

The Level of Smartphone Addiction and Its Relationship to High Blood Pressure Among Middle-Aged and Elderly People in Rural Areas of China

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Objective: There is a lack of research on the association between smartphone addiction and hypertension (HTN) in middle-aged and elderly populations, and their associations with employment status and sleep quality are still unclear.

Methods: This study was conducted in 85 villages in southeastern China. A total of 975 middle-aged and elderly participants (mean age: 60.70 years; 483 males and 492 females) were included. Demographic data were collected. Smartphone addiction was assessed using the Smartphone Addiction Scale–Short Version (SAS-SV), and sleep quality was measured using the Brief version of the Pittsburgh Sleep Quality Index (B-PSQI). Multiple regression and moderated mediation analyses were used to explore the potential moderating role of employment status (employed vs. unemployed/retired) and the mediating role of sleep quality in the association between smartphone addiction and HTN.

Results: A total of 415 (42.56%) individuals were suffering from HTN. Smartphone addiction was significantly and positively associated with sleep quality ($p < 0.001$). And sleep quality was also significantly positively associated with HTN ($p < 0.05$). Distinct patterns were observed across employment status groups, with a significant association between smartphone addiction and HTN in unemployed/retired participants (1.511, 95% CI: 1.140–2.002, $p = 0.004$), whereas this association was mediated by sleep quality among employed participants. The direct association was 0.940 (95% CI: 0.787–1.122) and the indirect association was 1.034 (95% CI: 1.002–1.071).

Conclusion: Smartphone addiction is associated with HTN among middle-aged and elderly individuals in rural China. Among unemployed or retired individuals, smartphone addiction may be directly associated with HTN, whereas among employed individuals, this association may be mediated by sleep quality. Reducing excessive smartphone use in rural middle-aged and elderly residents and improving sleep quality (especially in employed individuals) may help mitigate HTN risk. Future studies are warranted to explore underlying mechanisms using longitudinal designs.

Keywords: smartphone addiction, sleep quality, hypertension, middle-aged and elderly, rural China

Introduction

Aging has emerged as a global challenge nowadays, and China has the world's largest aging population.^{1,2} The Internet penetration rate in China's rural areas has jumped to 55.9%,³ and more and more middle-aged and elderly people in rural areas are using smartphones due to the low entry barriers and affordable prices.⁴ Smartphones are beneficial for facilitating communication, access to information, and time-saving, and they can also be used for work, socialising and recreation.^{5–7}

However, excessive use of smartphones has brought about the problem of addiction.⁸ Smartphone addiction is defined as poor autonomy and overuse of smartphones, which takes precedence over other daily activities in one's personal life and has negative physical, emotional, and social impacts.⁹ Smartphone addiction is significantly correlated with an increase in negative emotions and a decrease in self-control ability.¹⁰ The South Korean government has classified the older people as its high-risk and potential risk group.¹¹ And in a participatory observation study in rural China, 17 out of 29 elderly people interviewed were found to be using smartphones for more than 10 hours a day.³

Smartphone addiction among older people damages their health and disrupts their daily lives.⁹ It is associated with negative impacts such as poor sleep quality, depression, anxiety, and stress.¹² The elderly's peak smartphone usage is likely influenced by their daily activity engagement, social interaction requirements, and sleep disorders such as insomnia during nighttime hours.^{3,13} More frequent nighttime checking of one's smartphone was associated with lower sleep quality.¹⁴

In rural China, village aging is evident due to the out-migration of young people, with a countless number of left-behind and empty nest elderly.¹⁵ People experiencing loneliness or social isolation may be more susceptible to addiction, as using smartphone allows one to connect with others and provides immediate relief from loneliness.^{12,16} The retirement due to advanced age and absence of their offspring might damage their mental health.¹ The middle-aged and elderly people have started using smartphones out of boredom, and some of the older ones have even lost the company of their spouses, which exacerbates these feelings.³

Meanwhile, middle-aged and older people are at a stage of major transition in their employment status, physical functioning and social identity.¹ Retired middle-aged and older adults have more leisure time to explore new areas of life.³ However, the majority of Chinese rural residents do not enjoy the same high level of pension and healthcare as urban workers. Some of them thus have to continue working, the mental impact of which is still controversial.¹

Smartphone addiction has been found to be associated with higher blood pressure in younger age groups.^{17,18} As a major risk factor for cardiovascular disease, hypertension (HTN) is a chronic underlying condition with high prevalence and high health impact.¹⁹ Its well-established risk factors are family genetic history,²⁰ alcohol consumption¹⁹ and a high-sodium, low-potassium diet.²¹ The prevalence of HTN typically increases with age, with a notable surge after age 45, resulting in higher rates among middle-aged and elderly individuals.²²

The prevalence of HTN is higher in rural areas than in urban areas in China,²¹ which may be due to higher salt intake in rural areas and lack of health education and health care facilities. Moreover, despite the declining health status of rural older people, their healthcare expenditure is decreasing with age.²³ Meanwhile, rural elderly people face greater challenges in smartphone addiction than urban older people due to generally lower levels of education, poorer economic status, lack of adequate social security and empty nesters.³

The high rate of smartphone usage among middle-aged and elderly people may be not suitable to be directly compared to that of young people. There is a lack of research on the association between smartphone addiction and HTN in middle-aged and elderly populations, and their associations with employment status and sleep quality are still unclear.

Mediation analysis is a valuable statistical tool that can help elucidate potential pathways linking an exposure to an outcome and is increasingly being used in observational studies.^{24,25} The aim of this study was to investigate the association between smartphone addiction and HTN in a rural middle-aged and elderly population and to assess whether employment status and sleep quality moderate or mediate this relationship.

Subjects and Methods

Study Design

This study was a stratified random sampling, cross-sectional observational study conducted in all 85 villages of Guangze County, Fujian Province, located in southeastern China. This research was conducted from March 2024 to February 2025. The study adhered to the Declaration of Helsinki and was approved by the Guangze County General Hospital Institutional Review Board (Approval Number: GZXXY-202400001). Informed consent was obtained from all individual participants included in the study. Subjects were randomly selected in each village through the primary public health system and recruited into the study by the village doctors. The sampling frame was derived from the resident health records maintained by the primary public health system under the National Basic Public Health Service program.

Eligible residents were stratified by village and age group. Within each stratum, participants were randomly selected using a computerized random number procedure. Village doctors then contacted the selected individuals and invited them to participate in the study through home visits or scheduled appointments. Small non-monetary tokens of appreciation (eg., daily necessities) were provided after participation and were not contingent on survey completion. The research team designed the study, developed the questionnaire, and provided standardized training to village physicians on data collection procedures. It was responsible for overseeing data collection, performing quality control, and analyzing the collected data.

The inclusion criteria for this study were: (1) age 45 years or older, (2) residence in their village for more than 6 months (only individuals who had resided in the study area for at least six months were included to ensure stable exposure patterns and reliable health records), and (3) willingness to participate in the study and provide informed consent. The exclusion criteria were: (1) absence from the village during the study period, (2) refusal to have blood pressure measured, (3) inability to complete the questionnaire even with the assistance of a village doctor, and (4) cognitive impairment. The minimum sample size required for this study was calculated to be 929 based on Cohen's $f^2 = 0.02$ (small effect size), $\alpha = 0.05$, and power = 0.80, assuming approximately 10 predictors in the multiple regression model.

Measures

The subjects' age and sex were recorded based on their ID card information. In this study, middle-aged adults refers to participants aged 45–59 years, and elderly adults refers to participants aged 60 years and older. Subjects were instructed by village doctors to complete questionnaires covering education, income, marital status, employment status, smoking, alcohol consumption, the Smartphone Addiction Scale–Short Version (SAS-SV)¹⁷ and Brief version of the Pittsburgh Sleep Quality Index (B-PSQI).²⁶ Additionally, subjects were asked to wear light clothing and slippers for height and weight measurements. Body mass index (BMI) equals weight divided by height squared.

Smartphone addiction was assessed using the Chinese version of the SAS-SV questionnaire.¹⁷ Minor wording modifications were made to improve applicability for middle-aged and elderly adults. Specifically, school-related contextual description (eg., references to class attendance or assignments) that are relevant to adolescents were removed, while the original item meanings, scale structure, and response options were retained. For example, the original item “Due to smartphone use, I have difficulty concentrating in class” was adapted by removing the phrase “in class”, while retaining the core meaning related to attentional difficulty. The SAS-SV is a 10-item, 6-point Likert scale, with scores ranging from 1 (strongly disagree) to 6 (strongly agree), yielding a total score ranging from 10 to 60 points. Higher scores represent more severe smartphone addiction. The scale focuses on behavioral dependence and impaired control rather than usage frequency only, allowing differentiation between work-related smartphone use and addictive use. Previous studies have demonstrated that the SAS-SV possesses good reliability and validity among Chinese adults, including middle-aged and older adults.¹⁷

Sleep quality was assessed using the B-PSQI.²⁶ It is a simplified version of the PSQI, consisting of 6 questions and 5 scoring items derived from these questions. Each scoring item ranges from 0 to 3 points, with a total score of up to 15 points; higher scores indicate poorer sleep quality. The Chinese version of the B-PSQI has been used in several previous studies.²⁷

HTN was assessed by trained and certified village doctors using a validated electronic sphygmomanometer. Blood pressure was measured in a seated position after the participant had rested quietly for at least 5 minutes.²⁸ Subjects were asked to avoid alcohol, smoking, coffee/tea, and exercise for at least 30 minutes prior to blood pressure measurement. During each visit, blood pressure was measured twice at 1-minute intervals, and the average of the two readings was recorded. If the two readings of systolic blood pressure (SBP) or diastolic blood pressure (DBP) differed by more than 5 mmHg, a third measurement was taken, and the average of the three readings was recorded. For participants without a prior history of HTN, blood pressure measurements were repeated on three separate visits conducted on different days. HTN was diagnosed if SBP ≥ 140 mmHg and/or DBP ≥ 90 mmHg was observed consistently across all three visits, based on the averaged readings obtained at each visit. For participants with a documented prior diagnosis of HTN or current use of antihypertensive medication, HTN status was determined based on medical records from the primary public health system.

Statistical Analysis

The normality of the variables was tested using the Shapiro–Wilk test. For comparing differences between two groups, the Mann-Whitney *U*-test was employed for non-normally distributed data, while the *t*-test was used for normally distributed data. Spearman correlation analysis adjusted with the Benjamini-Hochberg method was used for non-normal variables. Mediation analysis with 95% bootstrap CI (10000 simulations) was used to explore the direct association between SAS-SV scores and HTN as well as the indirect association via employment status and B-PSQI scores.

All statistical analyses were conducted in R (version 4.2.2, The R Foundation for Statistical Computing). The R packages ‘lavaan’²⁶ (version 0.6.15) and ‘bruceR’²⁷ (version 0.8.10) were used for the mediation analysis, and the regression model reports were generated by the R package ‘modelsummary’²⁸ (version 1.2.0). The significance level α was set to 0.05.

Results

Basic Characteristics of the Study Subjects

A total of 1275 subjects were initially sampled via the primary public health system. Of these, 300 (23.5%) were excluded on site: 155 refused blood-pressure measurement, 112 returned incomplete questionnaires or had missing key variables, 31 were unable to complete the questionnaire even with assistance because of illiteracy, hearing or vision problems, and 2 were suspected of cognitive impairment. Consequently, 975 participants (483 males and 492 females) constituted the final analytical sample. There were 415 HTN subjects while 560 non-HTN subjects. The basic characteristics of the study population are shown in Table 1. The mean age of the entire study population was 60.70 years old and the median age was 58.84 years old.

Table 1 Baseline Characteristics of the Study Population

Variables	Total	Non-HTN	HTN	<i>p</i>
N	975 (100)	560 (57.44)	415 (42.56)	
Age				<0.001
Mean (SD)	60.70 (9.75)	58.63 (9.46)	63.49 (9.44)	
Median (IQR)	58.84 (14.77)	56.48 (12.92)	61.87 (14.71)	
Sex (%)				0.370
Male	483 (49.54)	270 (48.21)	213 (51.33)	
Female	492 (50.46)	290 (51.79)	202 (48.67)	
Education (%)				<0.001
No Formal Education	106 (10.87)	45 (8.04)	61 (14.70)	
Elementary School	394 (40.41)	212 (37.86)	182 (43.86)	
Middle School	362 (37.13)	233 (41.61)	129 (31.08)	
High School	53 (5.44)	31 (5.54)	22 (5.30)	
Technical School	30 (3.08)	21 (3.75)	9 (2.17)	
Junior College	27 (2.77)	15 (2.68)	12 (2.89)	
College/University	3 (0.31)	3 (0.54)	0 (0.00)	
Income (%)				<0.001
≤1000 RMB	215 (22.05)	100 (17.86)	115 (27.71)	
1001–2000 RMB	246 (25.23)	146 (26.07)	100 (24.10)	
2001–3000 RMB	254 (26.05)	138 (24.64)	116 (27.95)	
3001–4000 RMB	139 (14.26)	97 (17.32)	42 (10.12)	
4001–5000 RMB	60 (6.15)	38 (6.79)	22 (5.30)	
5001–6000 RMB	28 (2.87)	20 (3.57)	8 (1.93)	
6001–9000 RMB	15 (1.54)	7 (1.25)	8 (1.93)	
9001–12000 RMB	5 (0.51)	5 (0.89)	0 (0.00)	
12,001–15,000 RMB	5 (0.51)	3 (0.54)	2 (0.48)	
≥15001 RMB	8 (0.82)	6 (1.07)	2 (0.48)	

(Continued)

**Table 1** (Continued).

Variables	Total	Non-HTN	HTN	p
Marriage (%)				0.380
Unmarried	12 (1.23)	8 (1.43)	4 (0.96)	
Divorce	13 (1.33)	9 (1.61)	4 (0.96)	
Widowed	69 (7.08)	34 (6.07)	35 (8.43)	
Married	881 (90.36)	509 (90.89)	372 (89.64)	
Employment Status				0.010
Employed	633 (64.92)	383 (68.39)	250 (60.24)	
Unemployed/Retired	342 (35.08)	177 (31.61)	165 (39.76)	
BMI				<0.001
Mean (SD)	23.53 (3.15)	22.94 (2.90)	24.32 (3.29)	
Median (IQR)	23.38 (4.00)	22.83 (3.45)	24.22 (4.38)	
Smoking (%)				0.002
No	679 (69.64)	405 (72.32)	274 (66.02)	
Abstinence	43 (4.41)	14 (2.50)	29 (6.99)	
Yes	253 (25.95)	141 (25.18)	112 (26.99)	
Alcohol Drinking (%)				0.001
No	590 (60.51)	366 (65.36)	224 (53.98)	
Abstinence	142 (14.56)	67 (11.96)	75 (18.07)	
Yes	243 (24.92)	127 (22.68)	116 (27.95)	
B-PSQI Score				<0.001
Mean (SD)	4.67 (2.82)	4.34 (2.67)	5.12 (2.96)	
Median (IQR)	4.00 (3.00)	4.00 (4.00)	5.00 (4.00)	
SAS-SV Score				0.254
Mean (SD)	20.15 (12.45)	20.28 (11.94)	19.96 (13.12)	
Median (IQR)	14.00 (19.00)	16.00 (19.00)	12.00 (18.00)	

Abbreviations: HTN, hypertension; SD, standard deviation; IQR, interquartile range; BMI, body mass index; B-PSQI, brief version of the Pittsburgh sleep quality index; SAS-SV, smartphone addiction scale-short version.

Compared to the non-HTN group, subjects of the HTN group were significantly older ($p < 0.001$), had an overall lower educational level ($p < 0.001$) and had lower income ($p < 0.001$). The median BMI of HTN group was 24.22, while the median BMI of non-HTN group was 22.83. The BMI was significantly higher in the subjects of HTN group than in the non-HTN group ($p < 0.001$).

The median B-PSQI score for the total 975 subjects was 4.00 points. Median B-PSQI score was significantly lower in the non-HTN group than in the HTN group ($p < 0.001$). In addition, the median SAS-SV score for our study population was 14.00 points. Median SAS-SV score in the HTN group was overall lower but not statistically significant than that in the non-HTN group ($p = 0.254$).

Multiple Regression Models

The multiple logistic regression models presented in Table 2 showed that the SAS-SV score did not exhibit a significant association with HTN ($p > 0.05$). Additionally, the employment status was not significantly associated with HTN in both model 2 and model 3 as well ($p > 0.05$). The interaction term between unemployed/retired status and SAS-SV score was significantly and positively associated with HTN after adjusting for age, gender, educational status, income, marital status, BMI, smoking and drinking consumption (OR: 1.572, 95% CI: 1.146–2.175, $p < 0.01$).

Table 3 presents the results of multiple regression models for B-PSQI and HTN. SAS-SV score was significantly and positively associated with B-SPQI score (β : 0.200, 95% CI: 0.126–0.275, $p < 0.001$). The interaction term between unemployed/retired status and SAS-SV score was negatively and not significantly associated with B-PSQI score (β : -0.096, 95% CI: -0.230–0.037, $p > 0.05$), but it was significantly positively associated with HTN (OR: 1.607, 95% CI:

Table 2 Multiple Logistic Regression Models for HTN

Variable	Model 1	Model 2	Model 3
SAS-SV Score	0.974 (0.857, 1.106)	1.101 (0.948, 1.278)	0.971 (0.815, 1.155)
Employment Status			
Employed	–	Reference	Reference
Unemployed/Retired	–	0.975 (0.700, 1.353)	1.011 (0.724, 1.409)
Unemployed/Retired × SAS-SV	–	–	1.572** (1.146, 2.175)

Notes: OR (95% CI). ** $p < 0.01$. Bold values indicate significance at $p < 0.05$. Model 1: No adjustment. Model 2 and 3: Adjusted for age, sex, education, marriage, income, BMI, smoking, and alcohol drinking.

Abbreviations: HTN, hypertension; SAS-SV, smartphone addiction scale-short version; OR, odds ratio; CI, confidence interval.

Table 3 Multiple Regression Models for B-PSQI and HTN

Variable	B-PSQI Score	HTN
SAS-SV Score	0.200*** (0.126, 0.275)	0.940 (0.787, 1.122)
Employment Status		
Employed	Reference	Reference
Unemployed/Retired	−0.133 (−0.276, 0.010)	1.039 (0.742, 1.451)
Unemployed/Retired × SAS-SV	−0.096 (−0.230, 0.037)	1.607** (1.168, 2.231)
B-PSQI Score	–	1.181* (1.020, 1.371)

Notes: β (95% CI) for the B-PSQI model score and OR (95% CI) for the HTN model. Adjusted for age, sex, education, marriage, income, BMI, smoking, and alcohol drinking. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Bold values indicate significance at $p < 0.05$.

Abbreviations: B-PSQI, brief version of the Pittsburgh sleep quality index; HTN, hypertension; SAS-SV, smartphone addiction scale-short version; OR, odds ratio; CI, confidence interval.

1.168–2.231, $p < 0.01$). In addition, B-PSQI score was also significantly positively associated with HTN (OR: 1.181, 95% CI: 1.020–1.371, $p < 0.05$).

We further tested age group (middle-aged versus elderly) as a potential effect modifier by including interaction terms between age group and smartphone addiction, employment status, and sleep quality. None of the interaction terms reached statistical significance (all $p > 0.05$), indicating that age group did not significantly modify the associations under investigation. Therefore, middle-aged and elderly participants were analyzed together in subsequent analyses.

Moderated Mediation Analysis

The results of moderated mediation analysis have been shown in Table 4. In the unemployed/retired population, there was a significant association between SAS-SV score and HTN (OR: 1.511, 95% CI: 1.140–2.002, $p = 0.004$). However,

Table 4 Moderating and Mediating Association

Path	Estimate	95% CI	p
SAS-SV - HTN^a			
Employed	0.940	(0.787, 1.122)	0.494
Unemployed/Retired	1.511	(1.140, 2.002)	0.004
SAS-SV - B-PSQI^b			
Employed	0.200	(0.126, 0.275)	<0.001
Unemployed/Retired	0.104	(−0.011, 0.218)	0.075
SAS-SV - B-PSQI - HTN^a			
Employed	1.034	(1.002, 1.071)	0.048
Unemployed/Retired	0.995	(0.954, 1.031)	0.182

Notes: a: OR, b: β . Bold values indicate significance at $p < 0.05$.

Abbreviations: SAS-SV, smartphone addiction scale-short version; HTN, hypertension; B-PSQI, brief version of the Pittsburgh sleep quality index; OR, odds ratio; CI, confidence interval.

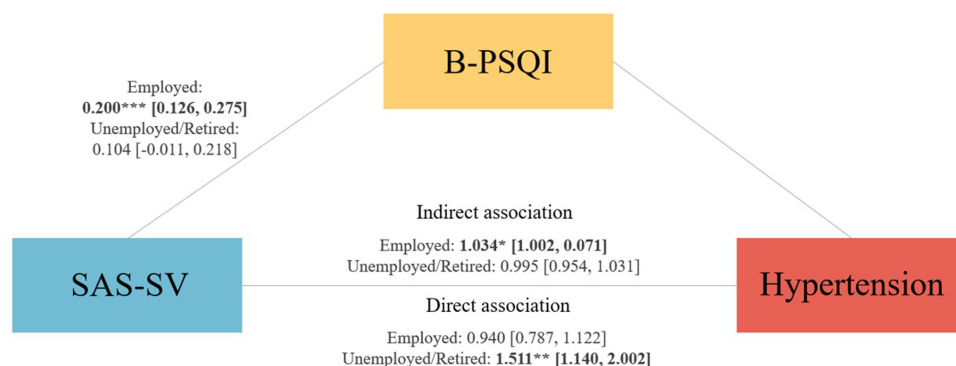


Figure 1 The direct association of hypertension with smartphone addiction and the indirect association via sleep quality among people with different employment status. SAS-SV: the total score of Smartphone Addiction Scale-Short Version. B-PSQI: the total score of Brief version of the Pittsburgh Sleep Quality Index. OR: odds ratio; CI: confidence interval. The 95% CIs were generated by 10000 bootstrap simulations. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Bold values indicate significance at $p < 0.05$.

the same significant association was not observed in the employed population (OR: 0.940, 95% CI: 0.787–1.122, $p > 0.05$). Sleep quality mediated the pathway of smartphone addiction associated with HTN among the employed people (Figure 1). The direct association was 0.940 (95% CI: 0.787–1.122, $p > 0.05$), and the indirect association was 1.034 (95% CI: 1.002–1.071, $p < 0.05$).

Discussion

In this study, we found that smartphone addiction was associated with HTN among middle-aged and elderly people in rural China, with the association varying across subgroups defined by employment status and sleep quality.

As smartphone permeates every social sector, public services are increasingly digitized.¹¹ For example, people are increasingly opting to pay with smartphones over cash. The usage of smartphones confers a multitude of advantages to rural residents, including facilitating their lives through e-commerce platforms and diversifying their diets.^{29–31} In recent years, short-video platforms have rapidly attracted the middle-aged and elderly population.³² The enjoyment of usage, the urge for self-expression and the desire to connect with others all contribute to the digital practices.^{33,34} It not only enhances their self-perception and self-worth but also inadvertently exacerbates smartphone addiction.³

This trend is particularly evident as it reflects the fact that the middle-aged and the elderly are seeking new ways to define themselves and engage with post-retirement life.⁴ There has been a lot of concern about the identity change of them after retirement. The retirement age in China has a wide range depending on the circumstances,³⁵ and it is roughly in line with the situation of the middle-aged and elderly groups covered in our study.

In order to provide pension security for rural residents, China launched a national programme called the New Rural Pension Scheme (NRPS) in 2009. Rural residents who have reached the age of 60 can receive a basic old-age pension if they meet certain criteria.³⁶ The scheme has relatively succeeded in covering target population. However, it fails to meet the basic needs of the elderly or the middle-aged in rural areas, and pension benefits are still very low in some areas.³⁷ With an inadequate pension, they are more likely to continue working and participate in manual labour that has a negative health impact in order to earn a living.³⁸ In rural China, 54.2% of the elderly population are in the over-age labour force, indicating a prevalent trend of overage employment.¹

Besides, China's urbanization process and the large-scale rural-urban migration of young adults have resulted in a widespread phenomenon of elderly people being left behind in rural areas.¹⁵ In China, the middle-aged and elderly population generally has a strong sense of family values.³⁹ A portion of them may consider replacing the monetary support of their children with their own income, thereby reducing the financial burden on adult children.⁴⁰

In general, it is common for middle-aged and older people in rural areas to work beyond their retirement age due to the insufficiency of pension income and their desire to reduce the burden on their families. Therefore the high work rate found in this study is representative.

In the present study, smartphone addiction is significantly associated with HTN among middle-aged and elderly adults who are unemployed or retired. They have more free time and may use smartphones more frequently.³ One plausible explanation is that excessive smartphone use may be associated with reduced physical activity and activities of daily living,⁴¹ which in turn has been linked to a higher prevalence of HTN.⁴² Physical activity is defined as any bodily movement resulting from skeletal muscle contraction that results in energy expenditure above the resting level.⁴³ Numerous guidelines have recommended it as a means of preventing HTN.^{44–46} Studies from different countries have confirmed that it is negatively associated with the development of HTN.¹⁹ Smartphone addiction may also lead to sedentary behaviour. A study of Spanish university suggested that it is associated with a higher risk of developing HTN.⁴²

We also found that smartphone addiction was significantly associated with HTN through sleep quality among employed older ones. Previous studies have found an effect of sleep quality on blood pressure. Poor sleep quality is related to elevated blood pressure variability, which might have some adverse effects on multiple organ systems,⁴⁷ mainly in the form of sleep disruption and obstructive sleep apnoea (OSA).^{48,49} Individuals suffering from OSA tend to have a surge in blood pressure in the mornings.⁵⁰ A more recent study suggested a cumulative effect of poor sleep quality and lack of physical activity on blood pressure.⁵¹ In our study, the employed older population tends to engage in manual labour, and the work itself entails a certain amount of physical activity.⁴³ However, since they might can only play with their smartphones after work, excessive use of smartphones at night may have a greater impact on sleep quality.¹²

There are some limitations of our study. These findings pertain specifically to rural Chinese populations; whether similar associations hold in urban populations awaits further investigation. Moreover, we only studied the middle-aged and elderly population, and future studies might be conducted on multiple age groups. Finally, it is a cross-sectional study, and further longitudinal studies are needed to determine the moderating and mediating mechanisms through which smartphone addiction associates with HTN among people with different employment status.

The findings of this study have several public health implications. Given the high prevalence of both smartphone use and HTN among middle-aged and elderly populations in rural areas, smartphone addiction should be recognized as a potential behavioral risk factor that may contribute to cardiovascular health disparities. From a preventive perspective, tailored strategies should be developed according to employment status. For unemployed or retired individuals, interventions should focus on reducing sedentary behavior and promoting alternative daily activities. For employed individuals, particular attention should be paid to nighttime smartphone use and its impact on sleep quality. Interventions such as sleep hygiene education, limiting screen exposure before bedtime, and promoting awareness of the health consequences of poor sleep may be beneficial. At the community and policy levels, integrating smartphone addiction screening into primary healthcare services and routine chronic disease management programs may help identify high-risk individuals. Moreover, it is also necessary to be mindful of the psychological situation of middle-aged and elderly people in rural areas and to strengthen their old-age security.

For future research, longitudinal studies are needed, and objective measurements (such as digital device usage tracking and wearable sleep monitoring) should be incorporated to reduce potential bias associated with self-reported data. Further investigation into the biological and behavioral mechanisms underlying the associations is warranted. Finally, expanding the study population to include urban residents and different cultural contexts would enhance the generalizability of the findings.

Conclusions

Smartphone addiction is associated with HTN among middle-aged and elderly people in rural China, with employment status serving as a potential moderator and sleep quality as a possible mediator of this relationship. Limitations include the cross-sectional design, which precludes causal inference, and the rural-only sample, limiting generalizability to urban settings. Addressing smartphone addiction in rural middle-aged and elderly residents and improving sleep quality in employed individuals are recommended. Future researches could consider extending the lens to urban settings and embracing longitudinal perspectives.

Data Sharing Statement

Some of the data that support the findings of this study can be seen in the article. The remaining data are available from the corresponding author upon reasonable request.

Ethics Approval and Informed Consent

The study was approved by the Guangze County General Hospital Institutional Review Board (Approval Number: GZXYY-202400001). Informed consent was obtained from all participants involved in the study.

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Author Contributions

Liandi Cheng: Formal analysis, methodology, writing – original draft. Yunhao Zheng: Conceptualization, data curation, formal analysis, methodology, visualization, writing – review and editing. Xiaoguang Chen: Data curation, funding acquisition, investigation, project administration, writing – review and editing. Jiazhi Wu: Investigation, supervision, methodology, writing – review and editing. Yixuan Pan: Formal analysis, visualization, writing – review and editing. Xin Xiong: Conceptualization, methodology, writing – review and editing. Zheng Ye: Conceptualization, methodology, writing – review and editing. All authors gave final approval of the version to be published, approved the submission of the article to the journal, and agreed to be accountable for all aspects of the work.

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References

1. Chen Y, Wang K, Zhao J, Zhang Z, Wang J, He L. Overage labor, intergenerational financial support, and depression among older rural residents: evidence from China. *Front Public Health*. 2023;11:1219703. doi:10.3389/fpubh.2023.1219703
2. Liu S, Lu Y, Wang D, et al. Impact of digital health literacy on health-related quality of life in Chinese community-dwelling older adults: the mediating effect of health-promoting lifestyle. *Front Public Health*. 2023;11:1200722. doi:10.3389/fpubh.2023.1200722
3. Zhang H, He R. A study on digital inclusion of Chinese rural older adults from a life course perspective. *Front Public Health*. 2022;10:974998. doi:10.3389/fpubh.2022.974998
4. Xu Y, Zeng K, Dong L, Zheng X, Si Y. Understanding older adults' smartphone addiction in the digital age: empirical evidence from China. *Front Public Health*. 2023;11:1136494. doi:10.3389/fpubh.2023.1136494
5. Kim Y, Wang Y, Oh J. Digital Media Use and Social Engagement: how Social Media and Smartphone Use Influence Social Activities of College Students. *Cyberpsychol Behav Soc Net*. 2016;19(4):264–269. doi:10.1089/cyber.2015.0408
6. Oviedo-Trespalacios O, Nandavar S, Newton JDA, Demant D, Phillips JG. Problematic Use of Mobile Phones in Australia...Is It Getting Worse? *Front Psychiatry*. 2019;10:105. doi:10.3389/fpsyt.2019.00105
7. Shin DH, Shin YJ, Choo H, Beom K. Smartphones as smart pedagogical tools: implications for smartphones as u-learning devices. *Comput Hum Behav*. 2011;27(6):2207–2214. doi:10.1016/j.chb.2011.06.017
8. Bertocchi FM, De Oliveira AC, Lucchetti G, Use LALGS. Digital Addiction and Physical and Mental Health in Community-dwelling Older Adults: a Population-based Survey. *J Med Syst*. 2022;46(8):53. doi:10.1007/s10916-022-01839-7
9. Jeong JH, Bae SM. The Relationship Between Perceived Stress and Smartphone Addiction: the Mediating Effect of Rumination and The Mediated Moderating Effect of Mindfulness. *Psychiatry Invest*. 2024;21(4):340–351. doi:10.30773/pi.2022.0288
10. Zhong G, Shu Y, Zhou Y, Li H, Zhou J, Yang L. The relationship between social support and smartphone addiction: the mediating role of negative emotions and self-control. *BMC Psychiatry*. 2025;25(1):167. doi:10.1186/s12888-025-06615-8
11. Wang D, Liu X, Chen K, et al. Risks and protection: a qualitative study on the factors for internet addiction among elderly residents in Southwest China communities. *BMC Public Health*. 2024;24(1):531. doi:10.1186/s12889-024-17980-6
12. Khan A, McLeod G, Hidajat T, Edwards EJ. Excessive Smartphone Use is Associated with Depression, Anxiety, Stress, and Sleep Quality of Australian Adults. *J Med Syst*. 2023;47(1):109. doi:10.1007/s10916-023-02005-3

13. Busch PA, Hausvik GI, Ropstad OK, Pettersen D. Smartphone usage among older adults. *Comput Hum Behav.* **2021**;121:106783. doi:10.1016/j.chb.2021.106783
14. Shoval D, Tal N, Tzischinsky O. Relationship of smartphone use at night with sleep quality and psychological well-being among healthy students: a pilot study. *Sleep Health.* **2020**;6(4):495–497. doi:10.1016/j.sleh.2020.01.011
15. Liu C, Eriksson T, Yi F. Offspring migration and nutritional status of left-behind older adults in rural China. *Econ Hum Biol.* **2021**;41:100996. doi:10.1016/j.ehb.2021.100996
16. Mahapatra S. Smartphone addiction and associated consequences: role of loneliness and self-regulation. *Behav Inf Technol.* **2019**;38(8):833–844. doi:10.1080/0144929X.2018.1560499
17. Luk TT, Wang MP, Shen C, et al. Short version of the Smartphone Addiction Scale in Chinese adults: psychometric properties, sociodemographic, and health behavioral correlates. *J Behav Addict.* **2018**;7(4):1157–1165. doi:10.1556/2006.7.2018.105
18. Zhu J, Wang S, Wu Y, et al. Smartphone addiction habit is positively associated with coronary artery disease and its severity in Chinese adults: a case-control study. *Front Cardiovasc Med.* **2024**;11:1374797. doi:10.3389/fcvm.2024.1374797
19. Diaz KM, Shimbo D. Physical activity and the prevention of hypertension. *Curr Hypertens Rep.* **2013**;15(6):659–668. doi:10.1007/s11906-013-0386-8
20. Wang NY, Young JH, Meoni LA, Ford DE, Erlinger TP, Klag MJ. Blood pressure change and risk of hypertension associated with parental hypertension: the Johns Hopkins Precursors Study. *Arch Intern Med.* **2008**;168(6):643–648. doi:10.1001/archinte.168.6.643
21. Ueshima H, Zhang XH, Choudhury S. Epidemiology of hypertension in China and Japan. *J Hum Hypertens.* **2000**;14(10–11):765–769. doi:10.1038/sj.jhh.1001054
22. Tao S, Wu X, Duan X, et al. Hypertension prevalence and status of awareness, treatment and control in China. *Chin Med J.* **1995**;108(7):483–489.
23. Yang Z, Norton EC, Stearns SC. Longevity and Health Care Expenditures: the Real Reasons Older People Spend More. *J Gerontol B Psychol Sci Soc Sci.* **2003**;58(1):S2–S10. doi:10.1093/geronb/58.1.S2
24. Rijnhart JJM, Lamp SJ, Valente MJ, MacKinnon DP, Twisk JWR, Heymans MW. Mediation analysis methods used in observational research: a scoping review and recommendations. *BMC Med Res Methodol.* **2021**;21(1):226. doi:10.1186/s12874-021-01426-3
25. Nguyen TQ, Schmid I, Stuart EA. Clarifying causal mediation analysis for the applied researcher: defining effects based on what we want to learn. *Psychol Methods.* **2021**;26(2):255–271. doi:10.1037/met0000299
26. Sancho-Domingo C, Carballo JL, Coloma-Carmona A, Buysse DJ. Brief version of the Pittsburgh Sleep Quality Index (B-PSQI) and measurement invariance across gender and age in a population-based sample. *Psychol Assess.* **2021**;33(2):111–121. doi:10.1037/pas0000959
27. Tu Z, He J, Zhai Q, et al. Psychometric properties of the Brief Version of Pittsburgh Sleep Quality Index (B-PSQI) among Chinese male sailors on 18-hr rotating shift schedule. *Psychol Assess.* **2023**;35(12):1108–1119. doi:10.1037/pas0001278
28. Sun Y, Mu J, Wang DW, et al. A village doctor-led multifaceted intervention for blood pressure control in rural China: an open, cluster randomised trial. *Lancet Lond Engl.* **2022**;399(10339):1964–1975. doi:10.1016/S0140-6736(22)00325-7
29. Jin T, Li L. Does Smartphone Use Improve the Dietary Diversity of Rural Residents? Evidence from Household Survey Data from 5 Provinces. *Int J Environ Res Public Health.* **2022**;19(17):11129. doi:10.3390/ijerph191711129
30. Sekabira H, Qaim M. Can mobile phones improve gender equality and nutrition? Panel data evidence from farm households in Uganda. *Food Policy.* **2017**;73:95–103. doi:10.1016/j.foodpol.2017.10.004
31. Parlasca MC, Mußhoff O, Qaim M. Can mobile phones improve nutrition among pastoral communities? Panel data evidence from Northern Kenya. *Agric Econ.* **2020**;51(3):475–488. doi:10.1111/agec.12566
32. Cotten SR, Schuster AM, Seifert A. Social media use and well-being among older adults. *Curr Opin Psychol.* **2022**;45:101293. doi:10.1016/j.copsyc.2021.12.005
33. Kubik S. Motivations for cell phone use by older Americans. *Gerontechnology.* **2009**;8(3):150–164. doi:10.4017/gt.2009.08.03.007.00
34. Hong SJ, Tam KY. Understanding the Adoption of Multipurpose Information Appliances: the Case of Mobile Data Services. *Inf Syst Res.* **2006**;17(2):162–179. doi:10.1287/isre.1060.0088
35. Zhao Y, Hu Y, Smith JP, Strauss J, Yang G. Cohort profile: the China Health and Retirement Longitudinal Study (CHARLS). *Int J Epidemiol.* **2014**;43(1):61–68. doi:10.1093/ije/dys203
36. Yan P, Li F, Nicholas S, et al. Impact of pension income on healthcare utilization of older adults in rural China. *Int J Equity Health.* **2023**;22(1):166. doi:10.1186/s12939-023-01985-5
37. Chen Y, Zhao L, Fan Y, Xie B. Does the New Rural Pension Scheme improve residents' livelihoods? Empirical evidence from Northwestern China. *PLoS One.* **2021**;16(4):e0250130. doi:10.1371/journal.pone.0250130
38. Zhang Z, Luo Y, Robinson D. Who Are the Beneficiaries of China's New Rural Pension Scheme? Sons, Daughters, or Parents? *Int J Environ Res Public Health.* **2019**;16(17):3159. doi:10.3390/ijerph16173159
39. Williamson JB, Fang L, Calvo E. Rural pension reform in China: a critical analysis. *J Aging Stud.* **2017**;41:67–74. doi:10.1016/j.jaging.2017.04.003
40. Eggleston K, Sun A, Zhan Z. The Impact of Rural Pensions in China on Labor Migration. *World Bank Econ Rev.* **2016**;1hw032. doi:10.1093/wber/lhw032
41. Demir OB, Bilgin A, Yilmaz FT. Smartphone addiction among elderly individuals: its relationship with physical activity, activities of daily living, and balance levels. *BMC Public Health.* **2025**;25(1):965. doi:10.1186/s12889-025-22145-0
42. Beunza JJ, Martínez-González MA, Ebrahim S, et al. Sedentary behaviors and the risk of incident hypertension: the SUN Cohort. *Am J Hypertens.* **2007**;20(11):1156–1162. doi:10.1016/j.amjhyper.2007.06.007
43. Caspersen CJ, Powell KE, Christenson GM. Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. *Public Health Rep.* **1985**;100(2):126–131.
44. Brook RD, Appel LJ, Rubenfire M, et al. Beyond medications and diet: alternative approaches to lowering blood pressure: a scientific statement from the American heart association. *Hypertens.* **2013**;61(6):1360–1383. doi:10.1161/HYP.0b013e318293645f
45. Pescatello LS, Franklin BA, Fagard R, et al. American College of Sports Medicine position stand. Exercise and hypertension. *Med Sci Sports Exerc.* **2004**;36(3):533–553. doi:10.1249/01.mss.0000115224.88514.3a
46. Whelton PK, He J, Appel LJ, et al. Primary prevention of hypertension: clinical and public health advisory from The National High Blood Pressure Education Program. *JAMA.* **2002**;288(15):1882–1888. doi:10.1001/jama.288.15.1882

47. Gosmanova EO, Mikkelsen MK, Molnar MZ, et al. Association of Systolic Blood Pressure Variability With Mortality, Coronary Heart Disease, Stroke, and Renal Disease. *J Am Coll Cardiol*. 2016;68(13):1375–1386. doi:10.1016/j.jacc.2016.06.054
48. Liu X, Logan J, Kwon Y, Lobo JM, Kang H, Sohn MW. Visit-to-visit blood pressure variability and sleep architecture. *J Clin Hypertens Greenwich Conn*. 2021;23(2):323–330. doi:10.1111/jch.14162
49. Lettau F, Schwarz EI, Stradling JR, Kohler M. Blood Pressure Variability in Obstructive Sleep Apnoea: data from 4 Randomised Controlled CPAP Withdrawal Trials. *Respir Int Rev Thorac Dis*. 2017;93(5):311–318. doi:10.1159/000465528
50. Marrone O, Bonsignore MR. Blood-pressure variability in patients with obstructive sleep apnea: current perspectives. *Nat Sci Sleep*. 2018;10:229–242. doi:10.2147/NSS.S148543
51. De Havenon A, Falcone G, Rivier C, et al. Impact of sleep quality and physical activity on blood pressure variability. *PLoS One*. 2024;19(4):e0301631. doi:10.1371/journal.pone.0301631

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