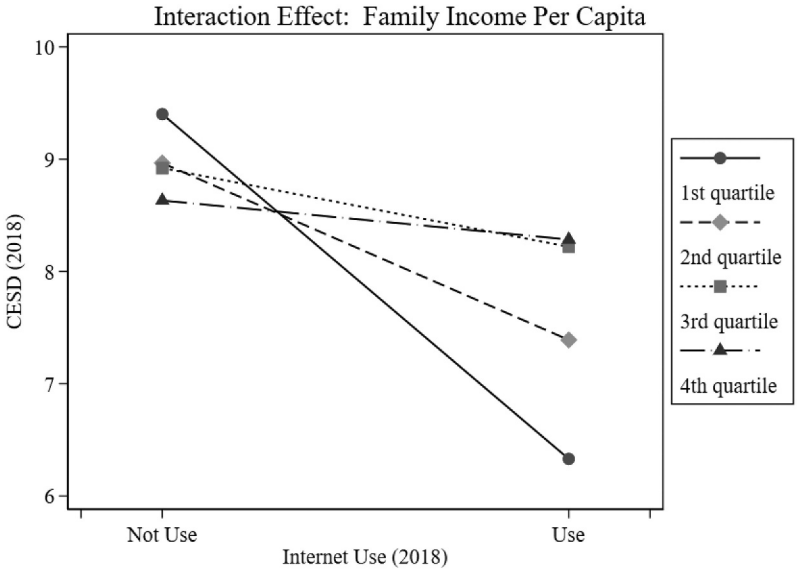

Figure 1. Interaction effect of family income per capita.

scores into a binary variable would reduce the variance and lead to a loss of information about the changes of participants' depressive symptoms.

Moreover, we used an alternative measurement of education level by recoding it into a new dichotomized variable (i.e., illiterate or not). We repeated the

regression models and the results were similar with the main analysis (see Supplementary Table S6). After controlling for covariates, new internet use significantly reduced the CES-D score at follow-up by 1.087 points ($p < .05$). The effect of internet use on CES-D scores was significantly smaller among participants in the 3rd quartile (B = 2.515, $p < .05$) and the 4th quartile (B = 2.914, $p < .01$) of PCI.

Discussion

Using national representative and longitudinal data, this study revealed that the start of internet use by older adults was associated with lower levels of depressive symptoms. Moreover, participants with poor economic status appear to benefit more from internet use in terms of psychological well-being.

We found that older adults who transitioned from being nonusers to new users of the internet showed a lower level of depressive symptoms than those who remained nonusers during a three-year period. This result was similar to the findings in previous studies. For instance, cross-sectional studies based on the HRS in the United States (Byrne et al., 2021; Heo et al., 2015) concluded that internet use was related to higher levels of life satisfaction and lower levels of loneliness. Similarly, longitudinal research based on the ELSA in England (Lam et al., 2020; B. C-P. Liu, 2020) found that internet use at baseline was linked with lower levels of loneliness or depressive symptoms at follow-up. This current study enriched the evidence for the longitudinal association of internet use and Chinese older adults' psychological well-being. The possible reasons might be as follows: First, transitioning from nonusers to users could enhance access to various types of information (including healthcare-related information), thus stirring a greater feeling of independence in older adults (Karavidas et al., 2005). Second, internet use can enable older adults to maintain and even increase social interaction regardless of distance and mobility constraints, leading to reduced loneliness and depressive symptoms (Mohan & Lyons, 2022; K. Yu et al., 2021).

Beyond the existing evidence that older people with better economic status reported a higher likelihood of internet use (Heponiemi et al., 2022; Wallinheimo & Evans, 2022), the present study revealed that the association between new internet usage and lower depressive symptoms was more evident among older adults with relatively lower economic status. This finding was similar to previous cross-sectional research that showed that internet users in the low-income group reported fewer mental health problems than their counterparts in the high-income group (Yuan, 2021). One possible explanation for this effect is that internet use makes people have more access to useful resources, such as education programs and healthcare services, which might reduce certain feelings of inferiority in individuals of different economic status (Y. C. Wang, 2019) and thus improve the psychological well-being of the

economically disadvantaged. Second, people with disadvantaged economic status may not be able to afford the expenditures of recreational and social activities (e.g., tickets, transportation, accommodation), but internet use may provide them with available approaches to engage in social interaction and relaxational activities, thus improving their mental health. This finding highlights the significance of paying special attention to older adults of lower economic status in social work practice to narrow the gray digital divide.

There are some limitations of this study. First, due to the restriction of the CHARLS questionnaire, the measurement of internet use was only based only on whether the internet was used or not. Specific information about the time, frequency, and behavioral pattern of internet use was not included. Second, internet use was measured by whether the participants had ever used the Internet in the past month, which might indicate a lower usage rate. Third, selection bias might exist, given that participants who did not participate in the follow-up survey were dropped. Moreover, as our research only focused on older adults who did not use the internet at baseline, the effect of continuous use on depressive symptoms was not examined. Lastly, as mental health status might also influence Internet use, we should be cautious in drawing causal relationships between new Internet use and depressive symptoms.

Conclusions

Based on a nationally representative and longitudinal survey, the current study confirmed that new internet usage was significantly associated with lower levels of depressive symptoms in Chinese older adults. Moreover, the advantageous effect of new internet usage on depressive symptoms was more profound among participants with poor economic status. Our findings extend the existing evidence by employing a longitudinal design and providing important implications for gerontological social work practice in developing regions. Special attention attached to older adults with inferior economic status would go far to bridge the gray digital divide and enable this vulnerable group to benefit from internet use. Social workers should provide more workshops or training on how to use computers or smartphones designed specifically for older adults, especially for those with relatively low economic status (Carney & Kandt, 2022; Mubarak & Nycyk, 2017). Social workers may deploy some public computers at community senior centers so that elderly people who are in a poorer economic situation and cannot afford to buy computers can have more opportunities to access the internet. In addition, it is suggested that social workers promote intergenerational communication between older and younger people. Support and encouragement from the younger generation can help older people adapt to and benefit from new technologies (C.-H. Wang & Wu, 2022).

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work was supported by the Humanities and Social Science Fund of Ministry of Education of China [grant number 23JYC840043] and the Research Grants Council of Hong Kong [grant number 17605119].

Ethical approval

The CHARLS was approved by the Institutional Review Board at Peking University. All participants provided informed consent.

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