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Original scientific paper

A PSM Model to Estimate the Impacts of Internet Use on Rural Residents' Health

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Abstract: As an important component of human capital, the contribution of health to accelerating economic development and technological progress is obvious.The Internet has had a profound impact on the lifestyle of rural residents. Using the nationally representative data from the 2017 Chinese General Social Survey (CGSS), this study estimates the impacts of internet use on residents' health in rural China. We employ the propensity score matching (PSM) model to address the selection bias. Our findings reveal that Internet use can reduce the physical and mental health of rural residents significantly. Disaggregated analysis indicates that Internet use has a greater positive effect on physical health of male, elderly, high-educated, and eastern regional rural residents. Internet use only had significant positive effects on mental health of female, middle-aged, high-educated and western regional rural residents. In addition, we explore the mechanisms by which Internet use affects rural residents' health from social network.

Keywords: internet use; ordered probit model; PSM model; residents' health

1 INTRODUCTION

As an important component of human capital, the contribution of health to accelerating economic development and technological progress is obvious (Schultz [1], 1961;Cozmaet et al. [2], 2018). The World Bank World Development Report (1993) clearly states that good health improves individual labor productivity and countries' economic growth rates [3]. Since the reform and opening up, the rich demographic dividend has injected strong impetus into China's economic development, and China's comprehensive strength has been rapidly improved. Since the beginning of the 21st century, China's population structure has gradually transformed to an aging society, and the demand for population quality has become increasingly urgent (Saima et al. [4], 2019). Under the shock of the COVID-19, people's health is a fundamental factor for maintaining steady economic growth in all countries. Thus, the importance of national health in China is obvious.

The 19th National Congress of the Communist Party of China (CPC) made a major policy decision on implementing the Healthy China strategy, which elevated the maintenance of people's health to a national strategic level. It sublimates the time significance and connotation of health further. The Outline of the "Healthy China 2030" Plan issued by the CPC Central Committee and The State Council clearly points out that health is an inevitable requirement for promoting people's all-round development, a basic condition for economic and social development, and an important symbol of national prosperity and national prosperity. According to the 14th Five-Year Plan for national health, the Chinese government will accelerate the establishment of a system that gives priority to people's health and integrates health into all policies. By 2025, the average life expectancy will continue to increase by about one year over the 2020 level, and the average healthy life expectancy will increase by the same proportion.

The Internet, usually defined as a set of Information and Communication Technologies (ICTs), is now a global network which has inter-connected more than half of the world population (Lopez-Fernandez [5], 2021; Choi [6], 2022; Chun [7], 20). In order to promote the implementation of the Healthy China strategy, the General Office of the State Council issued the Opinions on Promoting the Development of "Internet + Healthcare" in 2018, to encourage and regulate the application of the Internet in healthcare further. With the integration of the Internet with the medical and health industry, more and more residents use the Internet for online consultation. Moreover, with the orderly promotion of China's rural revitalization strategy, important progress has been made in the construction of digital villages. According to the 50th Statistical Report on China's Internet Development released by the China Internet Network Center (CNNIC), by the end of June 2022, the number of Internet users in China reached 1,051 billion. 293 million internet users were rural Internet users, accounting for 27,9% of the total number of Internet users. In addition, China's non-Internet users are still mainly in rural areas, accounting for 41,2% of the non-Internet users in rural areas which is 5,9 percentages higher than the proportion of the national rural population. Non-Internet users cannot access the Internet and encounter inconvenience in daily life such as travel, consumption, health care and work. They cannot enjoy the convenience brought by intelligent services. Obviously, the Internet has had a profound impact on the lifestyle of rural residents.

In recent years, there has been increased interest in research looking at the use of ICTs and its influence on both the individual and society. However, no consensus was reached. Some scholars believe that the Internet has a positive impact on residents' health. Ifroh and Permana (2022) found that it will be more convenient for residents to use the Internet to search for health information [8]. Duplaga (2021) found that Internet use is consistently associated with lower prevalence of chronic diseases and disability, as well as less frequent visits to health care facilities [9]. Li et al. (2022) believed that Internet use can improve self-accessed health and chronic disease status of the middle-aged and older population in China [10]. Tavares (2020) found that elderly people who use the Internet report better health status [11].

Other studies suggest that Internet use reduces mental health problems in older adults. Yuan (2021) believed that elderly people using the Internet more frequently have substantially lower odds of having mental health problems

[12]. Internet use can not only improve residents' mental health (Forsman and Nordmyr [13], 2017; Macdonald and Hülür [14], 2020), but also improve residents' subjective well-being (Lu and Kandilov [15], 2021). Internet use can reduce the loneliness of the elderly through social engagement. (Szabo et al. [16]，2018). Silva et al., (2022) found that the Internet use can serve as a moderating variable reducing the lonliness of people over 50 living alone [17]. Yu et al. (2022) found that middle-aged and older adults using the internet for socializing is associated with alleviated cognitive decline [18]. Shiferaw and Mehari (2019) found Internet use and eHealth literacy of health professionals is noticeably good [19].

However, some scholars believe that Internet use has a negative effect on residents' health. The Internet provides residents with a variety of entertainment, and compulsive Internet use is an antecedent to poor mental health (Ciarrochi et al. [20], 2016). Such problems are particularly pronounced among teenagers. Adolescents and young adults are avid Internet users. Online social media, such as social networking sites (e.g., Facebook, Instagram), status updating sites (e.g., Twitter) have become integral parts of adolescents' and young adults' lives (Pujazon-Zazik and Park [21], 2010). Özaslan et al. (2022) found that problematic Internet use can aggravate [22]. It can lead to mental health problems. Machimbarrena et al. (2019) found problematic internet use correlated negatively and significantly with adolescents' health-related quality of life [23].

Stevens et al. (2020) found problematic internet use negatively affected academic performance and lead to mental health symptoms among US college students [24]. Sayeed et al. (2021) analyzed university students in Bangladesh and came to a similar conclusion [25]. Do et al. (2013) found that excessive Internet use is a risk factor for depressive symptoms, suicidal ideation, weight status, and self-rated health among middle and high school students aged 13 - 18 years in South Korea [26]. Some scholars believe that Internet use can reduce the health of elderly residents. Gatto and Tak (2008) found that elderly people will have negative feelings after using the Internet [27]. Huang (2010) found that Internet use can reduce elderly residents's subjective well-being [28]. But Damant et al. (2017) found that Internet use has no effect on residents' well-being [29].

Grossman's health demand model points out that health is a capital that is gradually depleted. In order to live longer, people need to constantly invest in health to survive. An individual investment in health depends on the measurement of benefits and costs (Radu & Aurel [30], 2012; Elena et al. [31], 2016). Benefits include consumer goods that enhance the overall utility of investors and capital that can be used for market and non-market activities (Son & Park [32], 2022; Comăniță et al. [33], 2018). Costs include two parts: material factors such as time and money, and environmental factors that affect the efficiency of health investment.

As the rational economic men, when the investment benefit exceeds cost, people will choose to increase their health investment, otherwise they will reduce their health investment (Cucchiella et al. [34], 2020). In fact, the effects of Internet use on residents' health can be reflected in the reduction of transaction costs and the increase of social benefits. On the one hand, the online medical consultation platform simplifies the original tedious medical procedures and breaks down the communication barriers between doctors and patients. For patients, online consultation alleviates the congestion of hospitals, reduces the occupation of medical resources, and improves the utilization rate of medical and health resources. On the other hand, online consultation can solve the problem of information asymmetry in individual health management. The information asymmetry between the two sides of the transaction can lead to the moral hazard that induces adverse selection. While the Internet platform improves the matching degree between doctors and patients. In the early days, only doctors possess medical knowledge. Now the Internet has broken down barriers of expertise and helped residents better manage their health. Moreover, the effect of the Internet use on residents' health depends on whether residents themselves have a strong willingness to search for health information.

Compared with urban areas, medical resources are scarce in rural areas. Internet is an efficient tool for information retrieval. Rural residents can acquire medical knowledge and strengthen the cultivation of their own health behaviors through the Internet, especially for the elderly left behind in rural areas. The knowledge barriers lead to the lack of health knowledge among most elderly in rural areas, and the deep-rooted feudal thoughts also subtly drive the elderly to superstitious folk remedies and irrational medical treatment behavior. Internet can solve the problem of information asymmetry in the elderly's access to medical and health knowledge. Rural residents can retrieve massive information and choose treatment methods at home, which is more convenient than going to the hospital to register for diagnosis.

Rural society is a typical acquaintance society. Many residents have formed a social network with local flavor based on consanguinity, kinship, geography and business relationship because they have lived in the countryside for a long time. As a digital social interaction platform, Internet gives full play to its media properties and supports great interaction between different ages, different occupations and different groups (Kim et al. [35], 2022).

The continuous transformation of information media has completely reshaped the way people socialize. Individuals are woven into a huge spectrum of interpersonal relationships through the Internet. Internet use is divided into interpersonal communication and information acquisition, while social networks are divided into family and friendship relationships. And interpersonal communication can enhance social networks. Thus, Internet use improves the convenience of interpersonal communication and helps individuals develop social networks (Tang et al. [36], 2022). Internet use can also expand residents' social networks through social participation (Zhang and Li [37], 2022; Huang and Meng [38], 2022). Internet use and social engagement, particularly in cultural activities, may help older adults to maintain health literacy during ageing (Kobayashi [39] et al., 2015). Yoon (2020) found that race and socioeconomic status can influence the Internet use for health information for older adults [40].

In the context of " Internet + Healthcare", Internet use may improve rural residents' health through social

networks. Internet has eliminated the relative closure of rural areas, accelerated the flow of production factors, and provided an efficient and convenient communication channel for rural residents to communicate with the outside world and expand interpersonal relations. It can increase the accumulation of social capital of rural residents and improve rural residents' health further.

Although previous literature has explored the relationship between Internet use and residents' health, the research samples mainly focus on the young and elderly groups, and there are few studies on rural residents. Agriculture is the foundation of China, and the stability of agriculture contributes to the maintenance of social stability and unity. The protection and improvement of rural residents' health is related to the overall effect of Healthy China strategy. In addition, existing research mainly focuses on residents' health indicators such as sleep, loneliness and so on. Few researches focus on residents' comprehensive health. It is difficult to comprehensively grasp the relationship between Internet use and residents' health. In view of this, this study estimates the impact of Internet use on rural residents' health, utilizing order probit model and the propensity score matching (PSM) model and using data from 2017 Chinese General Social Survey (CGSS).

This study is articulated as follows: Section 2 presents data and description. Section 3 introduces estimation strategy. Section. 4 discusses the estimation results and Section. 5 is robustness. Section. 6 is mechanism analysis. The final section concludes and proposes policy implications.

2 DATA, VARIABLES AND DESCRIPTIVE STATISTICS

2.1 Data

This study uses the open-access data provided by Renmin University (Beijing, China). This data were collected by the Chinese General Social Survey (CGSS). CGSS is a nationwide sample survey project on household's micro information, which is the earliest nationwide, comprehensive and continuous academic survey project in China. This study uses the latest 2017 CGSS survey data. The data covers 12582 samples from 28 provinces (autonomous regions and municipalities directly under the Central government) in China excluding Hong Kong, Macao and Taiwan, Xinjiang and Tibet, which is nationally representative. The CGSS2017 survey includes data on residents' Internet use. According to the research needs, this study only selects the rural samples, and obtains 4086 valid samples after eliminating missing values and outliers.

2.2 Variables

2.2.1 Rural Resident's Health

The dependent variable of this study is rural resident's health. This study divides the health of residents into two parts: physical health and mental health. Firstly, we use the self-rated health question in the questionnaire to measure the residents' health. The CGSS question on physical health is "How would you describe your current health?". The answers are "very poor, poor, fair, good and very good", with values ranging from 1 to 5. Higher score indicates better physical condition. We use the psychological health question from the questionnaire: "How often have you felt depressed or depressed in the past four weeks?" to measure the resident's psychological health. The answers are "always, often, sometimes, rarely and never", with values ranging from 1 to 5. Higher score indicates better physical condition.

2.2.2 Internet USE

The core independent variable of this study is Internet use. According to the question "Your use of the Internet (including mobile Internet) over the past year". The answers are "never, rarely, sometimes, often and very often". We classify "sometimes, often and very often" as using the Internet, and assign a value of 1. We classify "never and rarely" as not using the Internet, and assign a value of 0.

2.2.3 Control Variables

Referring to the existing literatures, we control the following characteristic variables according to the questions listed in the CGSS2017 questionnaire to reduce the estimation bias caused by omitted variables. Control variables at the individual level include age, age square, gender, education, marriage, daily exercise, and medical insurance. Control variables at the household level include household per capita income and household size.

2.3 Descriptive Statistics

Meanings of variables and descriptive statistics are shown in Tab. 1. As shown in Tab. 1, 35,9% of rural residents use the Internet, and the average of physical health and mental health of rural residents is 3,189 and 3,601, respectively.

Tab. 2 shows the mean difference in health levels between rural residents who use the Internet and those who do not. The results show that the health level of rural residents using the Internet is relatively high. Compared with rural residents who do not use the Internet, rural residents who use the Internet have a higher physical health level of 0,863 units and a higher mental health level of 0,354 units, respectively.

In order to observe the potential association between Internet use and the health status of rural residents further, Fig. 1 and Fig. 2 show the proportion of rural residents who use the Internet and those who do not with different levels of physical health and mental health respectively. Fig. 1 shows that the proportion of rural residents who do not use the Internet is higher than that of rural residents who use the Internet in the samples whose physical health is poor. The proportion of rural residents who use the Internet is higher than that of rural residents who do not use the Internet in the samples whose physical health is good. It can be preliminarily judged that Internet use has a positive impact on the physical health of rural residents. Fig. 2 shows that the proportion of rural residents who do not use the Internet is all higher than that of rural residents who use the Internet under different mental health conditions. However, with the increase of mental health status, the proportion of rural residents who use the Internet increases,

while the proportion of rural residents who do not use the Internet decreases. It can be preliminarily judged that Internet use has a positive impact on the mental health of rural residents.

Table 1 Summary statistics

Variable	Definitions	*Mean*	*SD*[1]
Physical health	1 = very poor; 2 = poor = 2， 3 = fair; 4 = good; 5 = very good	3,189	1,168
Mental health	1 = always feeling down; 2 = often feeling down; 3 = sometimes feeling down; 4 = rarely feeling down; 5 = never feeling down	3,601	1,011
Internet use	1 if rural resident uses the Internet, 0 otherwise	0,359	0,480
Age	Age of rural resident in years	53,33	15,16
Age2	Age square	3,074	1,596
Gender	1 if rural resident is male = 1, 0 female	0,488	0,500
Education	Educational levels[2] of rural resident	3,484	2,030
Marriage	1 if rural resident is married, 0 otherwise	0,801	0,399
Daily exercise	Number of effective exercises (more than half an hour) in the past year	10,64	28,14
Medical insurance	1 if rural resident buys medical insurance, 0 otherwise	0,936	0,245
Household incomes per capita	Household incomes per capita (yuan), taking the logarithm in regression model	8,513	2,142
Family size	Number of family members	2,995	2,644

Note: [1]*SD*, standard deviation
[2]1 = illiteracy; 2 = private school; 3 = Primary school; 4 = junior high school; 5 = vocational high school; 6 = regular high school; 7 = technical secondary school; 8 = technical school; 9 = junior college (adult higher education); 10 = junior college (formal higher education); 11 = Undergraduate (adult higher education); 12 = undergraduate (formal higher education); 13 = postgraduate and above

Table 2 Analysis on the mean difference of health whether rural residents use the Internet or not

Variable	Use the internet	Not use the internet	Mean difference
Physical health	3,742	2,879	0,863***
Mental health	3,828	3,474	0,354***

Note: Numbers in the parentheses represent robust standard error.
Significance level: *$p < 0,1$; **$p < 0,05$; ***$p < 0,01$

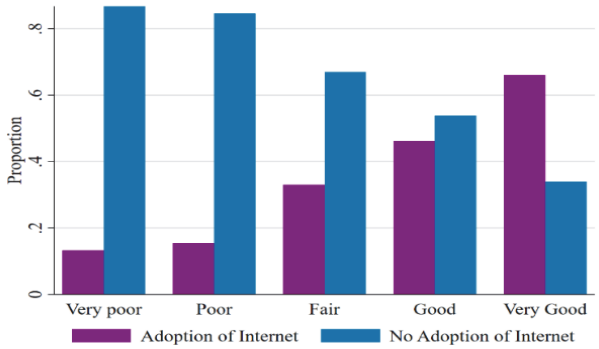

Figure 1 Proportion of Internet use under different levels of physical health

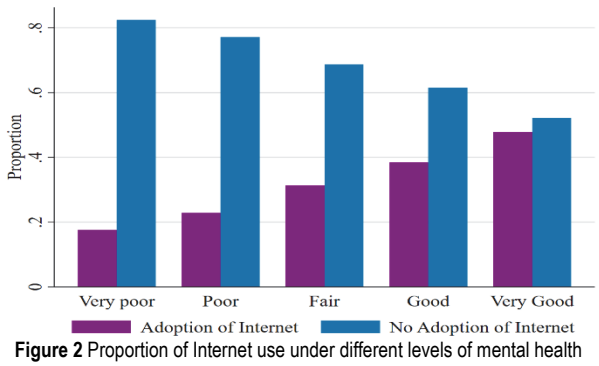

Figure 2 Proportion of Internet use under different levels of mental health

3 EMPIRICAL APPROACH

Considering the respondents' evaluation of health belongs to 1 - 5 ranking data, we use Order Probit model to investigate the impact of Internet use on rural residents' health. the dependent variable is health, and the independent variable is Internet use. This paper sets the regression equation to test the impact of Internet use on rural residents' health as follows.

$$Health_i = \beta Internet_i + \gamma X_i + \mu_i \tag{1}$$

$$Health_i = \begin{cases} 1, Health_i^* \le r_1 \\ 2, r_1 < Health_i^* \le r_2 \\ 3, r_2 < Health_i^* \le r_3 \\ 4, r_3 < Health_i^* \le r_4 \\ 5, r_4 \le Health_i^* \end{cases} \tag{2}$$

In Eq (1), $Health_i$ indicates the health level of rural residents including physical health and mental health. $Internet_i$ is a binary variable indicating whether rural residents use the Internet. If residents use the Internet, the value is 1; otherwise, the value is 0. X_i is a group of control variable vectors that affect the health level of rural residents. X_i includes individual and household level characteristic variables. μ_i is random error term.

In Eq. (2), $Health^*_i$ is the latent variable of rural residents' health level. r_1, r_2, r_3, r_4 are cutoff points meeting the conditions $r_1 < r_2 < r_3 < r_4$.We use Order Probit model to estimate the parameters in Eq. (1). However, the estimation coefficients of nonlinear regression models are not marginal effects of parameters. Then we calculate the marginal effect to measure the impact of Internet use on rural residents' health.

In addition, Internet use is not the result of random selection, but a self-selection process determined by individual and household level characteristic variables. Baseline regression result may have selection bias. We use Propensity Score Matching (PSM) method to construct a counterfactual framework for correction. We simulate a random test by matching and resampling. Suppose that the same rural resident uses the Internet and does not use the Internet at the same time. The difference of health between the two states is the impact of Internet use on rural residents' health. We set the model as follows:

$$ATT = E\left(Health_i^1 / Internet_i = 1\right) - \\ -E\left(Health_i^0 / Internet_i = 1\right) \tag{3}$$

ATT is short for the Average Treatment Effect on the Treated, which is the difference of health between a resident using the Internet and the counterfactual situation that is the same resident when he does not use the Internet. $E\left(Health_i^1 / Internet_i = 1\right)$ and $E\left(Health_i^0 / Internet_i = 1\right)$ indicate the health status of a residents using the Internet and the same resident when he does not using the Internet, respectively. We can observe $E\left(Health_i^1 / Internet_i = 1\right)$, but we cannot observe the counterfactual results $E\left(Health_i^0 / Internet_i = 1\right)$.

Firstly, we calculate the propensity score of residents using the Internet. Then we use multiple matching methods to match samples based on the propensity score and construct a control group. At this time, the treatment group and the control group have similar characteristics except for using the Internet, and the control group can be approximately regarded as the counterfactual situation of the treatment group. Finally, the difference of health between the treatment group and the control group is *ATT*.

4 RESULTS

4.1 Baseline Regression Results

Tab. 3 reports the estimated results of the impact of Internet use on the health of rural residents. Columns 1 - 3 show the impact of Internet use on rural residents' physical health. Columns 4 - 6 show the impact of Internet use on rural residents' mental health. Among them, columns 1 and 4 only consider the univariate relationship between Internet use and the health of rural residents. Columns 2 and 5 show the estimated results that control variables are added in baseline regression model. Columns 3 and 6 show the estimated results that province fixed effects are controlled further. In all the regression results, the coefficients of the Internet use variable are all significantly positive. The results show that Internet use is helpful to improve the health of rural residents. Column 3 shows the physical health level of rural residents who use the Internet is 0,261 units higher than that of rural residents who do not use the Internet. Column 6 shows the mental health level of rural residents who use the Internet is 0,116 units higher than that of rural residents who do not use the Internet.

Table 3 Baseline regression results

Variable	(1)	(2)	(3)	(4)	(5)	(6)
	Physical health			Mental health		
Internet use	0,820***	0,272***	0,261***	0,378***	0,140***	0,116**
	(0,035)	(0,046)	(0,047)	(0,035)	(0.047)	(0,047)
Age		−0,064***	−0,061***		−0,037***	−0,037***
		(0,007)	(0,007)		(0,007)	(0,007)
Age2		0,000***	0,000***		0,000***	0,000***
		(0,000)	(0,000)		(0,000)	(0,000)
Gender		0,126***	0,158***		0,144***	0,167***
		(0,034)	(0,034)		(0,034)	(0,034)
Education		0,069***	0,069***		0,065***	0,055***
		(0,010)	(0,010)		(0,010)	(0,010)
Marriage		0,121***	0,104**		0,238***	0,223***
		(0,045)	(0,046)		(0,045)	(0,046)
Daily exercise		−0,000	−0,000		−0,000	0,000
		(0,001)	(0,001)		(0,001)	(0,001)
Medical insurance		−0,008	−0,042		0,012	0,013
		(0,068)	(0,069)		(0,068)	(0,069)
Family size		0,010	0,004		0,011*	0,009
		(0,007)	(0,007)		(0,007)	(0,007)
Household incomes per capita		0,086***	0,077***		0,052***	0,045***
		(0,008)	(0,008)		(0,008)	(0,008)
Province FE	No	No	Yes	No	No	Yes
Observations	4086	4086	4086	4086	4086	4086

Note: Numbers in the parentheses represent robust standard error. Significance level: *$p < 0,1$; **$p < 0,05$; ***$p < 0,01$

4.2 Heterogeneity Analysis

In order to deepen the understanding of the relationship between Internet use and rural residents' health, and explore the group characteristics of the impact of the Internet on rural residents' health, we investigate which group's health level improves more after using the Internet.

4.2.1 The Impact of Internet Use on Rural Residents' Health by Gender

Male and female Internet users' habits are not the same. The impact of Internet use on male and female rural residents' health is not the same. This section examines the impact of Internet use on rural residents' health by gender. The regression results are shown in Tab. 4.

Columns 1 and 2 show the impact of Internet use on physical health of male and female rural residents, respectively. The regression results show that Internet use has a significant positive impact on residents' physical health in both males and females, which are statistically significant at a confidence level of 99%. Internet use has a greater positive impact on male rural residents' physical health. Male rural residents who use the Internet will improve their physical health level by 0,307 units; When female rural residents use the Internet, their physical health level will increase by 0,217 units.

Columns 3 and 4 show the impact of Internet use on mental health of male and female rural residents, respectively. The regression results show that Internet use only has a significant positive impact on female rural residents' mental health, which is statistically significant at a confidence level of 99%. The impact of Internet use on rural residents' mental health is mainly reflected in the

females. When female rural residents use the Internet, their mental health will increase by 0,176 units.

Table 4 Impact of Internet use on rural residents' health by gender

Variable	(1)	(2)	(3)	(4)
	Physical health		Mental health	
Internet use	0,307***	0,217***	0,047	0,176***
	(0,068)	(0,067)	(0,069)	(0,067)
Controls	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes
Observations	1995	2091	1995	2091

Note: Numbers in the parentheses represent robust standard error. Significance level: *$p < 0,1$; **$p < 0,05$; ***$p < 0,01$

4.2.2 The Impact of Internet Use on Rural Residents' Health by Education

Lack of skills and limited by education level are the main reasons for non-Internet users not to use Internet. Therefore, education level is one of the important factors affecting the Internet "usage gap" of rural residents. Based on the education level of rural residents, we divide the samples into three groups: high education level group (high school and above), middle education level group (middle school) and low education level group (primary school and below). Then we investigate the impact of Internet use on rural residents' health by education. The regression results are shown in Tab. 5.

Columns 1 - 3 show the impact of Internet use on the physical health of rural residents with high, middle and low education level respectively. The regression results show that Internet use has a significant positive impact on the physical health of rural residents with high, middle and low education level. Internet use has the largest positive impact on the physical health level of rural residents with high education level, followed by the low education level group. The middle education level group is impacted the least. The health level of rural residents with high education level will be improved by 0,279 units if they use the Internet. The health level of rural residents with middle education level will be improved by 0,202 units if they use the Internet. Rural residents with low education levels will improve their health by 0,214 units if they use the Internet.

Columns 4 - 6 show the impact of Internet use on the mental health of rural residents with high, middle and low education level respectively. Internet use only has a significant positive effect on the mental health of rural residents with high education level, which is statistically significant at a confidence level of 95%. The impact of Internet use on the mental health of rural residents is mainly reflected in the rural residents with high education level. The mental health of rural residents with high education level will be improved by 0,390 units if they use the Internet.

Table 5 Impact of Internet use on rural residents' health by education

Variable	(1)	(2)	(3)	(4)	(5)	(6)
	Physical health				Mental health	
Internet use	0,279*	0,202***	0,214***	0,390**	−0,054	0,109
	(0,152)	(0,078)	(0,070)	(0,153)	(0,079)	(0,071)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	535	1269	2282	535	1269	2282

Note: Numbers in the parentheses represent robust standard error. Significance level: *$p < 0,1$; **$p < 0,05$; ***$p < 0,01$

4.2.3 The Impact of Internet Use on Rural Residents' Health by Age

Age is also one of the important factors affecting the Internet "usage gap" of rural residents. Referring to the existing literature, we divide the samples into three groups: young group (under 40 years old), middle-aged group (40 - 60 years old) and elderly group (60 years old and above) to investigate the effect of Internet use on the health level of rural residents of different ages. The regression results are shown in Tab. 6.

Columns 1 - 3 show the impact of Internet use on the physical health of young, middle-aged and elderly rural residents respectively. The regression results show that Internet use has a significant positive impact on the physical health of young, middle-aged and elderly rural residents. Internet use has the largest positive impact on the physical health of elderly rural residents, followed by young rural residents. Middle-aged rural residents are impacted the least. When elderly rural residents use the Internet, their physical health will be improved by 0,369 units. Middle-aged rural residents who use the Internet will improve their health by 0,190 units. When young rural residents use the Internet, their physical health will be improved by 0,260 units.

Columns 4 - 6 show the impact of Internet use on the mental health of young, middle-aged and elderly rural residents respectively. Internet use only has a significant positive effect on the mental health of middle-aged rural residents, which is statistically significant at a confidence level of 90%. The promotion effect of Internet use on mental health of rural residents is mainly reflected in middle-aged rural residents. The mental health of middle-aged rural residents who use the Internet will be improved by 0,103 units.

Table 6 Impact of Internet use on rural residents' health by age

Variable	(1)	(2)	(3)	(4)	(5)	(6)
	Physical health			Mental health		
Internet use	0,260*	0,190***	0,369***	0,160	0,103*	0,114
	(0,134)	(0,060)	(0,119)	(0,133)	(0,060)	(0,119)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	785	1743	1558	785	1743	1558

Note: Numbers in the parentheses represent robust standard error. Significance level: *$p < 0,1$; **$p < 0,05$; ***$p < 0,01$

4.2.4 The Impact of Internet Use on Rural Residents' Health by Region

The level of economic development in different regions of China is different, so the Internet construction situation is different in different regions. In the early stage of Internet development, the developed eastern region had better digital infrastructure and higher economic level, and gained first-mover advantage in the popularization of Internet users. Although the Internet penetration rate in the central and western regions has increased rapidly with the booming development of mobile Internet, the difference of Internet penetration rate between the eastern region and the central regions is still 5,4 percentage by the end of 2021. The difference of Internet penetration rate between the eastern region and the west region is 9 percentages. Therefore, the health effects of Internet use on rural residents living in different areas are different.

In this study, we classify Beijing, Hebei, Liaoning, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong and Guangxi as the eastern region. Shanxi, Inner Mongolia, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei and Hunan are classified as the central region. Sichuan, Guizhou, Yunnan, Shaanxi, Gansu, Qinghai, Ningxia and Chongqing are classified as the western region. The regression results are shown in Tab. 7.

Columns 1 - 3 show the impact of Internet use on the physical health of rural residents in the eastern, central and western region respectively. The regression results show that Internet use has a significant positive impact on the physical health of rural residents in eastern, central and western regions. Internet use has the largest positive impact on the physical health of rural residents in eastern region, followed by rural residents in central region. Rural residents in western region are impacted the least. Rural residents in eastern China who use the Internet will improve their health by 0,320 units. Rural residents in central China who use the Internet will improve their health by 0,242 units. Rural residents in western China who use the Internet will improve their health by 0,237 units.

Columns 4 - 6 show the impact of Internet use on the mental health of rural residents in the eastern, central and western region respectively. Internet use only has a significant positive effect on mental health of rural residents in western China, which is statistically significant at a confidence level of 90%. The effect of Internet use on the mental health of rural residents is mainly reflected in the rural residents in western China. The mental health of rural residents in western China will be improved by 0,158 units if they use the Internet.

Table 7 Impact of Internet use on rural residents' health by region

Variable	(1)	(2)	(3)	(4)	(5)	(6)
	Physical health			Mental health		
Internet use	0,260*	0,190***	0,369***	0,160	0,103*	0,114
	(0,134)	(0,060)	(0,119)	(0,133)	(0,060)	(0,119)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	945	1957	1184	945	1957	1184

Note: Numbers in the parentheses represent robust standard error. Significance level: *$p < 0,1$; **$p < 0,05$; ***$p < 0,01$

4.3 Endogeneity Anaylysis

Since rural residents have self-selection bias when using the Internet, the propensity score matching method is used to eliminate the sample selection bias as much as possible and carry out unbiased estimation.

Firstly, we construct a probit model to calculate the probability score of rural residents using the Internet. Then the Internet users are matched with similar individuals who do not use the Internet according to their propensity scores. The matched samples should satisfy the common support hypothesis. Fig. 3 shows the verification results of the common support hypothesis. After matching, most samples of the treatment group and the control group are in the common value range (on support), and less sample loss. The matched samples satisfy the common support hypothesis.

Multiple matching methods are used to calculate the average treatment effect for the robustness of the conclusion. Tab. 6 shows the PSM estimation results of the impact of Internet use on rural residents' health. Panel A and Panel B present the PSM estimation results of the impact of Internet use on physical health and mental health respectively. After eliminating the differences of characteristics expect Internet use between treatment and control group, the average treatment effect on the treated (*ATT*) obtained by multiple matching methods listed in Tab. 6 are statistically significant. The *ATT* values are slightly different due to different matching methods.

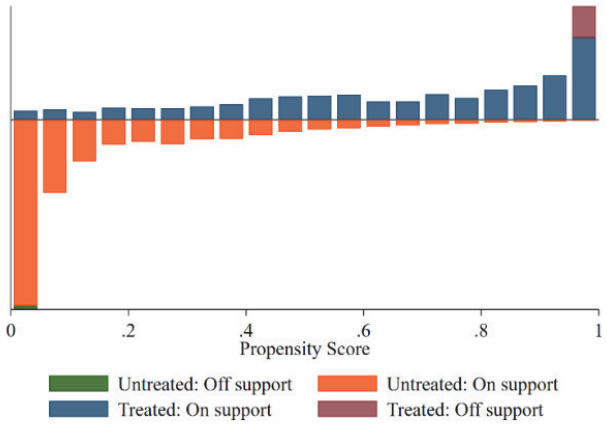

Figure 3 Range of on support

Tab. 8 shows that the *ATT* value ranges from 0,208 to 0,277 for the impact of Internet use on rural residents' physical health. The *ATT* value ranges from 0,143 to 0,247 for the impact of Internet use on rural residents' mental health. All the *ATT* values are positive and statistically significant at a confidence level of 95%. PSM estimation results indicate that the positive effect of Internet use on the health of rural residents is stable. After considering the

problem of sample self-selection bias, Internet use is helpful to improve the health of rural residents.

Table 8 PSM estimation results

Matching methods		*Treated*	*Control*	*ATT*	*S.E.*	*T-stat*
Panel A effect of internet use on physical health						
Nearest neighbor matching (k = 4)	Unmatched	3,742	2,879	0,863	0,036	24,21
	Matched	3,703	3,495	0,208	0,103	2,00
Radius matching (r = 0,05)	Unmatched	3,742	2,879	0,863	0,036	24,21
	Matched	3,703	3,457	0,246	0,088	2,79
Kernel matching	Unmatched	3,742	2,879	0,863	0,036	24,21
	Matched	3,703	3,460	0,243	0,088	2,75
Mahalanobis matching	Unmatched	3,742	2,879	0,863	0,036	24,21
	Matched	3,742	3,464	0,277	0,073	3,80
Panel B effect of internet use on mental health						
Nearest neighbor matching (k = 4)	Unmatched	3,828	3,474	0,354	0,032	10,90
	Matched	3,809	3,562	0,247	0,096	2,55
Radius matching (r = 0,05)	Unmatched	3,828	3,474	0,354	0,032	10,90
	Matched	3,808	3,649	0,159	0,080	1,98
Kernel matching	Unmatched	3,828	3,474	0,354	0,032	10,90
	Matched	3,808	3,638	0,170	0,080	2,11
Mahalanobis matching	Unmatched	3,828	3,474	0,354	0,032	10,90
	Matched	3,828	3,685	0,143	0,063	2,25

5 ROBUSTNESS

When studying the impact of Internet use on the health level of rural residents, different indicators and regression model may have inconsistent effects on the regression results. It may lead to the consequence of estimation results unreliable and unstable. In order to test the baseline regression results are stable enough and are not random phenomena of a sample estimation, we employ multiple methods to conduct robustness tests as follows.

5.1 Changing Regression Model

Firstly, we regard the dependent variable rural residents' health as a continuous variable and employ OLS model to estimate the coefficient. The estimated coefficient of OLS model is the marginal effect of the Internet use on rural residents' health. Column 1 and 3 of Tab. 9 show the effects of Internet use on rural residents' physical and mental health respectively. Coefficients of Internet use are positive, it indicates that Internet use improves rural residents' health.

In baseline regression, independent variable health includes five categories: very poor, poor, fair, good and very good Then we classify "very poor, poor, fair" as unhealthy, and assign unhealthy the value of 0. We classify "good, very good" as healthy, and assign healthy the value of 1. We convert the dependent variable health into a dummy variable and use probit model to regress. Column 2 and 4 of Tab. 9 show the effects of Internet use on rural residents' physical and mental health respectively. Coefficients of Internet use are positive; it indicates that Internet use improves rural residents' health.

Table 9 Change regression model

Variable	Physical health		Mental health	
	OLS	Probit	OLS	Probit
Internet use	0,271***	0,282***	0,112***	0,151***
	(0,045)	(0,058)	(0,043)	(0,057)
Controls	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes
Observations	4086	4086	4086	4086

Note: Numbers in the parentheses represent robust standard error. Significance level: *p < 0,1; **p < 0,05; ***p < 0,01

5.2 Changing Measure of Independent Variable

In the analysis above, the independent variable Internet use is mainly measured from the answer of question "your use of the Internet (including WAP) in the past year" in the questionnaire. Instead, we use the answer of question "in the past year, were you often engaged in the Internet in free time," or "in the last six months, have you ever been on the Internet, including using a variety of equipment such as computers, mobile phones, smart wearable devices etc. to surf the Internet" in the questionnaire to measure Internet use. Then put the new measured independent variable in baseline regression model to regress. Columns 1 and 2 of Tab. 10 show the effects of two alternative indicators of Internet use on rural residents' physical health respectively. Columns 3 and 4 of Tab. 10 show the effects of two alternative indicators of Internet use on rural residents' mental health respectively. The results show that the regression results after replacing the independent variable measurement are basically consistent with the baseline regression results. It indicates that the baseline regression results are robust.

Table 10 Change measure of independent variable

Variable	Physical health		Mental health	
	Question1	Question2	Question1	Question2
Internet use	0,295***	0.269***	0,120**	0,134***
	(0,048)	(0.048)	(0,048)	(0,048)
Controls	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes
Observations	4086	4086	4086	4086

Note: Numbers in the parentheses represent robust standard error. Significance level: *p < 0,1; **p < 0,05; ***p < 0,01

6 MECHANISM ANALYSIS

Internet use can not only directly increase rural residents' health, but also indirectly affect rural residents' health through "media". This section explores whether Internet use will increase the health of rural residents by increasing their social networks. The mediation effect model proposed by Baron (1986) is only suitable for linear regression model [41]. But the Order probit model used in the baseline regression is a nonlinear regression model.

Therefore, this paper draws on the KHB method proposed by Karlson (2010) to investigate the impact mechanism of Internet use on rural residents' health, that is, to test whether social networks are the channels through which Internet use affects rural residents' health [42].

Tab. 11 shows the estimated results of the mechanism analysis. Panel A shows the mechanism analysis results of the impact of Internet use on rural residents' physical health. The total and direct effects of Internet use on rural residents' physical health are positive, which are statistically significant at a confidence level of 99%. The results indicate that social networks play a mediating role in the process of Internet use affecting rural residents' physical health. The mediating effect of social network accounted for 8.89% of the total effect. These results indicate that social networks play a mediating effect on the impact of Internet use on the rural residents' physical health. Internet use improves the rural residents' physical health through social network.

Panel B shows mechanism analysis results of the impact of Internet use on rural residents' mental health. The total and direct effects of Internet use on rural residents' mental health are positive, which is statistically significant at a confidence level of 99%. The results indicate that social networks play a mediating role in the process of Internet use affecting rural residents' mental health. The mediating effect of social network accounted for 9,21% of the total effect. These results indicate that social networks play a mediating effect on the impact of Internet use on rural residents' mental health. Internet use improves rural residents' mental health through social network.

Table 11 Mechanism analysis

Mediating variable	Total effect	Direct effect	Indirect effect
Panel A Effect of internet use on physical health			
Social networks	0,091***	0,083***	0,008***
	(0,012)	(0,012)	(0,002)
Panel B Effect of internet use on psychology health			
Social networks	0,045***	0,041***	0,004***
	(0,012)	(0,012)	(0.002)

Note: Numbers in the parentheses represent robust standard error.
Significance level: *$p < 0,1$; **$p < 0,05$; ***$p < 0,01$

7 CONCLUSIONS AND POLICY IMPLICATIONS

In the context of " Internet + Healthcare", Internet use may improve rural residents' health through social networks. Internet has eliminated the relative closure of rural areas, accelerated the flow of production factors, and provided an efficient and convenient communication channel for rural residents to communicate with the outside world and expand interpersonal relations. It can increase the accumulation of social capital of rural residents and improve rural residents' health further.

Although previous literature has explored the relationship between Internet use and residents' health, the research samples mainly focus on the young and elderly groups, and there are few studies on rural residents. Agriculture is the foundation of China, and the stability of agriculture contributes to the maintenance of social stability and unity. The protection and improvement of rural residents' health is related to the overall effect of Healthy China strategy. In addition, existing research mainly focuses on residents' health indicators such as sleep, loneliness and so on. Few researches focus on residents' comprehensive health. It is difficult to comprehensively grasp the relationship between Internet use and residents' health. In view of this, this study estimates the impact of Internet use on rural residents' health, utilizing order probit model and the propensity score matching (PSM) model and using data from 2017 Chinese General Social Survey (CGSS).

Based on the baseline regression, the heterogeneity of the effect in different groups is also discussed further. Finally, we analyze the mechanism of the impact of Internet use on rural residents' health, and explore the mediating effect of social networks. The results showed that:

First, Internet use can significantly increase rural residents' health. Internet use can not only increase rural residents' health, but also increase rural residents' mental health. Rural residents who use the Internet are 0.261 units higher in physical health and 0.116 units higher in mental health than rural residents who do not use the Internet. The propensity score matching method is adopted in this study to solve the endogeneity problem caused by sample self-selection bias, and the regression results are still robust.

Second, Heterogeneity analysis results show that the impact of Internet use on rural residents' health are significantly different in different gender, different education level, different age and different regions. Compared with female rural residents, Internet use has a greater positive impact on physical health of male rural residents. However, Internet use only has a significant positive effect on mental health of female rural residents. Compared with rural residents with the middle and low education level, Internet use has the greatest positive impact on physical health of rural residents with high education level. Moreover, Internet use only has a significant positive effect on mental health of rural residents with high education level. Compared with young and middle-aged rural residents, Internet use has the greatest positive impact on physical health of elderly rural residents. Internet use only has a significant positive effect on mental health of middle-aged rural residents. Compared with rural residents in the central and western regions, Internet use has the greatest positive impact on physical health of rural residents in the eastern region. Internet use only has a significant positive effect on mental health of rural residents in western region.

Third, results of mechanism analysis show that Internet use can improve the social network of rural residents, and then improve their health level. That is, the promotion of social networks is an important mechanism for Internet use to promote rural residents' health.

Based on the above analysis, this paper puts forward policy suggestions as follows:

First, Chinese government should continue to build Internet infrastructure and increase Internet penetration, especially in rural areas. The accelerating construction of Internet infrastructure will help more rural residents use the Internet. The digital divide between different regions and groups has not yet been fully bridged, and the development of the Internet still needs to be deeply coordinated. Digital technology suitable for the elderly can be improved continually. This will help special groups share the achievements of information technology. It makes intelligent life warm and barrier-free.

Second, Chinese government should rationally guide the use of the Internet and give full play to its positive role to reduce the negative impact of Internet. While Internet use can improve health, spending too much time online can damage your health. And for the residents, especially adolescents who cannot self-control well, online games are more addictive. If Internet use is not properly controlled, it may have a negative impact on health. Therefore, the rational allocation of time for entertainment, work and study and the strengthening of self-discipline are of great significance for Internet use to improve the health of residents, especially students. Communities can also increase skill training on the use of the Internet for public welfare to improve the operation capability of computers, smart phones and other mobile communication devices of middle-aged and elderly rural residents.

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8 REFERENCES

[1] Schultz, T. W. (1961). Investment in human capital. *The American economic review*, *51*(1), 1-17.

[2] Cozma, P., Gavrilescu, M., Roşca, M., Apostol, L., Hlihor, R., & Gavrilescu, M. (2018). Evaluation of human health risks associated with pesticide dietary intake-an overview on quantitative uncertainty analysis. *Environmental Engineering and Management Journal*, *17*, 2263-2274. https://doi.org/10.30638/eemj.2018.224

[3] Blue, I. & Harpham, T. (1994). The World Bank World Development Report 1993: Investing in Health: Reveals the burden of common mental disorders, but ignores its implications. *The British Journal of Psychiatry*, *165*(1), 9-12. https://doi.org/10.1192/bjp.165.1.9

[4] Bharwana, S. A., Ali, S., Farid, M., Zubair, M., Rizwan, M., & Ahmad, R. (2019). Occupational health and safety conditions in small medium sized enterprises of iron furniture manufacturing units. *Environmental Engineering and Management Journal*, *18*, 545-553. https://doi.org/10.30638/eemj.2019.051

[5] Lopez-Fernandez, O. (2021). Emerging health and education issues related to internet technologies and addictive problems. *International Journal of Environmental Research and Public Health*, *18*(1). https://doi.org/10.3390/ijerph18010321

[6] Choi, J. W. & Jeong, E. R. (2022). A multi-output convolutional neural network-based distance and velocity estimation technique. *Journal of Logistics, Informatics and Service Science*, *9*(1), 11-25. https://doi.org/10.14704/WEB/V19I1/WEB19302

[7] Chun, Y. H. & Cho, M. K. (2022). An empirical study of intelligent security analysis methods utilizing big data. *Journal of Logistics, Informatics and Service Science*, *9*(1), 26-35. https://doi.org/10.14704/WEB/V19I1/WEB19311

[8] Ifroh, R. H. & Permana, L. (2022). Do Parents Use The Internet And Social Media To Child Health-Seeking Information? *Jurnal Kesehatan Komunitas*, *8*(2), 171-180. https://doi.org/10.25311/keskom.Vol8.Iss2.1209

[9] Duplaga, M. (2021). The association between Internet use and health-related outcomes in older adults and the elderly: a cross-sectional study. *BMC Medical Informatics and Decision Making*, *21*(1), 1-12. https://doi.org/10.1186/s12911-021-01500-2

[10] Li, L., Ding, H., & Li, Z. (2022). Does Internet Use Impact the Health Status of Middle-Aged and Older Populations? Evidence from China Health and Retirement Longitudinal Study (CHARLS). *International Journal of Environmental Research and Public Health*, *19*(6), 3619. https://doi.org/10.3390/ijerph19063619

[11] Tavares, A. I. (2020). Self-assessed health among older people in Europe and internet use. *International Journal of Medical Informatics*, *2020*. https://doi.org/10.1016/j.ijmedinf.2020.104240

[12] Yuan, H. (2021). Internet use and mental health problems among older people in Shanghai, China: The moderating roles of chronic diseases and household income. *Aging & Mental Health*, *25*(4), 657-663. https://doi.org/10.1080/13607863.2020.1711858

[13] Forsman, A. K. & Nordmyr, J. (2017). Psychosocial links between Internet use and mental health in later life: a systematic review of quantitative and qualitative evidence. *Journal of Applied Gerontology*, *36*(12), 1471-1518. https://doi.org/10.1177/0733464815595509

[14] Macdonald, B. & Hülür, G. (2020). Rethinking social relationships in old age: Digitalization and the social lives of older adults. *American Psychologist*, *75*(4). https://doi.org/10.2196/20306

[15] Lu, H. & Kandilov, I. T. (2021). Does mobile internet use affect the subjective well-being of older Chinese adults? An instrumental variable quantile analysis. *Journal of Happiness Studies*, *22*(7), 3137-3156. https://doi.org/10.1007/s10902-021-00365-6

[16] Szabo, A., Allen, J., Stephens, C., & Fiona, A. (2019). Longitudinal analysis of the relationship between purposes of internet use and well-being among older adults. *The Gerontologist*, *59*(1), 58-68. https://doi.org/10.1093/geront/gny036

[17] Silva, P., Matos, A. D., & Martinez-Pecino, R. (2022). Can the internet reduce the loneliness of 50+ living alone? *Information, Communication & Society*, *25*(1), 17-33. https://doi.org/10.1080/1369118X.2020.1760917

[18] Yu, X., Mu, A., Wu, X., & Liqin, Z. (2022). Impact of Internet Use on Cognitive Decline in Middle-Aged and Older Adults in China: Longitudinal Observational Study. *Journal of Medical Internet Research*, *24*(1). https://doi.org/10.2196/25760

[19] Shiferaw, K. B. & Mehari, E. A. (2019). Internet use and eHealth literacy among health-care professionals in a resource limited setting: a cross-sectional survey. *Advances in medical education and practice*, *10*. https://doi.org/10.2147/amep.s205414

[20] Ciarrochi, J., Parker, P., Sahdra, B., Marshall, S., Jackson, C., Gloster, A. T., & Heaven, P. (2016). The development of compulsive internet use and mental health: A four-year study of adolescence. *Developmental psychology*, *52*(2). https://doi.org/10.1037/dev0000070

[21] Pujazon-Zazik, M. & Park, M. J. (2010). To tweet, or not to tweet: gender differences and potential positive and negative health outcomes of adolescents' social internet use. *American journal of men's health*, *4*(1), 77-85. https://doi.org/10.1177/1557988309360819

[22] Özaslan, A., Yıldırım, M., Güney, E., Halime, Ş. G., & Elvan, İ. (2022). Association between problematic internet use, quality of parent-adolescents relationship, conflicts, and mental health problems. *International Journal of Mental Health and Addiction*, *20*(4), 2503-2519. https://doi.org/10.1007/s11469-021-00529-8

[23] Machimbarrena, J. M., González-Cabrera, J., Ortega-Barón, J., Marta, B. F., Aitor, Á. B., & Blanca, T. (2019). Profiles of problematic internet use and its impact on adolescents' health-related quality of life. *International Journal of Environmental Research and Public Health*, *16*(20). https://doi.org/10.3390/ijerph16203877

[24] Stevens, C., Zhang, E., Cherkerzian, S., Justin, A. C., & Cindy, H. L. (2020). Problematic internet use/computer gaming among US college students: Prevalence and correlates with mental health symptoms. *Depression and Anxiety*, *37*(11), 1127-1136. https://doi.org/10.1002/da.23094

[25] Sayeed, A., Rahman, M. H., Hassan, M. N., Enryka, C., Satyajit, K., Al-Banna, H., Al-Riaj, H., Trisha, M., Amatul, E. M., & Tasdik, M. H. (2021). Problematic internet use associated with depression, health, and internet-use behaviors among university students of Bangladesh: A cross-sectional study. *Children and Youth Services Review*, *120*. https://doi.org/10.1016/j.childyouth.2020.105771

[26] Do, Y. K., Shin, E., Bautista, M. A., & Kelvin, F. (2013). The associations between self-reported sleep duration and adolescent health outcomes: what is the role of time spent on Internet use?. *Sleep medicine*, *14*(2), 195-200. https://doi.org/10.1016/j.sleep.2012.09.004

[27] Gatto, S. L. & Tak, S. H. (2008). Computer, Internet, and e-mail use among older adults: Benefits and barriers. *Educational Gerontology*, *34*(9), 800-811. https://doi.org/10.1080/03601270802243697

[28] Huang, C. (2010). Internet use and psychological well-being: A meta-analysis. *Cyberpsychology, behavior, and social networking*, *13*(3), 241-249. https://doi.org/10.1089/cyber.2009.0217

[29] Damant, J., Knapp, M., Freddolino, P., & Lombard, D. (2017). Effects of digital engagement on the quality of life of older people. *Health & Social Care in the Community*, *25*(6), 1679-1703. https://doi.org/10.1111/hsc.12335

[30] Radu, G. & Aurel, G. (2012). Mathematical model and computation program of the chamber furnace of boilers for air pollution reduction. *Environmental Engineering and Management Journal*, *11*, 557-565. https://doi.org/10.30638/eemj.2012.068

[31] Elena-Diana, C., Cristina, G., Raluca, M. H., & Maria, G. (2016). Occurrence of plastic waste in the environment: ecological and health risks. *Environmental Engineering and Management Journal*, *3*, 675-687. https://doi.org/10.30638/eemj.2016.073

[32] Son, H. J. & Park, H. (2022). An Empirical Study on Self-Esteem and Life Satisfaction of the Elderly. *Journal of System and Management Sciences*, *12*(1), 208-228.

[33] Comăniță, E., Cozma, P., Simion, I., Roșca, M., & Gavrilescu, M. (2018), Evaluation of eco-efficiency by multicriteria decision analysis. case study of eco-innovated and eco-designed products from recyclable waste. *Environmental Engineering and Management Journal*, *17*, 1791-1804. https://doi.org/10.30638/eemj.2018.178

[34] Cucchiella, F., D'Adamo, I., Gastaldi, M., Koh, L., Santibanez-Gonzalez, E. (2020). Assessment of GHG emissions in Europe: future estimates and policy implications. *Environmental Engineering and Management Journal*, *19*, 131-142. https://doi.org/10.1007/978-981-16-0490-4_4

[35] Kim, Y. S., Song, H. J., & Han, J. (2022). A Deepfake-Based Deep Learning Algorithm for Medical Data Manipulation Detection. *Journal of System and Management Sciences*, *12*(1), 13-24.

[36] Tang, D., Jin, Y., Zhang, K., & Dahua, W. (2022). Internet use, social networks, and loneliness among the older population in China. *Frontiers in Psychology*, *13*. https://doi.org/10.3389/fpsyg.2022.895141

[37] Zhang, Q. & Li, Z. (2022). The Impact of Internet Use on the Social Networks of the Elderly in China-The Mediating Effect of Social Participation. *International Journal of Environmental Research and Public Health*, *19*(15). https://doi.org/10.3390/ijerph19159576

[38] Huang, X. B. & Meng, C. (2022). The Impact of Internet Use on Community Participation of Older Adults: Evidence From China. *SAGE Open*, *12*(2). https://doi.org/10.1177/21582440221097387

[39] Kobayashi, L. C., Wardle, J., & von Wagner, C. (2015). Internet use, social engagement and health literacy decline during ageing in a longitudinal cohort of older English adults. *J. Epidemiol Community Health*, 2015, *69*(3), 278-283. https://doi.org/10.1136/jech-2014-204733

[40] Yoon, H., Jang, Y., Vaughan, P. W., & Michael, G. (2020). Older adults' internet use for health information: digital divide by race/ethnicity and socioeconomic status. *Journal of Applied Gerontology*, *39*(1), 105-110. https://doi.org/10.1177/0733464818770772

[41] Baron, R. M. & Kenny, D. A. (1986). The moderator-mediator variable distinction in social psychological research: Conceptu-al, strategic, and statistical considerations. *Journal of personality and social psychology*, *51*(6). https://doi.org/10.1037//0022-3514.51.6.1173

[42] Karlson, K. B., Holm, A., & Breen, R. (2010). Comparing Regression Coefficients Between Models using Logit and Probit: A New Method. *Social Science Electronic Publishing*, *42*(1), 286-313. https://doi.org/10.1177/0081175012444861

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