BMC Psychology

RESEARCH

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The impact of active social media use on the mental health of older adults

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Abstract

Background With the rising population age and the development of information technology in China, a growing number of older adults use social media as a means of social participation. The impact of posting on WeChat Moments on the mental health of older adults is worthy of attention.

Aim The aim of this study is to identify posting on WeChat Moments as an active social media use and analyze its impact on the mental health of older adults.

Method Using the survey data from the China Health and Retirement Longitudinal Study (CHARLS), we defined posting on WeChat Moments as an active social media use and used propensity score matching (PSM) to analyze the impact of such posting on the mental health of older adults.

Results The results of the study showed that posting statistically significantly improved the depression, self-rated health, and health satisfaction of older adults. Heterogeneity analysis showed that the female older-adult population and the younger older-adult population derived the most mental health benefit from posting on WeChat Moments.

Conclusion Posting on WeChat Moments statistically significantly improved the depression, self-rated health, and health satisfaction of older adults. Older adults who use WeChat and post on WeChat Moments derive much benefit from their active social media use.

Keywords Active social media use, WeChat, WeChat moments, Older adults, Mental health

Introduction

Population aging has become the basic national condition of China. In 2020, the Chinese government formally established active coping with aging as a national strategy. According to the main results of the seventh National Population Census of China released in 2021, there are 260 million people aged 60 and above in China, accounting for 18.70% of the total population, and the aging of the population has accelerated significantly [1]. While China's population aging has become an increasingly serious problem, the construction of communication networks and information systems has entered a period of rapid development in China. As the number of older adults using the Internet through mobile phones grows, the number of older adults using social media is

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also increasing rapidly. For example, the WeChat data report noted that the number of active WeChat users over 55 years old in 2016, 2017, and 2018 was 7.68 million, 50 million, and 61 million, respectively. Overall, 85% of these older adults used the social functions of WeChat (e.g., voice, likes, and videos, with voice chat accounting for the highest percentage at 95.8%) [2].

The use of social media among older adults can be regarded as a form of social participation, because such participation can come in the form of both formal activities, such as participation in volunteer activities and club activities, and informal activities, such as telephone calls and social interaction with friends [3]. Social participation is beneficial to the physical and mental health of older adults [4]. Positive associations between social participation and health were found [5]. Social participation can effectively reduce the risk of depression in the elderly [6]. Social participation functions as a protective factor against the onset or development of chronic conditions [7]. Observational study evidence indicates that greater social participation in midlife and late life is associated with 30–50% lower subsequent dementia risk [8].

However, the impact of social media use on mental health is complex, and no consistent conclusion about it has been reached [9, 10]. This is because social media use is a concept that is difficult to define and measure. Social media include many different functions and activities, and the patterns of activity of two users who spend the same amount of time on social media every day may be completely different, making it difficult to measure the impact of social media use on other variables (e.g., subjective well-being) [11]. Therefore, the impact of social media use on mental health cannot be considered in the simple terms of use vs. nonuse but should be analyzed in terms of more specific use patterns [12]. Further study has suggested that it is not enough to consider only the frequency and duration of social media use but that we must consider active and passive use of social media [13]. Since traditional social participation can boost the mental health of older adults, the impact of active social media use on the mental health of older adults has become a new issue worth exploring, given that they increasingly use social media.

The widespread use of social media has led to many studies on the impact of social media use on mental health [14]. Some of these studies have found a significant positive impact of the use of social media (e.g., Facebook and Instagram) on subjective well-being [10, 13, 15, 16]. It has the ability to keep older adults cognitively engaged, improve health communication, and increase social connectedness [17]. Higher level of social media communication is associated with lower levels of loneliness through social contact and perceived social support [18]. Older adults are unable to use social media, which may affect their social support and intergenerational relationships and cause depression [19]. On the other hand, some studies have suggested that social media use has a significant negative impact on mental health [20]. Existing studies suggest that there is an association between problematic social media use and perceived social isolation in older adults [21]. Some studies have shown that social media use has a complex impact on mental health [22]. Routine use is significantly lower among older adults (60+) compared with the other three age groups (18–29, 30–44, 45–59), The relationship of routine use with social well-being is weaker among older adults (60+) [23]. Despite the inconsistent findings on the impact of social media use on mental health, it is certain that there is a causal relationship between social media use and mental health [24].

The key reason for these inconsistent findings is that these studies define social media use too broadly, without distinguishing between the various activities that social media users can participate in [25]. Different social media contain a variety of content, which can be roughly divided into two categories: those that are actively used and those that are passively used [26]. Active use refers to activities that promote direct communication with other people, including targeted one-on-one direct communication, and untargeted communication. The active social media use can entail many kinds of information exchange, such as sending information, updating one's personal status, and sharing links [27]. Gerson et al. (2017) argued that active Facebook use describes the active participation of users in site interactions, content creation, and active communication with friends [11]. Therefore, active use can reflect an individual's self-concept, language, or thoughts, which can be used to interact with others [28].

Accordingly, Hypothesis 1: There is a positive effect of active social media use on the mental health of older adults.

Modern society has advanced to the point where people value health in their later years just as much [29]. There has been no direct analysis of the impact of active social media use on the mental health of older adults, but its impact on the mental health of adolescents has been explored. Active Facebook use, i.e., self-disclosure on Facebook, has been found to be positively correlated with subjective well-being [12, 26, 30, 31]. In addition to examining the impact of active social media use on adolescent health, existing studies have also found a significant gender difference in this impact [32, 33].

Accordingly, Hypothesis 2 is proposed: the impact of posting on WeChat Moments on the mental health of older adults has heterogeneity.

A comprehensive review reveals the following limitations in the existing research on the relationship between

active social media use and mental health. First, the focus has been on the impact of the active social media use among adolescents on their mental health, but there is a lack of research on the older adult population. As more older adults use social media through smartphones, the impact of active social media use on their mental health cannot be ignored. Second, most of the existing studies have focused on experimental investigations, which have comparatively analyzed the social media use of different groups but failed to systematically explore the impact of active social media use on mental health. Third, the endogeneity between active social media use and mental health has not been compensated for.

WeChat Moments, a function of the instant messaging application WeChat, is one of the most popular social media platforms in China. WeChat Moments is similar to Facebook, but posts made on the platform are only viewable to people on users' WeChat contact lists [34]. By dissecting the active engagement of older adults with social media platforms, this research endeavors to contribute to the formulation of efficacious intervention policies aimed at ameliorating their mental health. The resultant findings can potentially furnish empirical evidence, empowering China to proactively address the challenges posed by an aging society and facilitating the pursuit of successful aging among the elderly cohort. Given these traits, the aim of this study is to identify posting on WeChat Moments as an active social media use and analyze its impact on the mental health of older adults.

Method

Data source

The data used in the present study were from the 2018 and 2020 CHARLS, directed by the National School of Development of Peking University and run by the Institute of Social Science Survey of Peking University. CHARLS was a nationwide sample survey implemented in 2011 aiming to analyze the problem of population aging in China and promote interdisciplinary research on aging issues. The CHARLS survey samples covered 150 counties and districts, 450 villages, more than 10,000 families, and approximately 18,000 individuals aged 45 years and above, randomly selected from 28 provinces, autonomous regions, and municipalities directly under the central government. Using data from 2018 to 2020 surveys to construct panel data, this article only retained samples of older adults aged 60 and above. After excluding some samples with missing variables, a total of 12,227 valid samples were finally studied.

Measurement tools

The explained variables used in the present study to measure the mental health of older adults included negative emotion, positive emotion, self-rated health, and health satisfaction. In the CHARLS questionnaire, the "health status and function" module measured depressive symptoms using the short form of the Center for Epidemiological Studies Depression Scale (CES-D10). The 20-item CES-D has been widely used in various surveys to assess depressive symptoms in individuals and has been proven to have good validity and reliability when used in Asian populations [35]. The CES-D10 scale of the CHARLS questionnaire included two positive emotion items, five somatic symptom items, and three depressive emotion items. Based on the methods of existing literature [36], the 10 items were categorized into two psychometric properties, i.e., the frequency of negative affect and the frequency of positive affect.

Self-rated health was measured using the health as self-rated by older adults in the CHARLS questionnaire. Health satisfaction corresponded to the question "Are you satisfied with your health?" in the CHARLS questionnaire.

The core explanatory variable in the present study was the active social media use among older adults, that is, the item "Do you post on WeChat Moments?" (1 = yes and 0 = no) in the CHARLS questionnaire. We identify posting on WeChat Moments as an active use of social media, given that such posting can serve as a status update and instant communication. The group of elderly people who actively post on WeChat Moments is defined as the "treatment group", while those who don't post on WeChat Moments are defined as the "control group".

The control variables described individual and family characteristics of older adults. Individual variables included age, gender, education level, income, marital status, and objective physical condition [37–42], of which objective physical health included the number of chronic diseases and activities of daily living (ADLs) [43], and family status included support from their children [44] and place of residence [45, 46].

Table 1 shows the definitions and descriptive statistics of these variables. The respondents had a mean age of 69.2 years, with 48.55% females, 75.36% living with their spouse, and 42.25% living with their children. For the education level, based on the corresponding item in the CHARLS questionnaire, scores of 1 to 11 were assigned to the responses of no education (illiteracy); elementary school not completed; graduation from private school, elementary school, middle school, high school, and technical secondary school (including secondary normal school, vocational high school); and graduation with an associate degree, bachelor's degree, master's degree, and doctoral degree, respectively. The number of chronic diseases was defined by the respondent's answers about suffering from 11 chronic diseases (e.g., hypertension, dyslipidemia, and diabetes) on the CHARLS questionnaire. A higher assigned score indicated a worse

Table 1 Definitions and descriptive statistics of variables

Variable	Definition	Mean	Standard deviation	Minimum	Maximum
Explained variables					
Negative emotion	Continuous variable (8-32)	14.41	5.881	8	32
Positive emotion	Continuous variable (2–8)	5.36	2.055	2	8
Self-rated health	5 = very good; 4 = good; 3 = fair; 2 = bad; 1 = very bad	2.91	1.025	1	5
Health satisfaction	5 = extremely satisfied; 4 = very satisfied; 3 = somewhat satisfied; 2 = not very satisfied; 1 = not at all satisfied	3.14	0.871	1	5
Explanatory variable					
Posting on WeChat Moments	1 = yes; 0 = no	0.07	0.260	0	1
Individual variables					
Age	Continuous variable	69.17	7.077	60	91
Gender	1 = male; 2 = female	1.51	0.500	1	2
Marital status	1 = with spouse; 0 = without spouse	0.75	0.431	0	1
Education level	Continuous variable	2.99	1.899	1	11
Living arrangement	1 = living with children; 0 = not living with children	0.42	0.494	0	1
Chronic diseases	Number of chronic diseases	0.68	1.031	0	11
Disability status	Number of ADLs that cannot be performed	0.20	0.784	0	6
Family status variables					
Family income	Logarithm of respondent's annual income	9.20	1.753	1.211	17.481
Living area	1 = urban; 0 = rural	0.30	0.460	0	1
N	12,227				

Table 2 Comparison between the treatment and the control group

	Negative emotion	Positive emotion	Self-rated health	Health satisfaction
Posted on WeChat Moments(*N* = 776)	12.448	6.287	3.167	3.216
Did not post on WeChat Moments(*N* = 11451)	14.612	5.263	2.890	3.128
MeanDiff	2.364***	-1.023***	-0.278***	-0.087**

Note: *, **, and *** indicate statistical significance at the levels of 10%, 5%, and 1%, respectively

physical health status. The disability status came from their answers to questions on ADLs. More ADLs that could not be performed indicated a more severely disabled status.

Table 2 shows the relationship between posting on WeChat Moments and the mental health of older adults. It can be seen that elderly people who posted on WeChat Moments had lower negative emotion scores but higher positive emotion, self - rated health and health satisfaction scores than those who did not. We compare the differences between the treatment group and the control group. The difference between the two groups was statistically significant.

Statistical method

Considering that the mental health of the elderly is influenced by multiple factors, including personal characteristics (age, gender, health status, etc.), family characteristics (family income, place of residence, etc.), and active social media use (posting on WeChat Moments). Therefore, a multiple regression model can comprehensively consider these factors to analyze the independent impact of each factor on mental health while controlling other factors. Moreover, since the data of various variables is continuous, the multiple regression model can handle such data structure well, fitting the data through establishing linear relationships to reveal the potential relationships between variables. We used STATA 17.0 software for statistical analysis. Following Eline (2015) [47], the Multiple Linear Regression (MLR) model was used in the present study to estimate the impact of posting on WeChat Moments on the mental health of older adults:

$$Y_{\mathrm{i}} = \alpha + \beta COF_i + \theta X_i + \varepsilon_i \quad (1)$$

where Y_i represents the mental health of the older adult, including negative emotion, positive emotion, self-rated health, and health satisfaction; COF_i indicates that the older adult posts on WeChat Moments when using WeChat; X_i denotes control variables, including respondents' personal characteristics (e.g., age, gender, education level, income, marital status, objective physical condition) and family characteristics (e.g., whether living with their children and their place of residence); and ε_i is the random disturbance term.

In terms of the specific subjects of the present study, the posting on WeChat Moments by older adults was

not random and might be impacted by factors such as age, gender, and socioeconomic status. The problem of sample selection bias could have lowered the reliability of the regression results, and hence a direct comparison of the mental health of older adults posting on WeChat Moments (the treatment group) and older adults not posting on WeChat Moments (the control group) could lead to biased results. A reciprocal causal relationship between posting on WeChat Moments and the mental health of older adults may lead older adults who post on WeChat Moments to become healthier but may also cause older adults with good mental health to post more on WeChat Moments.

Posting on WeChat Moments as defined in Model (1) may have an endogeneity problem due to the omission of variables or reverse causality [48]. This is because when older adults have certain mental health problems, they are more likely to post on WeChat Moments in order to be more socially engaged and seek social support. Therefore, the reverse causality between mental health and posting cannot be ignored. In addition, whether or not older adults post on WeChat Moments may be influenced by factors such as personal habits, their surrounding environment, and their mastery of WeChat functions, which are unobservable factors. Therefore, the present study uses PSM to address the endogeneity problem [49]. PSM constructs a "counterfactual" framework that approximates a randomized trial, so that when comparing the effects of the treated group and the control group, the net effect can be obtained by avoiding the bias due to confounding factors.

We first used Logistic Regression to estimate the probability of each individual receiving the treatment based on the covariates, i.e., the propensity score. Individuals in the treatment group were then matched to individuals in the control group based on the calculated propensity score. Matching methods include: nearest matching, radius matching (with a radius of 0.01), and kernel matching (using the default kernel function and bandwidth). Finally, corresponding matching was carried out according to the above probability, and the difference between self-rated health and mental health (i.e., ATT, the average treatment effect) was calculated based on the matched sample group.

The present study focused on the net effect of the influence of the posting on WeChat Moments on the mental health of older adults, i.e., the ATT on the treated, which is estimated as follows:

$$Y_i = Y_{0i} + (Y_{1i} - Y_{0i})\, D_i \tag{2}$$

$$ATT = E\,(Y_{1i} - Y_{0i} | D_i = 1) \tag{3}$$

In Eq. (2), D_i is the treatment variable, which means that D_i = 1 when individual i is an older adult in the treated group (i.e., who posted on WeChat Moments) and D_i = 0 when individual i is in the control group (i.e., who did not post on WeChat Moments). Equation (3) gives the ATT, i.e., the net effect of posting on WeChat Moments on the mental health of older adults.

There were obvious differences in the posting pattern as an active social media use by older adults of the different genders. For example, female older adults liked to post what happened around them on WeChat Moments through text, photos, and videos to share their daily life and spread their pride and joy. In contrast, male older adults rarely post about their daily life, mood, or various activities they participate in but more often share a variety of news and information or express their opinions on hot topics or social phenomena. Therefore, we hypothesize that there is a large gender difference in the impact of posting on WeChat Moments on mental health.

Although posting on WeChat Moments overall gave a statistically significant boost to the mental health of older adults, studies have found that age has a statistically significant impact on the mastery and use of information and communication technologies by older adults, and it becomes increasingly difficult for older adults to integrate into the "digital world" as they get older [35, 50]. Although it is easier for older adults to use and post on WeChat Moments, there are substantial differences in the specific implementation of posting on WeChat Moments by older adults of different ages. In the older-adult age range, younger people can more easily master the various operations of posting on WeChat Moments and hence are more proficient in and benefit more from posting there.

To further overcome the influence of unobservable variables and verify the causal relationship between posting on WeChat Moments and the mental health of older adults, we use a Differences-in-Differences (DID) model to test the robustness of the estimation results. Firstly, we selected the samples that could not post on WeChat Moments in the 2018 survey, and then divided these samples into two groups, one was the treatment group, which would post on WeChat Moments in the 2020 survey, and the other was the control group, which still could not post on WeChat Moments in the 2020 survey. By comparing the health changes of the control group sample from 2018 to 2020, we can get the impact of other factors besides posting on WeChat Moments. Finally, we subtract the health changes of the control group from the treatment group to obtain the results that represent the impact of posting on WeChat Moments on health of older adults after removing the influence of other factors. The DID model is set as follows:

$$Y_{\mathrm{i}} = \alpha + \beta Y20 + \gamma COF_i + \delta Y20 \cdot COF_i + \theta X_i + \varepsilon_i \quad (4)$$

In the above model, $Y20$ is a time variable, with a value of 1 for the year 2020 and 0 for the year 2018; parameter δ is the coefficient of the interaction term $Y20 \cdot COF_i$, reflecting the impact on the health of older adults after they start posting on WeChat Moments.

Results

MLR estimates

Table 3 presents the results of using multiple regression models to estimate the impact of posting on WeChat Moments on the mental health of older adults. The dependent variables of Models 1 to 4 were negative emotion, positive emotion, self-rated health, and health satisfaction, respectively. The results showed that the coefficient of the variable of posting on WeChat Moments in the four models was −0.821, 0.486, 0.156, and 0.147, respectively, and the variable was statistically significant at the level of 1%, 1%, 5%, and 1%. The coefficients of the age variable in Table 3 show that age had a statistically significant impact on the negative emotion, self-rated health, and health satisfaction of older adults, indicating that the mental health of older adults declined with age.

PSM estimates

Table 4 reports the ATT results calculated using the three matching methods. In terms of the average treatment effect of negative emotion, the ATT values after matching using the nearest matching, radius matching, and kernel matching were −0.763, -0.062, and −0.075, respectively; the ATT values for positive emotion using the three matching methods were 0.488, 0.423 and 0.448. The ATT values for self-rated health using the three matching methods were 0.059, 0.074, and 0.098, respectively, and the ATT values for health satisfaction using the three matching methods were 0.006, 0.011, and 0.023.

Heterogeneity

Table 5 shows the estimated impact of posting on WeChat Moments on the mental health of older adults by gender. It can be seen that, in terms of negative emotion, posting on WeChat Moments significantly reduced the negative emotions of both male and female older adults. In terms of the mean of ATTs obtained using the three matching methods, posting on WeChat Moments reduced the negative emotion scores by 0.599 and 0.787 for male and female older adults, respectively, indicating that posting on WeChat Moments had a statistically significantly greater impact on the negative emotion of female older adults than male older adults. In terms of positive emotion, posting on WeChat Moments also had

Table 3 Baseline regression Estimation results

Variable	Model 1	Model 2	Model 3	Model 4
	Negative emotion	Positive emotion	Self-rated health	Health satisfaction
Posting on	-0.821***	0.486***	0.156**	0.147***
WeChat Moments	(-3.629)	(6.174)	(4.158)	(4.225)
Age	0.055***	-0.004	-0.003**	-0.007***
	(-6.195)	(-1.357)	(-2.430)	(4.816)
Gender	1.534***	-0.060***	-0.062***	-0.089***
	(13.606)	(1.524)	(-3.477)	(-5.114)
Education level	-0.267***	0.125***	0.001**	0.039***
	(-8.140)	(10.933)	(0.236)	(-7.799)
Marital status	-1.030***	0.202***	0.006	0.013*
	(-7.726)	(4.360)	(0.311)	(0.631)
Family income	-0.199***	0.087***	0.026***	0.009*
	(-6.282)	(7.883)	(5.120)	(-1.753)
Place of residence	-0.940***	0.226***	0.120***	0.038*
	(-7.297)	(5.027)	(5.888)	(1.915)
Living arrangement	-0.040	0.064*	0.034**	0.054***
	(-0.371)	(-1.695)	(-2.033)	(-3.225)
Chronic diseases	0.844***	-0.078***	-0.198***	-0.137***
	(16.829)	(-4.482)	(-25.772)	(-17.754)
Disability status	1.518***	-0.237***	-0.236***	-0.198***
	(16.782)	(-7.528)	(-21.743)	(-14.246)
Constant term	19.330***	4.162***	3.041***	3.057***
	(25.665)	(15.871)	(26.789)	(26.426)
Sample size	12,227	12,227	12,227	12,227

Note: (1) *, **, and *** indicate statistical significance at the levels of 10%, 5%, and 1%, respectively. (2) Values in parentheses are heteroscedasticity standard errors

Table 4 PSM results (ATT)

Dependent variable: negative emotion							
Matching method	**Treated group**	**Control group**	**ATT**	**SE**	**t value**	**Number of samples in the treated group(N)**	**Number of samples in the control group(N)**
Nearest matching	12.963	13.726	-0.763***	0.291	-2.62	755	11,470
Radius matching	12.991	13.6121	-0.062***	0.219	-2.84	747	11,470
Kernel matching	12.963	13.715	-0.075***	0.215	-3.49	756	11,470
Dependent variable: positive emotion							
Nearest matching	6.155	5.667	0.488***	0.112	4.32	755	11,470
Radius matching	6.143	5.720	0.423***	0.083	5.08	747	11,470
Kernel matching	6.153	5.705	0.448***	0.082	5.47	756	11,470
Dependent variable: self-rated health							
Nearest matching	3.080	3.021	0.059*	0.052	1.74	771	13,401
Radius matching	3.077	3.003	0.074*	0.039	1.87	763	13,401
Kernel matching	3.080	2.982	0.098**	0.039	2.52	772	13,401
Dependent variable: health satisfaction							
Nearest matching	3.136	3.142	0.006**	0.041	2.14	755	11,470
Radius matching	3.134	3.123	0.011*	0.033	1.72	747	11,470
Kernel matching	3.136	3.11	0.023*	0.032	1.77	756	11,470

Note: ATT refers to the difference in the mean mental health between the treated group and the control group; SE is the standard error; *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively

Table 5 Heterogeneity analysis (grouping by gender)

Dependent variable	Matching method	Male sample		Female sample	
		ATT	SE	ATT	SE
Negative emotion	Nearest matching	-0.520**	0.513	-0.977***	0.355
	Radius matching	-0.582***	0.388	-0.632***	0.257
	Kernel matching	-0.695***	0.380	-0.751***	0.253
Positive emotion	Nearest matching	0.178**	0.180	0.556***	0.148
	Radius matching	0.397***	0.133	0.432***	0.107
	Kernel matching	0.416***	0.132	0.448***	0.106
Self-rated health	Nearest matching	0.069***	0.079	0.142***	0.069
	Radius matching	0.060***	0.063	0.097*	0.052
	Kernel matching	0.088***	0.062	0.111***	0.051
Health satisfaction	Nearest matching	0.030**	0.075	0.079*	0.055
	Radius matching	0.015**	0.056	0.031*	0.042
	Kernel matching	0.002**	0.055	0.044*	0.041

Note: ATT refers to the difference in the mean mental health between the treated group and the control group; SE is the standard error; *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively

a statistically significant impact on both male and female older adults. In terms of the mean of ATTs obtained by the three matching methods, posting on WeChat Moments increased the positive emotion scores by 0.330 and 0.479 for male and female older adults, respectively, indicating that female older adults boosted their positive emotion more by posting on WeChat Moments. The mean self-rated health and the mean health satisfaction obtained under the three matching methods reflected the same patterns. Posting on WeChat Moments statistically significantly increased the self-rated health and health satisfaction of female older adults by 0.117 and 0.051, respectively, and increased those of male older adults by 0.072 and 0.016, respectively.

Table 6 shows the estimated impact of posting on WeChat Moments on the mental health of older adults in different age groups. In this study, "Positive emotion", "Self - rated health", and "Health satisfaction" are positive outcome variables, while "Negative emotion" is a negative outcome variable. For positive outcome variables, the larger the ATT value, the stronger the impact on the treatment group under the same other conditions. That is, posting on WeChat Moments has a statistically significant effect on improving the mental health of the elderly. For the negative outcome variable "Negative emotion", a larger ATT value indicates that posting on WeChat Moments has a worse effect in alleviating this negative situation.

Table 6 Heterogeneity analysis (grouping by age)

Dependent variable	Matching method	Under 70 years old		70 years old and above	
		ATT	SE	ATT	SE
Negative emotion	Nearest matching	-1.283*	0.653	-0.647***	0.322
	Radius matching	-0.670*	0.497	-0.593***	0.244
	Kernel matching	-1.060***	0.479	-0.703***	0.240
Positive emotion	Nearest matching	0.492**	0.280	0.480***	0.123
	Radius matching	0.460***	0.230	0.407***	0.091
	Kernel matching	0.561***	0.205	0.422***	0.090
Self-rated health	Nearest matching	0.098*	0.129	0.046**	0.058
	Radius matching	0.152*	0.089	0.061***	0.044
	Kernel matching	0.164*	0.086	0.082*	0.044
Health satisfaction	Nearest matching	0.142*	0.099	0.032*	0.047
	Radius matching	0.078*	0.083	0.004*	0.036
	Kernel matching	0.086*	0.081	0.011*	0.036

Note: ATT refers to the difference in the mean mental health between the treated group and the control group; SE is the standard error; *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively

Table 7 DID model Estimation results

VARIABLES	Negative emotion	Positive	Negative emotion	Positive
Posting on WeChat Moments × year	-0.525**	0.573***	0.071**	0.022**
	(-2.297)	(6.237)	(1.611)	(0.640)
Control variable	Yes	Yes		Yes
Constant	19.819***	4.432***	2.730***	2.229***
	(24.820)	(15.979)	(22.759)	(18.661)
Sample size	11,977	11,977	11,977	11,977

Note: (1) *, **, and *** indicate statistical significance at the levels of 10%, 5%, and 1%, respectively. (2) Values in parentheses are heteroscedasticity standard errors

We found that in the age group under 70, posting on WeChat Moments statistically significantly lessened their negative emotion, with the mean ATT using the three matching methods being 1.004, and statistically significantly increased their positive emotion, self-rated health, and life satisfaction, with the mean ATTs by the three matching methods being 0.504, 0.138 and 0.102, respectively. In those aged 70 years and above, although posting on WeChat Moments had a statistically significant impact on their mental health, the mean ATT from the three matching methods showed that their negative emotion was reduced by 0.356 while their positive emotion, self-rated health, and life satisfaction were increased by 0.068, 0.075, and 0.086, respectively.

Robustness test

The article uses the DID model to test the robustness of the results. The most direct method to estimate the impact of posting on WeChat Moments on the health of t older adults is to compare the differences in health before and after learning to posting on WeChat Moments. However, this difference may be influenced not only by posting on WeChat Moments but also by other time-varying factors. To eliminate the interference of other factors, this article adopts the DID model to accurately estimate the impact of posting on WeChat Moments on the health of older adults. The results in Table 7 show that all coefficients of the impact of posting on WeChat Moments on the health of older adults are statistically significant, thus supporting the conclusion mentioned above.

Discussion

With the increasing demographic aging and the development of information technology in China, social media have been used by a growing number of older adults as a means of social participation. As WeChat is the number-one social media application for older adults, the impact of posting on WeChat Moments as an active social media use on the mental health of older adults is worthy of attention. In this study, we used panel data from the CHARLS survey in 2018 and 2020 to analyze the impact of posting on WeChat Moments on the mental health of older adults using the PSM method. Unlike many existing studies that have analyzed the impact of social media use on mental health with adolescents as the target population [51, 52], we took older adults as the target population to investigate any impact that WeChat posting had on their mental health. In addition, we attempt to identify posting on WeChat Moments as an active use of social media and analyze its impact on the mental health of older adults, given that such posting can serve as a status update and instant communication. Last, there are gender differences in the relationship between social media

use and mental health among adolescents in existing studies, but there is no research on whether such differences exist in the older adult population. This study provides a comprehensive analysis to fill this knowledge gap.

Our findings indicate that the negative emotion of older adults who posted on WeChat Moments was significantly less than that of older adults who did not, while the positive emotion of the former was statistically significantly greater than that of the latter, meaning that posting on WeChat Moments reduced the occurrence of depression among older adults to a certain extent, thereby improving their mental health. The impact of posting on WeChat Moments on the self-rated health of older adults was statistically significantly positive, indicating that older adults who posted on WeChat Moments had a statistically significantly higher self-rated health score than those who did not, which means that posting on WeChat Moments could improve the self-rated health status of older adults to some extent. Posting had a statistically significant positive impact on the health satisfaction of older adults, indicating that this group was more satisfied with their own health. Therefore, posting on WeChat Moments statistically significantly improved the depression, self-rated health, and health satisfaction of older adults, implying that older adults who used WeChat and posted on WeChat Moments could benefit more from the active social media use. This result is the same as that of the adolescent group [53, 54]. But there are also studies suggesting that passive social media use may also have some positive consequences [55]. This provides an inspiration for our further research on different modes of social media engagement interacting with the mental health of older adults.

A possible explanation for these findings is that entering old age is an important transition in life, and many older adults change their daily lives accordingly [56], sometimes by reducing their communication with the outside world [57], thereby narrowing their range of social participation. Social media, as one of the digital technologies, plays a crucial role in helping individuals access information [58]. Posting on WeChat Moments allows older adults to share what they have seen and heard in their circle of friends and share their happiness with others, so that they can receive likes and comments from relatives and friends as well as establish emotional ties with them through the positive responses on the platform. These emotional ties can be regarded as a kind of social participation of older adults. Although active social media use may not be necessary to achieve beneficial effects [59].

Posting on WeChat Moments as an active social media use can also play a role in emotional catharsis and active expression of emotions, which can help older adults to actively establish a bridge of communication with the outside world [60], reduce their loneliness [61, 62], enrich their daily life [63, 64], gain social compensation [65], and thereby improve their mental health. In addition, the mastery of the new technologies involved in using WeChat and posting on WeChat Moments can give older adults a sense of accomplishment and make them believe that they can still keep pace with an advancing society [66], thereby enhancing their self-confidence [67], which is beneficial to their mental health.

Encouraging the active use of social media among the elderly holds significant clinical implications. By actively sharing their rehabilitation experiences and positive life attitudes on social media, older adults can not only enhance their own psychological resilience but also inspire others with similar experiences. This creates a beneficial atmosphere of mutual support, fostering mental well-being within the elderly community. For instance, an elderly individual who has recovered from mild depression shared his experience of improving mood through exercise and social interaction on social media, received many likes and encouragement, and at the same time inspired other elderly people to actively face life and prevent the recurrence of depression. Such practices serve as a form of health education [68]. Moreover, social media has emerged as a tool in the treatment of depression. Social media skits are important mental health tools for treating depression [69]. This indicates that social media can be a valuable resource for promoting mental health and providing support for those suffering from depression.

The coefficients of the gender variable show that male older adults had better mental health than female older adults. This is because as age increases, when facing health and life problems, female older adults are more susceptible to mental fluctuations and thus have a lower mental health level than male older adults. Education level and family income also were positively correlated with their mental health of older adults. The coefficients of the place of residence variable indicated that the mental health of older adults living in urban areas was better than that of older adults in rural areas. One possible reason is that older adults living in urban areas have better material living conditions, and the accessibility to and quality of basic public services in urban areas are better than those in rural areas. The respondents' objective physical health was an important factor, as an increase in the number of chronic diseases or ADL limitations statistically significantly impaired their mental health.

Although social media use can promote the mental health of older adults, depressed individuals may use social media more often [27]. Through social media use, older adults can seek interaction with the outside world, increase communication with family and friends, and lower the risk of social exclusion in the Internet

era, suggesting a reciprocal relationship between social media use and better mental health [70]. It has also been pointed out that social participation as an explanatory variable may have endogeneity problems, leading to an overemphasis on its positive function by omitting other important information in the causal analysis [36]. Therefore, there may be a reciprocal causal relationship between posting on WeChat Moments and the mental health of older adults. Other, unobservable factors may also interfere with the effect of posting on WeChat Moments as a core variable.

PSM estimation results show, after controlling for selection bias, the results of the three matching methods on the impact of posting on WeChat Moments on the negative emotion, positive emotion, self-rated health, and health satisfaction of older adults were highly consistent and passed the significance test. These results indicate that posting on WeChat Moments had a positive impact on the mental health of older adults. While controlling for the same interference variables, posting reduced the negative emotion of older adults by 0.983 on average, while the positive emotion, self-rated health, and health satisfaction of older adults increased by 0.434, 0.197, and 0.089, respectively. These results indicate that, given that all characteristics of the two groups were similar, the mental health of older adults who posted on WeChat Moments was statistically significantly better than that of older adults who did not.

In the above section, we have discussed the overall impact of posting on WeChat Moments on the mental health of older adults. The results showed that posting on WeChat Moments statistically significantly lessened the negative emotion and amplified the positive emotion of older adults, as well as having a positive impact on their self-rated health and life satisfaction. Considering that posting on WeChat Moments had different impacts on the mental health of different groups of older adults, we explored the impact of posting on WeChat Moments on the mental health of different groups of older adults from the perspective of gender and age. Since the PSM method can accurately calculate the average treatment effects of the treated and control groups, this section directly reports the results of the PSM estimation of the different impacts of posting on WeChat Moments on the mental health of different groups of older adults.

Our results indicate that gender differences as well as age differences in the mental health effects of social media use [33, 71]. One possible explanation is that when female older adults post on WeChat Moments, they are better at sharing their life and psychological status and interacting with family and friends [12, 72]. Women are motivated by the ability to maintain close ties and gain social information. Men are motivated by the ability to gain general information [73]. And females both posting and viewing social media more often than their male counterparts [74]. And older adults still face a barrier to posting on WeChat Moments [75], especially those in the high end of this age range.

Limitations and future directions

This study has the following limitations. Firstly, we only discussed the active use of social media by posting on WeChat Moments, without exploring other social media platforms such as Sina Weibo, Xiaohongshu, and TikTok. The generalization of our findings should be considered cautiously.

Secondly, to address the endogeneity problem, this study used Propensity Score Matching (PSM), which attempted to approximate a randomized trial by constructing a "counterfactual" framework. However, PSM is not a perfect solution and comes with its own limitations. It relies on the assumption of unconfoundedness, which assumes that all relevant variables affecting both the treatment assignment (posting on WeChat Moments) and the outcome variables (mental health) are included in the propensity score model. If there are important omitted variables or unobservable factors that affect WeChat Moments posting and mental health, it will lead to biased estimation.

Thirdly, the frequency and duration of social media use could not be included in the analysis of this study due to the limitations of the CHARLS data. It should be noted that the robustness test splited the whole sample into two sub-samples (high-frequency use group and low-frequency use group). Specifically, we grouped respondents according to their frequency of posting on WeChat Moments. However, the CHARLS survey did not directly inquire about the frequency of posting on WeChat Moments. The frequency of Internet access was used as a proxy for estimating the frequency of posting. This approach may introduce inaccuracies and assumptions about the actual frequency of posting, leading to potential measurement errors.

Lastly, national data are not available from CHARLS and some areas were not included in this study. Given the limitations of the data, the findings of our study should be regarded as indicative rather than conclusive. When implementing these findings, a cautious and context-specific strategy is required. It is also crucial to explicitly articulate the limitations, enabling other researchers and practitioners to make well - informed decisions.

Future research intends to investigate the use of social media by older adults in more detail and to obtain fuller data to provide a comprehensive understanding of the relationship between social media use and the mental health of older adults. Considering that active social media use can express users' own thoughts and emotions, it is clearly insufficient to merely analyze the

relationship between active social media use and mental health. In subsequent research, it is necessary to analyze the content of posts made by users on social media. By leveraging the development of machine learning (ML) and deep learning (DL) models, research on the correlation between the content users post on social media and their mental health status can be carried out.

Conclusion

All in all, we find that posting on WeChat Moments significantly improved the depression, self-rated health, and health satisfaction of older adults. This means that older adults who use WeChat and post on WeChat Moments derive much benefit from their active social media use. As the elderly population grows and more elderly people use smartphones to access social media, the impact of active social media on their mental health cannot be ignored. Even if the impact on the elderly is relatively small, given the large and expanding scale of the elderly population and the high costs of negative consequences like depression and addiction, small impacts matter at scale. Therefore, it is necessary for the Chinese government to help older adults actively integrate into digital life at the policy level, eliminate their barriers to Internet access as much as possible, and increase the popularity of smartphones among older adults to help them find a sense of belonging through WeChat Moments and thereby obtain psychological comfort. Moreover, the endogeneity between social media use and mental health has not been fully explored, leading to a misinterpretation of the causal relationship. This study uses PSM-DID to address this issue and improve research accuracy.

Acknowledgements
We would like to thank the National School of Development of Peking University for providing the CHARLS data.

Author contributions
All authors were involved in planning of the study and interpretation of results.WN and LJ conducted the data analysis and wrote the first draft of the paper. SDQ critically reviewed the paper and edited the manuscript. All authors read and approved the final manuscript.

Funding
This work was supported in part by the National Natural Science Foundation of China (No. 71873067).

Data availability
The dataset analyzed during the current study is available in the CHARLS repository, https://charls.charlsdata.com/pages/data/111/en.html.

Declarations

Ethical statement
This is a secondary analysis using the CHARLS data, and the original survey was approved by the Biomedical Ethics Review Committee of Peking University (IRB00001052–11015). All participants signed written informed consent forms before the survey. They knew their data were for academic research and could withdraw at any time. The publicly available data have undergone strict anonymization. Personal identity - identifying information (such as names, ID numbers, detailed addresses, etc.) has been removed, and only de - identified research variables are retained. This study strictly complies with the CHARLS data use terms. All analyses are for scientific purposes.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Received: 26 September 2024 / Accepted: 24 March 2025
Published online: 24 April 2025

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