The Relationship between App Use and Smartphone Addiction in the Elderly: The Moderating Effect of Loneliness

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Abstract: In recent years, smartphone addiction among the elderly has become a social problem. However, smartphone addiction among the elderly has been rarely studied, and its mechanism remains unclear. To address this gap, this study aims to analyze the correlation between app use in four categories (social, information, entertainment, and shopping) and smartphone addiction among the elderly and examined the moderating effect of loneliness. A questionnaire survey was conducted on 492 elderly aged above 60 and above in China. The key findings are: (1) There is a significant positive correlation between information, entertainment and shopping app use and smartphone addiction among the elderly; (2) Loneliness significantly moderates the relationship between information app use and shopping app use and smartphone addiction in the elderly. When loneliness level is high, information app use and shopping app use can exacerbate smartphone addiction in the elderly. Particularly, these findings contribute to a deeper understanding of the correlation between the use of different types of app use and smartphone addiction in elderly, especially for those who experience high levels of loneliness, in order to develop guidelines or intervention measures to promote healthy smartphone use among addicted older smartphone users.

Keywords: Smartphone addiction; Mobile application use; The elderly; Loneliness; Moderating effect

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1. Introduction

In the past decade, The rapid development of information and communication technology (ICT) over the past decade has significantly transformed human lifestyles. The widespread adoption of smartphones has revolutionized how we communicate, receive information, and entertain ourselves, making smartphones an indispensable part of everyday life. Increasingly, mobile applications are serving various functions in the realms of information, communication, entertainment, and commerce, turning smartphones into multifunctional devices that many people carry with them at all times. While this technological transformation has brought numerous conveniences, it has also introduced potential negative side effects, particularly the problem of smartphone addiction.

At the same time, the issue of population aging has become increasingly severe. According to data from the National Bureau of Statistics of China, by the end of 2022, the population aged 60 and above reached 280 million, accounting for 19.8% of the total population. The National Aging Office predicts that by 2033, the elderly population in China will exceed 400 million, comprising one-quarter of the total population, and by 2053, it will peak at 487 million, making up more than one-third of the total population. These are staggering numbers, indicating that China has entered a stage of moderate aging and will transition into a stage of severe aging in the coming decades.

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According to the latest report from the China Internet Network Information Center, the 52nd "Statistical Report on China's Internet Development," as of June 2023, the number of internet users in China exceeded one billion, with an internet penetration rate of 76.4%. Among them, 13.0% were elderly individuals aged 60 and above, further increasing the proportion of older people in the overall internet user base. The digital divide between different age groups is steadily narrowing. The 53rd "Statistical Report on China's Internet Development" shows that by December 2023, over 140 million smartphones and smart TVs had undergone upgrades to better suit the elderly. This further demonstrates that older people are adopting and using digital devices with a positive attitude. The "2022 Beijing Elderly Smartphone Usage Habits and Attitudes Survey" also reports that over 80% of elderly individuals most frequently use smartphones for social functions, such as phone calls, messaging, and social chatting, as well as for offline payments, news, and online shopping. Moreover, a 2021 longitudinal survey on the factors influencing elderly health and family happiness, jointly conducted by the China Population and Development Research Center, the China Family Planning Association, and the National School of Development at Peking University, collected data from over 17,000 elderly individuals aged 65 and above in 482 sample counties across 26 provinces, as well as data from more than 8,500 adult children of elderly individuals. The survey results showed that over half of elderly individuals aged 65 to 69 use smartphones, and the percentage of those aged 70 to 79 using smartphones reached 31.2%, while 1.3% of centenarians also used smartphones. These figures suggest that elderly individuals are actively embracing the digital era, with the penetration of smartphones in their daily lives steadily increasing, allowing them to use smartphones for various aspects of daily life.

As smartphone penetration continues to rise, researchers have found worrying trends of smartphone addiction across all age groups, including the elderly^[1]. As early as 2020, the "2020 Elderly People's Internet Life Report," jointly released by two content platforms, Qutoutiao and The Paper, first revealed the online behavior preferences of millions of elderly individuals aged 60 and above. One statistic indicated that among one million elderly users, 1,900 spent more than 10 hours per day actively using a single app on Qutoutiao, 4,000 users were active for over 8 hours, and over 12,000 elderly users had an average daily active time of more than 6 hours. The report also stated that over 100,000 elderly individuals nationwide were living in a monotonous and lonely manner, spending nearly all their time on smartphones or mobile internet. Content providers and social platforms appear eager to cultivate and retain this segment of users. Due to the elderly's large age but short internet usage history, a series of physical and mental health problems stemming from smartphone addiction are increasingly common.

Several factors may contribute to smartphone addiction among the elderly. Retirement and decreased social mobility mean that older adults typically have fewer social obligations and more free time (Jones, 2020)^[2]. Particularly around the age of 60, with fewer social roles and weakened offline relationships, smartphone use may increase, potentially leading to smartphone addiction (Jeong & Bae, 2022)^[3]. Psychological issues related to aging, such as loneliness and depression, may also cause elderly individuals to overuse apps and social media for validation or entertainment (Wang et al., 2018)^[4]. Compared to younger people, elderly individuals appear to exhibit deeper physical and psychological symptoms associated with smartphone addiction withdrawal (Csibi et al., 2021)^[5]. Additionally, cognitive decline may make it more difficult for some elderly individuals to self-regulate and limit their smartphone usage. Many elderly individuals lack awareness of healthy technology habits, as they are not digital natives (Wesley, 2006)^[6].

There is already substantial research on smartphone use and addiction among younger generations and the negative effects of smartphone addiction, such as the psychological impact on Indian adolescents (Davey et al., 2014)^[7], social and academic problems among Tanzanian students (Mboya et al., 2020)^[8], and psychological and health issues among South Korean children (Lee et al., 2018)^[9]. These studies primarily focus on younger populations, leaving a gap in exploratory research on the same issue among the elderly. The mechanisms behind smartphone addiction in the elderly remain unclear.

Therefore, this study categorizes app use into four types to examine whether these four types of app use (social,

information, entertainment, and shopping) is significantly related to smartphone addiction in the elderly, and whether and how loneliness moderates these relationships. To address these questions, this study uses validated scales to measure app use, smartphone addiction levels, loneliness, and several demographic and psychosocial variables among the elderly. The data collected are analyzed to determine whether loneliness significantly moderates the relationship between social, information, entertainment, and shopping app use and smartphone addiction among the elderly. The findings will reveal which types of mobile applications are most strongly associated with smartphone addiction among the lonely elderly, providing targeted guidance for preventing and addressing smartphone addiction in this vulnerable group, and reducing the related risks of social isolation, physical inactivity, distracted driving, and sleep disturbances.

2. Literature Review

(1) App use and smartphone addiction

The portability of smartphones distinguishes smartphone use from "traditional" internet use via computers, leading to differences in the symptoms of smartphone addiction and internet addiction (Lin et al., 2014)^[10]. Internet addiction typically involves excessive use of the internet for activities such as gaming, social networking, or browsing (Ben-Yehuda et al., 2016)^[11], whereas smartphone addiction refers to the dependence on various applications and functions provided by the device itself (Lin et al., 2014)^[10]. Smartphone addiction is characterized by excessive reliance on smartphones and uncontrolled use (Aljomaa et al., 2016)^[12], with symptoms such as extended screen time, difficulty in detaching from the phone, and interference with daily life. In recent years, extensive research has been conducted on smartphone addiction, revealing the influence of modern ICT, demographic, sociological, and psychological factors on this behavior. Zhitomirsky-Geffet et al. (2016) aimed to study this phenomenon from a cross-generational perspective and compared the predictive factors of smartphone addiction across different age groups^[13]. Kwon et al. (2016) examined addictive behavior based on app consumption at the individual level, replacing self-reported surveys or general demand estimates. To empirically verify rational addiction in the context of social app consumption, they collected and analyzed 13 months of weekly app usage data from thousands of smartphone users^[14]. Aljomaa et al. (2016) investigated whether smartphone addiction varies by gender, social status, education level, monthly income, and daily usage time^[12].

In this study, app use refers specifically to the use of mobile applications rather than general smartphone use. Gafni et al. (2017) highlighted that while smartphones provide hardware and connectivity, mobile applications offer structured and interactive content necessary for effective learning^[15]. Therefore, app use and smartphone use are distinct concepts. Previous studies often treated app usage duration and frequency as predictive factors of smartphone addiction (Yang et al., 2022)^[16]. However, in recent years, apps have emerged that help users track their excessive smartphone use and mitigate the potential mental health risks. Jeong et al. (2016) examined smartphone addiction by investigating two app categories—social networking sites (SNS) and games—among 944 respondents from 20 elementary schools in South Korea. They found that while both SNS and games are positive predictors of smartphone addiction, SNS usage has a stronger predictive effect than games^[17]. Swar et al. (2017) used self-determination theory to examine the moderating role of self-help mobile apps on the relationship between social media engagement, smartphone addiction, and distraction^[18]. Chen (2018) collected large-scale data to investigate the relative contributions of psychological and social factors in predicting different levels of social app (LINE) usage, emphasizing the importance of considering specific app types to understand smartphone addiction^[19].

Most existing research considers app use as a single predictor of smartphone addiction or explores the relationship between one or two categories of app use and smartphone addiction. However, few studies have subdivided app use into multiple categories and examined their respective correlations with smartphone addiction,

particularly among individuals aged 60 and above. This is the core issue that this study aims to explore.

(2) Four categories of app use and smartphone addiction

Unlike internet addiction, smartphone addiction is unique to the multifunctionality of the device, encompassing a broader range of addictive behaviors, such as gaming, social media, and communication, all integrated into one device (Choi et al., 2015)^[20]. Therefore, multi-category app usage has become an important factor in exploring smartphone addiction. Abbasi (2021) demonstrated that the type of content used on smartphones significantly influences smartphone addiction, likely due to differences in gratification derived from various app categories^[21]. Most mobile applications are designed to meet specific needs for shopping, entertainment, and social interaction (Hsu & Lin, 2015)^[22]. Nysveen et al. (2015) categorized mobile applications based on their intended purpose and user interaction into four main types: social apps (e.g., social networks), information apps (e.g., news), entertainment apps (e.g., games), and shopping apps (e.g., e-commerce)^[23]. This categorizes the most commonly used apps into four types: social app use, information app use, entertainment app use, and shopping app use.

Social apps are an important category in smartphone use and significantly impact smartphone addiction. As studies on young people in Switzerland have shown, social networks are among the most relevant smartphone functions and key predictors of smartphone addiction (Haug et al., 2015)^[24]. Research has found that participants who spend more time on social media apps experience more withdrawal symptoms, including anxiety, depression, and cravings, when not using their phones (Fernandez et al., 2019)^[25]. As gratification increases, users need to spend more time on social apps to achieve the same mood boost (Hsiao et al., 2016)^[26]. This indicates that heavy social app use can alter the brain's reward system, leading to dependency (Schou Andreassen et al., 2014)^[27]. Social apps like WeChat, Weibo, and QQ allow users to share their lives, view others' updates, and connect with like-minded groups. Numerous studies have found correlations between social app use and smartphone addiction among the elderly. For instance, Nahas et al. (2018) found that excessive social media and gaming app use was closely related to higher scores on the smartphone addiction scale among elderly participants^[28], a finding echoed by Park et al. (2021)^[29]. Social app use has been significantly correlated with increased smartphone addiction among older adults, as these apps meet key social needs for this demographic (Busch et al., 2021)^[30]. Therefore, the following hypothesis is proposed:

H1: Social app use is significantly and positively correlated with smartphone addiction among the elderly.

Smartphones have become a primary source of news and information (Sarwar & Soomro, 2013)^[31]. Whether international news, local events, or updates in technology, sports, or entertainment, users can access information instantly through their phones. Information apps like TOPBuzz, Tencent News, and Netease News provide real-time global news, triggering usage that may increase dependence on smartphones. The immediacy and accessibility of information heighten users' reliance on smartphones, creating a continuous need to stay updated with global events (Lundquist et al., 2014)^[32]. Boumosleh & Jaalouk (2018) suggested that using information apps for news and education is associated with varying degrees of smartphone addiction, particularly among elderly individuals who rely on these apps for daily updates and learning^[33]. However, Busch et al. found that elderly users who mainly used information apps were less likely to exhibit addictive behaviors compared to those who used social or gaming apps. According to Nahas et al. (2018), the impact of information apps on smartphone addiction among older users is mixed: some use these apps to manage their addiction symptoms, while others become increasingly dependent on them^[28]. Based on these differing results, this study poses the following research question:

RQ1: Is information app use significantly and positively correlated with smartphone addiction among the elderly?

Entertainment apps, offering a variety of content, are associated with an increased risk of smartphone addiction among older adults (Park et al., 2021)^[29]. These apps may prompt overuse due to arousal and emotional regulation (Hoffner, 2015)^[34]. Users can experience temporary relief from boredom or stress through entertainment apps, but this behavior can become reinforced, leading them to spend excessive time on games or streaming videos, such as Happy Cancellation, Happy Poker, Kwai, TikTok, etc. These apps provide diverse forms of entertainment, including music, movies, TV series, and games, stimulating addiction by offering mental stimulation and fulfilling needs for achievement and relaxation. By providing immersive and escapist experiences in short bursts, entertainment apps can foster prolonged use and potential addiction (James & Drennan, 2005)^[35]. Busch et al. (2021) found that older adults who frequently use entertainment apps are more likely to develop smartphone addiction, indicating a strong link between entertainment use and addictive behavior^[30]. Boumosleh & Jaalouk (2018) further confirmed that gaming and entertainment app usage was closely associated with higher levels of smartphone addiction among elderly participants^[33]. However, Bae (2022) found that while entertainment needs are met through various smartphone apps, they do not significantly impact the development of smartphone addiction among older adults in Korea^[36]. Thus, this study proposes the following research question:

RQ2: Is entertainment app use significantly and positively correlated with smartphone addiction among the elderly?

Smartphone convenience has made shopping significantly easier. Shopping apps like Taobao, JD.com, Freshhema, and Missfresh allow users to shop anytime, anywhere, making the process more appealing. E-commerce platforms provide a wide selection of products, convenient payment options, and fast delivery services, making shopping more enjoyable (Salehi et al., 2012)^[37]. These apps also automatically recommend similar products and run shopping promotions, such as discounts and lotteries, which can increase browsing time and stimulate users' desire to shop, potentially leading to over-reliance on shopping apps. Shopping apps are a significant predictor of smartphone addiction, particularly among older adults who are more susceptible to the convenience and accessibility provided by these apps (Bolle, 2014)^[38]. Prodanova & Chopdar (2024) found that smartphone addiction significantly impacts older users' shopping behavior and life outcomes, indicating a strong correlation between shopping app use and smartphone addiction^[39]. Nahas et al. (2018) also found that excessive shopping app use was linked to higher smartphone addiction scores, especially among elderly users who relied on these apps for convenience^[28]. However, some studies, such as Park et al. (2021)^[29] and Prodanova & Chopdar (2024)^[39], found no statistically significant relationship between mobile shopping and smartphone addiction among older users. These studies suggest that while shopping apps are frequently used by older adults, they do not significantly increase the risk of smartphone addiction, or their usage may be influenced by other factors that mitigate addictive behavior. Therefore, the following research question is posed:

RQ3: Is shopping app use significantly and positively correlated with smartphone addiction among the elderly?

From the above literature, it can be concluded that different types of app content satisfy individuals' various satisfaction needs among the elderly and have a significant correlation with smartphone addiction. In this study, the researcher will explore whether the aforementioned four categories of app use (social, information, entertainment, and shopping) are significantly correlated with smartphone addiction among the elderly.

(3) Loneliness as a moderator

Loneliness, which refers to the degree of dissatisfaction and isolation that individuals experience in interpersonal relationships (Peplau, 1985), has been found to play an important role in smartphone addiction. In their study, Bian et al. (2015) aimed to investigate the role of psychological attributes, such as shyness and loneliness, as well as smartphone use patterns, in predicting smartphone addiction symptoms and social capital. The findings of this study have clear implications for treatment and intervention by parents, educators, and policymakers, emphasizing the significant links between smartphone addiction and smartphone use, loneliness,

and shyness. Enez Darcin et al. (2016) conducted research in Istanbul, Turkey, exploring the relationship between smartphone addiction, social phobia, and loneliness among university students. It is worth noting that lonely individuals often rely on smartphones excessively for social compensation and distraction (Pepper & Harvey, 2018).

Loneliness is a common experience for the elderly, and smartphones have emerged as a potential solution to alleviate this issue (Busch et al., 2021). Consequently, the elderly population is more susceptible to excessive smartphone use as a means of combatting loneliness (Busch et al., 2021). The significance of loneliness in the elderly's technology overuse is well-established (Wilson, 2018). Moreover, studies have indicated that loneliness may amplify the association between social app use, entertainment app use, and smartphone addiction (Mahapatra, S, 2019). In particular, older adults with higher levels of loneliness tend to overuse smartphones as a way to compensate for limited social interactions and satisfy the need for distraction from negative emotions heightened by isolation (Al-Kandari& Al-Sejari, 2021). Yang& Jin (2022) further support these findings, suggesting that loneliness acts as a mediating variable for excessive Internet use among middle-aged and elderly individuals, rather than being the cause of their addiction.

Loneliness appears as a predictive or mediating variable for smartphone addiction in existing studies; however, it has not been considered a moderating variable for the impact of certain influencing factors on smartphone addiction. Therefore, it is important to recognize loneliness as a psychological factor that may interact with different categories of app use, consequently increasing the risk of smartphone overuse. Addressing and assessing loneliness in older adults may aid in reducing excessive smartphone use, which is often driven by social compensation and inappropriate distraction. Thus, this article proposes the following research questions:

Loneliness refers to an individual's sense of dissatisfaction and isolation in interpersonal relationships (Peplau, 1985)^[40]. Numerous studies have shown that loneliness plays an important role in smartphone addiction. Bian et al. (2015) aimed to explore how psychological attributes, such as shyness and loneliness, and smartphone use patterns predict smartphone addiction symptoms and social capital^[41]. The study emphasized the importance of understanding the links between smartphone addiction, loneliness, and shyness for parents, educators, and policymakers when developing interventions. Darcin et al. (2016) explored the relationship between smartphone addiction, social anxiety, and loneliness in a sample of university students from Istanbul, Turkey^[42]. Lonely individuals tend to overuse smartphones as a form of social compensation and distraction (Peper et al., 2018)^[43].

For the elderly, loneliness is often a common condition, and smartphones provide a potential remedy to alleviate it. Older adults are therefore more prone to excessive smartphone use as a way to fill their sense of Ioneliness (Busch et al., 2021)^[30]. Loneliness is a key predictor of overuse of technology among the elderly (Wilson, 2018)^[44]. Yang & Jin (2022) found that loneliness acted as a mediating variable in the excessive internet use of middle-aged and older adults, but it was not the root cause of their addiction^[45]. In Yue et al.'s (2022) study, loneliness moderated the relationship between social app use and smartphone addiction, with higher levels of loneliness exacerbating older adults' addictive use of social media^[46]. Some research also suggests that loneliness may strengthen the relationship between the use of social and entertainment apps and smartphone addiction (Mahapatra, 2019)^[47]. Specifically, older adults experiencing greater loneliness are more likely to overuse smartphones to compensate for a lack of social interaction and to distract themselves from negative emotions associated with isolation (Al-Kandari & Al-Sejari, 2021)^[48]. Kim et al. (2021) demonstrated that loneliness plays a significant moderating role in the relationship between social app use and smartphone addiction, suggesting that lonely elderly individuals are more susceptible to developing smartphone addiction through social app use^[49]. Wen et al. (2023) also found that loneliness significantly moderated the relationship between social app use and smartphone addiction, especially among older adults, where increased loneliness intensified addiction-related behaviors linked to social media use^[50]. Based on these findings, the following hypothesis is proposed:

H2: Social app use is more strongly correlated with smartphone addiction among elderly individuals with high levels of loneliness compared to those with low levels of loneliness.

This study posits that loneliness should be regarded as an important psychological factor that may interact with not only social app use but also the other three app categories (information, entertainment, and shopping), increasing the risk of excessive smartphone use. Assessing and addressing loneliness in older adults may help curb the overuse of smartphones as a maladaptive form of social compensation and distraction. Compared to social app use, there is significantly less literature on loneliness as a moderator between information, entertainment, and shopping app use and smartphone addiction in the elderly.

Yang et al. (2022) found that loneliness significantly moderated the relationship between information app use and smartphone addiction, with higher levels of loneliness leading to more pronounced addictive behaviors among elderly users^[16]. However, this study only explored the relationship during the COVID-19 pandemic in Hong Kong, which has certain limitations and may not represent periods outside of the pandemic. Therefore, the following research question is raised:

RQ4: Is information app use more strongly correlated with smartphone addiction among elderly individuals with high levels of loneliness compared to those with low levels of loneliness?

Kim et al. (2021) investigated smartphone proficiency and use among older users in South Korea and found that loneliness moderated the relationship between entertainment app use and smartphone addiction, indicating that lonely older adults were more likely to develop addictive behaviors^[49]. Xu et al. (2023) collected data on smartphone usage from elderly users in China and similarly found that elderly individuals experiencing loneliness tend to rely more heavily on entertainment apps, which, in turn, increases their likelihood of developing smartphone addiction^[51]. However, MacDonald & Schermer (2021) found no significant relationship between loneliness and smartphone use, particularly in relation to entertainment and information apps, and smartphone addiction among older adults^[52]. Thus, the following research question is posed:

RQ5: Is entertainment app use more strongly correlated with smartphone addiction among elderly individuals with high levels of loneliness compared to those with low levels of loneliness?

Currently, there is little literature examining the relationship between loneliness, shopping app use, and smartphone addiction. Malaeb et al. (2022) studied boredom proneness, loneliness, and smartphone addiction among Lebanese young adults, highlighting that although shopping apps are frequently used, loneliness did not significantly exacerbate smartphone addiction^[53]. Shen & Wang (2019) examined loneliness and excessive smartphone use among Chinese college students and found that loneliness moderated the relationship between shopping app use and smartphone addiction, with the effect of loneliness varying depending on the specific motivation behind app use^[54]. However, research specifically exploring the moderating role of loneliness in the relationship between shopping app use and smartphone addiction among the elderly is scarce. Yang et al. (2022) mentioned that during the pandemic, loneliness had a clear moderating effect on the relationship between shopping app use and smartphone addiction among elderly users who relied on these apps for convenience^[16]. Therefore, the following research question is posed:

RQ6: Is shopping app use more strongly correlated with smartphone addiction among elderly individuals with high levels of loneliness compared to those with low levels of loneliness?

3. Materials and Methods

(1) Data source

The participants in this study were elderly smartphone users aged 60 and above from various regions from

China. Data were collected through a questionnaire survey. During the questionnaire design process, the measurement of all variables was based on scales from previous studies, with modifications or simplifications made to reflect the actual circumstances of the elderly in China. Reliability analyses were conducted for each scale, and standardized Cronbach's α coefficients were reported. The final version of the questionnaire was uploaded to "Questionnaire Star" (a Chinese online survey platform), and a total of 517 responses were collected. After filtering out anomalous data, the number of valid responses was 492.

(2) Measurement

App use

App use is the core independent variable in this study. The study measured app use based on the functionality of apps, categorizing smartphone use into four types: social, information, entertainment, and shopping apps (Hsu & Li, 2015)^[55]. Common social apps include WeChat, Weibo, and QQ, etc; common information apps include TOPBuzz, Tencent News, NetEase News, etc; common entertainment apps include Happy Cancellation, Happy Poker, Kwai, TikTok, etc; and common shopping apps include Taobao, JD.com, Freshhema, and Missfresh, etc. App use was measured using a five-point Likert scale (1=Never, 2=Rarely, 3=Sometimes, 4=Often, 5=Always).

Smartphone addiction

Smartphone addiction is the dependent variable in this study. The research referenced the Smartphone Addiction Scale-Short Version (SAS-SV) (Kwon et al., 2013) to assess individuals' risk and severity of smartphone addiction^[56]. This scale evaluates individuals' dependence on smartphones, including usage time, frequency, and duration. It also assesses the impact of smartphone use on individuals' daily life, work, and learning, such as neglecting work plans or experiencing difficulty concentrating during class, or physical discomfort like wrist or neck pain from excessive use. Additionally, the scale measures self-regulation, resistance to smartphone use, and psychological health. The scale consists of 10 items, using a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree), with higher scores indicating a greater level of smartphone addiction. The standardized Cronbach's α coefficient for the scale was 0.923, indicating high data reliability.

Moderator variable

Loneliness is the moderator variable in this study. We used the Chinese simplified version of the ULS-8 loneliness scale (Hays & DiMatteo, 1987) to assess the loneliness of elderly participants^[57]. In this study, the ULS-8 includes six positively framed items related to loneliness and two negatively framed items (non-loneliness items). Each item is scored on a four-point frequency scale (1=Never, 2=Rarely, 3=Sometimes, 4=Always), with the scoring for positive items (non-loneliness items) reversed. Higher scores indicate greater loneliness. The reliability of the total scale in this study was good, with a standardized Cronbach's a coefficient of 0.819.

Control variable

The control variables measured in this study include demographic variables, self-rated health, life satisfaction, and social support.

Demographic variables include: (1) Gender (0=Male, 1=Female); (2) Age, measured as actual age; (3) Years of education; (4) Monthly income (in 1000 RMB); (5) Living situation (0=Non-living alone, 1=Living alone).

Self-rated health (SRH) was used to measure health status. Self-assessed health is considered a simple indicator of older adults' health and has been found to predict future health outcomes (Meng et al., 2014)^[58]. The question asked was, "How would you rate your current health status?" Responses were scored from 1 to 5, ranging from "severely ill" to "very healthy," with higher values indicating better health.

Life satisfaction was defined by Shin & Johnson (1978, p. 478) as "an overall assessment of the quality of a person's life according to chosen criteria."^[59] Life satisfaction in this study was measured using a single self-rated

question: "I am satisfied with my current life," using a 5-point Likert scale (1=Strongly disagree to 5=Strongly agree).

To minimize the length of the survey and participant burden with minimal information loss, this study used a six-item short form of the Multidimensional Scale of Perceived Social Support (MSPSS) (Porter et al., 2019) to measure social support^[60]. It uses a 5-point Likert scale (1=Strongly disagree to 5=Strongly agree) to assess perceived social support from three sources: friends, family, and significant others. The standardized Cronbach's a coefficient for the scale was 0.893, indicating high reliability.

(3) Data analysis

The aim of this study is to explore the correlation between four types of app use—social, information, entertainment, and shopping—and smartphone addiction among the elderly, as well as the moderating role of loneliness in these relationships. To achieve this, a questionnaire survey was conducted, and data from 492 valid responses were cleaned. Some categorical control variables were encoded as dummy variables for measurement purposes, and the data were analyzed using STATA 16. Given that multicollinearity may reduce or eliminate the contribution of certain variables to the regression model, all variables were mean-centered prior to conducting Ordinary Least Squares (OLS) regression analysis to mitigate multicollinearity. The results of this study could provide valuable insights for formulating strategies to improve digital literacy and optimize smartphone usage among the elderly.

4. Results

(1) Descriptive statistics

Variable	N(Percentage) or M(SD)	N				
Gender						
Male	213(43.3%)	492				
Female	279(56.7%)					
Age	68.37(5.653)	492				
Years of education	11.05(4.361)	492				
Income(1000RMB)	5.22(7.319)	492				
	Residential situation	·				
Not living alone	441(89.6%)	492				
Living alone	51(10.4%)	492				
Self-rated Health	3.38(1.020)	492				
Life Satisfaction	3.59(1.072)	492				
Social Support	3.52(0.871)	492				
Loneliness	2.62(0.653)	492				
Social App Use	3.44(1.088)	492				
Information App Use	3.19(1.160)	492				
Entertainment App Use	3.11(1.249)	492				
Shopping App Use	3.10(1.223)	492				
Smartphone Addiction	3.21(0.849)	492				

Table 1. Descriptive statistics

After excluding 24 participants under the age of 60 and one participant who did not pass the screening questions, the final sample size consisted of 492 participants. Descriptive statistics for smartphone addiction, app use categories (social, information, entertainment, and shopping), demographic characteristics (gender, age, years of education, monthly income, and living situation), and psychosocial variables (self-rated health, social support, and life satisfaction) are presented in Table 1.

Table 1 provides preliminary evidence of relationships between key variables. Based on this, the next step involves conducting Ordinary Least Squares (OLS) regression analysis to predict smartphone addiction and loneliness based on app use variables while controlling for sociodemographic and psychosocial factors.

(2) The impact of app use on smartphone addiction in the elderly

1) Direct effect

The results of the OLS regression analysis do not support H1, while addressing Research Questions RQ1 to RQ3. As shown in Table2 Model1, social app use was not significantly positively correlated with smartphone addiction in the elderly, thus failing to support H1. This suggests that more frequent social app use does not correspond to higher levels of smartphone addiction symptoms. However, information app use (B=0.140, SE=0.035, β =0.191, p<0.001), entertainment app use (B=0.118, SE=0.031, β =0.173, p<0.001), and shopping app use (B=0.141, SE=0.033, β =0.203, p<0.001) were all significantly positively correlated with smartphone addiction among the elderly, thereby addressing RQ1 through RQ3. This indicates that older adults may use information, entertainment, or shopping apps for various purposes, such as obtaining information, relaxing, or purchasing goods, but these behaviors may gradually evolve into dependency or even addiction. This reflects the increasingly significant role that smartphones play in the daily lives of older adults, underscoring the potential risks and the need for appropriate guidance and interventions to mitigate addictive behaviors.

2) Interaction effect

As shown in Table2 Model2, the interaction effects of loneliness with information app use (B=0.183, SE=0.054, β =0.052, p<0.001) and shopping app use (B=0.197, SE=0.061, β =0.200, p<0.001) on smartphone addiction were significantly positive, thereby answering RQ4 and RQ6. Specifically, the correlations between information app use/shopping app use and smartphone addiction were stronger in elderly individuals with lower levels of loneliness compared to those with higher levels of loneliness. This suggests that loneliness significantly strengthens the positive relationship between information and shopping app use and smartphone addiction among the elderly.

From the simple slope analysis in Figure 1, it can be observed that, when loneliness is high, information app use significantly reinforces smartphone addiction among the elderly (Gradient of slope=0.245, t=1.681, p<0.001); however, when loneliness is low, the correlation between information app use and smartphone addiction is not significant (Gradient of slope=0.008, t=1.634, p>0.05). This result indicates that the elderly who are more lonely are more likely to develop smartphone addiction when using information apps, while those who do not feel lonely are less likely to become addicted to smartphones, even with higher information app use.

Figure 2, following a model similar to Figure 1, shows that when loneliness is high, shopping app use significantly reinforces smartphone addiction among the elderly (Gradient of slope=0.267, t=1.371, p<0.001); however, when loneliness is low, the correlation between shopping app use and smartphone addiction is not significant (Gradient of slope=0.011, t=1.325, p>0.05). This result indicates a strong positive correlation between shopping app use and smartphone addiction among the elderly with high levels of loneliness. In contrast, for those with lower levels of loneliness, shopping app use does not significantly increase the likelihood of smartphone addiction.

	Model 1		Model 2		
	Coef.	SE	Coef.	SE	
Gender (female=1)	003	.068	.018	.065	
Age	.007	.006	.007	.006	
Years of educattion	011	.008	010	.008	
Income(1000RMB)	003	.005	003	.004	
Residention situation (Not living alone=1)	.054	.109	024	.105	
Self-rated health	.053	.033	.046	.031	
Life Satisfaction	.039	.034	.029	.032	
Social Support	.076	.040	.076	.038	
Loneliness	.155**	.052	.036	.052	
Social App Use	.011	.038	.003	.036	
Information App Use	.140***	.035	.126***	.033	
Entertainment App Use	.118***	.031	.103***	.029	
Shopping App Use	.141***	.033	.139***	.032	
Loneliness×Social App Use			113	.060	
Loneliness×Information App Use			.183***	.052	
Loneliness×Entertainment App Use			011	.048	
Loneliness×Shopping App Use			.197**	.061	
Constant	.576	.480	1.023	.463	
R ²	0.288 0.366		366		
a Dependent Variable: Y Smartphone addiction					
Note. *p < 0.05; **p < 0.01; ***p < 0.001					

Table 2. OLS regression analysis results



Figure 1. The moderating effect of loneliness and information app use on smartphone addiction among the elderly



Figure2. The moderating effect of loneliness and shopping app use on smartphone addiction among the elderly

5. Discussion

This study presents two key findings: (1) After categorizing app use into four types—social, information, entertainment, and shopping—it was found that information app use, entertainment app use, and shopping app use were significantly positively correlated with smartphone addiction in the elderly, while social app use was not significantly associated with smartphone addiction. (2) Loneliness, as a moderating variable, significantly influenced the relationship between information app use and shopping app use and smartphone addiction among the elderly. Specifically, higher levels of loneliness intensified the association between information. These findings highlight that certain types of app use carry addiction risks, particularly for vulnerable groups like the elderly. This underscores the need for greater awareness and moderation in the use of information and shopping apps among the elderly to prevent potential addiction. This study provides valuable insights into how different app functionalities and individual differences contribute to smartphone addiction, offering support for preventive and intervention efforts.

The study deepens the understanding of smartphone addiction, particularly with respect to different types of app use and their interaction with loneliness among the elderly. First, the finding that information, entertainment, and shopping app use are significantly positively associated with smartphone addiction aligns with previous research. For example, Abbasi et al. (2021) pointed out that specific content consumption can exacerbate smartphone addiction, particularly through apps that provide instant gratification, such as information and shopping apps^[21]. Additionally, Aljomaa et al. (2016) found that smartphone addiction is more common in certain groups, where frequent app use often leads to higher dependency^[12]. This suggests that older adults' frequent use of information and shopping apps may be driven by the desire for instant information and convenient shopping, which in turn enhances their dependence on these apps. The positive correlation between information app use (e.g., news, weather, health apps) and smartphone addiction among the elderly can be understood from both content features and user needs. Information apps are characterized by immediacy and continuous updates, which are particularly appealing to older adults, who may frequently use such apps to stay informed (Abbasi et al., 2021)^[21]. These apps satisfy the curiosity and need for information about current events of the elderly, leading them to check and update information constantly, which can result in a cycle of frequent use and addiction. Additionally, the content provided by information apps is often closely related to the health and well-being of the elderly. For instance, health-related apps offer advice and information on disease prevention, which can alleviate health anxiety in older adults but may also increase their dependency on these apps for constant updates (Chen, 2020)^[19].

Similarly, entertainment app use (e.g., video, music, and gaming apps) is significantly positively associated with smartphone addiction among the elderly. These apps offer diverse entertainment options that fulfill older adults' needs to pass time and alleviate loneliness (Mahapatra, 2019)^[47]. After retirement or with reduced social activities, smartphones become an important source of entertainment for older adults. The high accessibility, interactivity, and personalized recommendations of entertainment apps allow users to easily find content of interest, often leading to prolonged use. Furthermore, the emotional and narrative elements of some entertainment content (e.g., video platforms or short films) can create a sense of immersion, making it difficult for users to disengage (Busch et al., 2021)^[30]. Overuse of entertainment apps not only consumes older adults' time but can also negatively affect their quality of life, thereby increasing the risk of smartphone addiction (Fernandez et al., 2020)^[25].

Shopping apps also showed a significant positive correlation with smartphone addiction among the elderly due to the convenience of online shopping. Shopping apps allow older adults to purchase necessary items without leaving their homes, especially during periods of immobility or the COVID-19 pandemic. This convenience encourages frequent use of shopping apps (Hsiao et al., 2016)^[26]. Shopping platforms like Taobao and Pinduoduo utilize big data to make personalized recommendations, further enhancing older adults' desire to shop. Additionally, discount promotions and competitive search functions often lead older adults to spend more time browsing products, reinforcing addictive behaviors (Arif et al., 2016)^[61]. Research indicates that shopping apps can stimulate the desire to purchase through product recommendations, prompting frequent browsing and purchases (Kwon et al., 2016)^[14].

Secondly, this study found that social app use was not significantly associated with smartphone addiction among the elderly, consistent with the findings of Jeong et al. (2016)^[17]. Social apps are often viewed as tools for maintaining social connections. For the elderly, social app use is primarily aimed at maintaining existing social relationships rather than seeking new ones. This usage pattern differs from that of younger people, as older adults tend to value the depth rather than the breadth of their social interactions (Al-Kandari & Al-Sejari, 2021)^[48]. Therefore, social app use is less likely to result in addictive behavior among the elderly.

Another key finding of this study is that loneliness significantly moderates the relationship between information and shopping app use and smartphone addiction. This is consistent with Bian and Leung's (2015) research, which found a significant positive correlation between loneliness and smartphone addiction^[41]. When older adults feel lonely, they are more likely to turn to information and shopping apps to cope with their loneliness, as Mahapatra (2019) pointed out, loneliness drives people to rely more on digital tools for emotional regulation^[47]. However, when loneliness is low, the impact of information and shopping app use on addiction is not significant. This moderating effect underscores the importance of loneliness in smartphone addiction, which warrants further exploration in future research (Haug et al., 2015)^[24].

In summary, the results of this study identify risk factors for smartphone addiction among the elderly, expanding the existing literature on smartphone addiction, particularly regarding individual differences and the effects of app types. This study highlights the importance of loneliness as a moderator and provides theoretical support for future

preventive and intervention strategies. Future research should continue to explore how reducing loneliness and promoting healthy digital behaviors can lower the risk of smartphone addiction in older adults. Policymakers and health advocates should help older adults recognize the risks of addiction associated with information and shopping app use and teach them how to use these apps responsibly. Additionally, community and family support systems could reduce loneliness by providing more offline social opportunities, thereby indirectly decreasing smartphone dependence (Billieux et al., 2015)^[62]. For instance, Fernandez et al. (2020) emphasized that short-term digital detox could be an effective method to reduce addictive behaviors, and future interventions could explore the application of similar strategies among the elderly^[25].

Additionally, the cross-sectional design of this study limits the ability to draw causal conclusions, as it only addresses the correlation between app use and smartphone addiction among the elderly. Cross-sectional studies collect data at a single point in time, which allows for the observation of associations but does not establish causality between variables. A longitudinal study that tracks participants over time would provide stronger causal inferences regarding the impact of app use on smartphone addiction in older adults. This also highlights potential directions for future research.

Future studies could investigate fluctuations within the elderly population to examine whether increased app usage leads to emotional decline, implying a causal relationship. Additionally, a longitudinal approach could follow a cohort over time, using diary studies to assess whether higher initial social media use predicts poorer health outcomes in the future. Other moderating factors, such as depression and cognitive impairment, could also be incorporated into future research. Individual differences might influence the effects of social media use. For instance, individuals with depression might experience greater negative effects due to social comparisons on apps. Those with mild cognitive impairment may struggle to use apps correctly, potentially exposing themselves to risks like oversharing or fraud. Identifying vulnerable groups could guide targeted interventions and policies to protect users. Therefore, focusing on these groups in future research is of critical importance.

6. Conclusion

Smartphone addiction among the elderly is becoming an increasingly concerning social phenomenon, as it can have immeasurable negative impacts on the physical and mental health of an already vulnerable group. This study aims to measure the correlation between multiple categories of app use and smartphone addiction in the elderly, with loneliness as a moderating factor. The findings provide a foundation for targeted interventions to prevent addiction in this population, particularly regarding the use of apps prone to addiction. The results indicate that information, entertainment, and shopping app use are positively associated with smartphone addiction among older adults. Moreover, loneliness intensifies the relationship between information and shopping app use and smartphone addiction, especially among those with high levels of loneliness.

Developers and policymakers should consider measures to prevent the overdevelopment and excessive app use with addictive potential. Features such as usage limits or pop-up warnings after prolonged use may help reduce addiction risks. Family members can support elderly individuals by modeling healthy app use behaviors and monitoring screen time. Community centers and elder care facilities should offer digital literacy programs that equip the elderly with the skills to monitor and regulate their app usage habits. Finally, this study calls for collaboration among app developers, policymakers, healthcare providers, and families to use technology for the benefit of older adults while ensuring their well-being.

7. Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could

have appeared to influence the work reported in this paper.

8. Data Availability

Data will be made available on request.

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