

## RESEARCH ARTICLE

Offline and online social networking and  
life satisfaction among older adults in China:  
Evidence from the Chinese Longitudinal Aging  
Social Survey, 2018–2023

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## Abstract

China's rapid population aging raises important challenges for understanding how social relationships shape well-being in later life. While both offline social networking and online communication have been linked to life satisfaction, existing studies rely largely on cross-sectional data and rarely examine how these two forms of social engagement jointly shape well-being. Using three waves of the Chinese Longitudinal Aging Social Survey (CLASS, 2018–2023;  $N = 18,294$ ), we estimated within-person (fixed-effects) associations between offline social networking, social-communicative internet use, and life satisfaction. The results show that online social networking was positively associated with life satisfaction, whereas offline social networking did not exhibit a significant within-person association. More importantly, a positive interaction effect indicates that offline and online social networking were complementary rather than substitutive, such that the well-being benefits of online social networking were greater for individuals with richer offline social ties. This complementary pattern was more pronounced among younger older adults, men, and those living with others. These findings suggest that digital engagement operates within, rather than independently of, existing social structures, and that policies promoting digital inclusion alongside offline social participation may yield greater well-being gains in aging societies.

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## 1. Introduction

## 1.1. Offline social networking and life satisfaction in later life

Understanding how social relationships shape well-being in later life has become increasingly salient amid rapid population aging (Fernandez-Portero *et al.*, 2023; Iwasa *et al.*, 2025; Saha, 2024). In China, where the population aged 60 and above exceeded 290 million in 2023 and is projected to surpass 400 million by 2035 (National Bureau of Statistics of China, 2024), identifying the determinants of older adults' well-being is both a theoretical imperative and a policy priority (G. Cheng & Yan, 2021; Zhang *et al.*, 2021).

Life satisfaction, defined as a cognitive evaluation of the overall quality of life (Diener *et al.*, 1985; McFeeley *et al.*, 2023), is a central indicator of subjective well-being. A substantial body of research underscores the importance of social relationships in shaping life satisfaction (Chia *et al.*, 2025; Saha, 2024). The convoy model conceptualizes individuals as embedded in dynamic networks that provide emotional and instrumental support (Antonucci *et al.*, 2014; Fuller & Ajrouch, 2020; Gu, Wang, *et al.*, 2025), while the socioemotional selectivity theory (SST) emphasizes the prioritization of emotionally meaningful ties in later life (Carstensen, 2021; Charles, 2020; Gu, Wang, *et al.*, 2025). Empirical evidence consistently documents positive associations between social networks and life satisfaction across diverse contexts (W. Cheng *et al.*, 2022; Cornwell & Schafer, 2016; Foong *et al.*, 2023; He *et al.*, 2017; Park & Kang, 2023; Singh & Singh, 2020; Tomini *et al.*, 2016).

While this literature establishes robust positive associations, its implications for within-person dynamics in later life are more nuanced. SST's emphasis on relationship quality over network breadth implies that changes in network size or contact frequency, which represent typical sources of within-individual variation, may not translate into higher life satisfaction. For older adults, the maintenance of close, emotionally salient ties is more important than network expansion (Charles, 2020; Gu, Wang, *et al.*, 2025). Activity theory similarly distinguishes meaningful engagement from activity volume (Gu, Wang, *et al.*, 2025). Moreover, within-person changes in offline social networks may be linked to adverse life events (e.g., health shocks and spousal loss), thereby attenuating observed associations.

Despite these qualifications, the core proposition that social relationships support well-being led to the following hypothesis (H):

- H1: Offline social networking is positively associated with life satisfaction at the within-individual level.

## 1.2. Social-communicative internet use and life satisfaction

Existing research often treats social relationships as a single domain (Wei *et al.*, 2026), overlooking differences between offline and online networking. This limitation has become more salient with digitalization (China Internet Network Information Center [CNNIC], 2024; Gu, Feng, Wang, *et al.*, 2025), which has transformed how older adults maintain and experience social relationships.

The diffusion of digital communication technologies has introduced new forms of social participation in later life. In China, approximately 43% of older adults reported regular internet use by 2023, with platforms such as WeChat widely

used for everyday communication (CNNIC, 2024). Online social networking enables older adults to maintain contact despite mobility constraints and geographic separation and has been linked to improved well-being (X. Cheng *et al.*, 2024; Gaia *et al.*, 2021; Kim & Shen, 2020; Ractham *et al.*, 2022; D. Zhou *et al.*, 2022; J. Zhou, 2018).

The association can be understood through uses and gratifications theory, which posits that individuals use media to satisfy social and emotional needs (Gu, Wang, *et al.*, 2025). Social-communicative internet use (SCI), defined as digital communication with family and friends (Gu, Feng, Yang, *et al.*, 2025), is well-suited to meeting these needs by enabling timely and interactive contact.

The SST further suggests that older adults may benefit from digital communication that supports the maintenance of emotionally close ties (Charles, 2020; Gu, Wang, *et al.*, 2025). By reducing barriers to contact, such use may provide more flexible support for life satisfaction than offline networking, which is often constrained by health and logistical factors.

Empirical evidence largely supports this expectation. A review of 25 studies found that information and communication technology (ICT) use reduces social isolation and enhances subjective well-being among older adults (Gu, Feng, Wang, *et al.*, 2025). It also showed that social media use is positively associated with subjective well-being, particularly when used for communication with family members and friends. Based on these theoretical and empirical considerations, we proposed the following hypothesis:

- H2: SCI is positively associated with life satisfaction at the within-individual level.

## 1.3. Complementarity versus substitution between offline and online social networking

A central question concerns how online networking relates to offline social ties. Two competing perspectives dominate the literature. The complementarity hypothesis posits that online communication reinforces existing social relationships, thereby enhancing their benefits (Benvenuti *et al.*, 2020; Chu *et al.*, 2023; Hampton & Wellman, 2003; Wellman *et al.*, 2001). In contrast, the substitution hypothesis suggests that online communication may displace offline engagement, potentially weakening social ties (Kraut *et al.*, 1998; Yang *et al.*, 2021). Empirical evidence remains mixed, and few studies examine their interaction using longitudinal data.

We argue that the complementarity hypothesis is theoretically more compelling in the Chinese context. The social enhancement perspective suggests that online communication amplifies existing social resources

rather than creating new ties (Benvenuti *et al.*, 2020; Chu *et al.*, 2023; Kraut *et al.*, 1998; Wellman *et al.*, 2001). Individuals embedded in richer offline networks have more relationships that digital communication can help maintain (Gu, Wang, *et al.*, 2025). Accordingly, SCI is expected to yield greater well-being returns for those with stronger offline social ties.

The structure of dominant digital platforms in China further supports this expectation. Platforms such as WeChat primarily function as tools for maintaining pre-existing relationships—family members, long-standing friends, and former colleagues. Online communication thus extends rather than replaces offline social ties (Gu, Wang, *et al.*, 2025). This platform structure makes substitution less likely in the Chinese context.

Longitudinal evidence is consistent with this view. Gu, Feng, Wang, *et al.* (2025) reviewed studies and found that ICT use typically reinforces rather than displaces offline social engagement, particularly when online and offline communication serve similar relational functions. Building on these theoretical and contextual considerations, we proposed the following competing hypotheses:

- H3a (Complementarity): Offline and online social networking are positively complementary, such that their interaction effect is positive.
- H3b (Substitution): Offline and online social networking are substitutive, such that their interaction effect is negative.

#### 1.4. Heterogeneity across demographic subgroups

The associations between social networking and life satisfaction may vary across older adults. We focused on differences by age, gender, and living arrangement. With respect to age, SST suggests that the salience of emotionally meaningful relationships increases with advancing age. However, digital literacy and ICT adoption decline markedly among the oldest-old (Gu, Wang, *et al.*, 2025). These patterns suggest that complementarity between offline and online social networking may be more pronounced among younger segments of the older population.

Gender differences in network structure also imply heterogeneity. Older men tend to maintain smaller, more homogeneous networks that rely heavily on spousal ties, whereas older women typically maintain broader and more diverse networks (Cohn-Schwartz & Schmitz, 2024; Cornwell & Schafer, 2016). These structural differences may translate into distinct patterns of online–offline integration.

Living arrangements provide another source of variation. Older adults who co-reside with others benefit

from embedded offline social interaction, which can support complementary use of online communication. By contrast, those living alone lack this baseline, which may limit the extent of such complementarity. Evidence from the Chinese context is consistent with this expectation (Gu, Feng, Yang, *et al.*, 2025).

Taken together, these considerations indicate systematic heterogeneity in the association between social networking and life satisfaction. We therefore proposed the following hypothesis:

- H4: The complementary effect of offline and online social networking is stronger among younger older adults, men, and those living with others.

#### 1.5. The current study

This study examines how offline and online social networking jointly relate to life satisfaction among older adults in China, using three waves of the Chinese Longitudinal Aging Social Survey (CLASS 2018, 2020, and 2023).

It makes three contributions. First, using panel data and two-way fixed-effects models, we estimated within-individual associations between social networking and life satisfaction, reducing bias from time-invariant confounders. Second, we tested the complementarity and substitution hypotheses by including an interaction between offline and online networking. Third, we examined heterogeneity in these relationships across age, gender, and living arrangement.

## 2. Data and methods

### 2.1. Data source

This study used three waves of CLASS conducted in 2018, 2020, and 2023 by Renmin University of China. CLASS employs a stratified, multistage probability sampling design to obtain a nationally representative sample of Chinese adults aged 60 and above. The survey covers health status, social participation, family relationships, economic conditions, and psychological well-being.

The age threshold of 60 is consistent with China's statutory retirement age for male workers and broadly aligned with that for female workers (55 for white-collar and 50 for blue-collar employees). It therefore represents both an institutionally defined transition to post-retirement life and the conventional cutoff in Chinese gerontological research and aging policy.

The analytical sample was restricted to respondents aged 60 or above at baseline who provided valid responses on the key study variables. After listwise deletion of missing values on the dependent variable (0.8% of person-year

observations), the final sample included 34,200 person-year observations from 18,294 unique individuals (2018:  $n = 11,306$ ; 2020:  $n = 11,304$ ; 2023:  $n = 11,590$ ). The sample was approximately gender-balanced (49.1% female), with ages ranging from 60 to 108 (mean = 71.4, SD = 6.65). Approximately 10.1% of respondents lived alone. Because the 2020 survey was conducted during the COVID-19 pandemic, we included year fixed effects to capture common shocks associated with the pandemic period.

## 2.2. Measures

### 2.2.1. Dependent variable

Life satisfaction was measured using a single-item question: “Overall, how satisfied are you with your current life?” Responses were recorded on a 5-point Likert scale (1 = very dissatisfied to 5 = very satisfied), with higher values indicating greater life satisfaction. The mean score in the full sample was 3.78 (SD = 0.84).

In the main analyses, life satisfaction was treated as a continuous variable and recoded as a binary indicator (1 = satisfied [categories 4–5]; 0 = not satisfied [categories 1–3]) in robustness checks (Ferrer-i-Carbonell & Frijters, 2004; D. Zhou *et al.*, 2022).

### 2.2.2. Offline social networking

Offline social networking refers to non-digital social relationships maintained with family members, relatives, and friends, encompassing the breadth of social contacts, emotional closeness, and exchange of social support (Cornwell & Schafer, 2016; Fuller & Ajrouch, 2020). It was measured using a six-item composite index—the offline social networking index (OSI)—constructed from the social support and social network modules of CLASS. The index captures three dimensions of relationships with family/relatives and friends: (i) contact breadth (number of individuals contacted at least monthly), (ii) emotional intimacy (number of individuals with whom personal matters can be discussed), and (iii) instrumental support (number of individuals who can provide practical help when needed).

Each item was coded on an ordinal scale ranging from 0 (none) to 5 (nine or more persons). All items were standardized ( $z$ -scores), and the OSI was computed as the sum of the six standardized items. Higher values indicate a larger, more emotionally close, and more supportive social network. The index draws on the convoy model (Antonucci *et al.*, 2014; Fuller & Ajrouch, 2020; Gu, Wang, *et al.*, 2025) and the multidimensional perspective on social support (Holt-Lunstad & Lefler, 2020; Lu *et al.*, 2023; Son, 2020),

capturing both network size and relationship quality.

### 2.2.3. Online social networking

Online social networking refers to digitally mediated communication and the maintenance of social relationships through internet-based platforms—such as WeChat and Douyin—including text messaging and voice or video calls (Gaia *et al.*, 2021; Gu, Feng, Yang, *et al.*, 2025; Kim & Shen, 2020). SCI was measured as a three-category variable constructed from two items in CLASS. The first item captured overall internet use frequency and was recoded into three categories (0 = non-use, 1 = occasional use, 2 = daily use). The second item captured primary online activities; respondents who reported “voice or video calls” or “text chatting” were classified as engaging in online social communication.

Combining these measures, respondents were categorized as: (0) non-users, (1) internet users without social-communicative use, and (2) internet users who engage in social communication. In the empirical analyses, SCI was treated as a categorical variable with non-users as the reference group. By separating general internet use (SCI = 1) from social-communicative use (SCI = 2), this approach targets the specific channel through which online activity may affect well-being (X. Cheng *et al.*, 2024; J. Zhou, 2018).

### 2.2.4. Control variables

We included the following time-varying covariates in the two-way fixed-effects models: marital status (1 = married/partnered), living arrangement (1 = living alone), self-rated health (1–5), number of chronic conditions, and activities of daily living (higher scores indicate greater limitations).

Time-invariant characteristics—including gender, education, and *hukou* status (China’s household registration system, distinguishing rural from urban residents)—were absorbed by individual fixed effects. We also estimated a sensitivity model that additionally included self-rated economic status (available only in 2020 and 2023; 1 = worse, 2 = about the same, 3 = better). Including this variable reduced the sample to 13,896 person-years observations but allowed adjustment for economic conditions.

## 2.3. Analytical strategy

### 2.3.1. Two-way fixed-effects model

We estimated a two-way fixed effect model of the form:

$$Satisfy_{it} = \alpha + \beta_1 OSI_{it} + \beta_2 SCI_{it} + \beta_3 (OSI_{it} \times SCI_{it}) + \gamma' X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (1)$$

where  $\mu_i$  is the individual fixed effect,  $\lambda_t$  is the wave fixed effect (accounting for common shocks including the COVID-19 pandemic), and  $\varepsilon_{it}$  is the idiosyncratic error term. Standard errors are clustered at the individual level to account for serial correlation within persons.

The identifying assumption was that within-person changes in social networking are uncorrelated with concurrent changes in the error term, conditional on fixed effects and time-varying covariates. Models were estimated using the *reghdfe* command in Stata (Correia & Constantine, 2014; Morishita-Suzuki, 2025).

Although life satisfaction was measured on an ordinal scale, we estimated linear two-way fixed-effects models for three reasons. First, standard ordered logit and probit models do not readily accommodate individual fixed effects in short panels due to the incidental parameters problem (Baetschmann *et al.*, 2015; Honoré *et al.*, 2025; Neyman & Scott, 1948). Second, after demeaning, the within-person residuals are approximately normally distributed, mitigating concerns about distributional misspecification (Angrist & Pischke, 2009; Petrova & Westerlund, 2020; Sommet & Lipps, 2025; D. Zhou *et al.*, 2022). Third, re-estimating the model using a binary specification with the CLASS data yields substantively similar results, providing empirical support for treating life satisfaction as approximately cardinal in this context.

To test hypotheses H3a and H3b, we constructed interaction terms between OSI and SCI. OSI was mean-centered prior to interaction to reduce multicollinearity and facilitate interpretation (Aiken & West, 1991; Hayes, 2022; Shieh, 2011). Because SCI was specified as a categorical variable, the interaction was implemented as a set of interaction terms between OSI and each SCI category.

These interaction terms assessed whether the association between offline social networking and life satisfaction varies across different types of internet use. A positive and statistically significant interaction coefficient indicates complementarity (H3a), whereas a negative coefficient indicates substitution (H3b).

### 2.3.2. Heterogeneity and robustness

We examined heterogeneity by estimating the two-way fixed-effects model separately by age group (60–69, 70–79, 80+), gender, and living arrangement (living alone vs. co-residing).

Robustness checks included: (i) a binary outcome specification estimated using a linear probability model; (ii) an alternative measure of online engagement based on internet use frequency; (iii) inclusion of self-rated economic status; and (iv) inclusion of home internet access

to proxy for access-related constraints. All analyses were conducted in Stata 19 (StatCorp, United States).

## 3. Results

### 3.1. Sample characteristics

Table 1 reports descriptive statistics for the full sample and by survey wave. Overall, life satisfaction remained relatively stable over time, with mean values of 3.776 in 2018, 3.723 in 2020, and 3.847 in 2023 (on a five-point scale).

The OSI showed a modest upward trend across waves, rising slightly from 2018 to 2023. Decomposing the index by component, both family- and friend-based interactions increased over time, with the most noticeable gains in friend contact breadth and emotional support.

In contrast, SCI increased substantially over the study period. The proportion of respondents engaging in online social communication rose from 16.0% in 2018 to 25.7% in 2020 and 50.8% in 2023, while the share of non-users declined sharply. This pattern reflects the rapid diffusion of digital communication technologies among older adults in China.

The sample was approximately gender-balanced, and mean age remained stable across waves (71–72 years), consistent with the rotating panel design. About 10% of respondents lived alone, a share that declined slightly over time. Health trends were mixed: self-rated health improved in 2023, but the average number of chronic conditions rose modestly.

### 3.2. Two-way fixed-effects model estimates

Table 2 reports two-way fixed-effects model estimates across four nested specifications (M1–M4). M1 includes OSI alone; M2 adds SCI without controls; M3 adds the full set of time-varying covariates; and M4 further incorporates OSI  $\times$  SCI interaction terms.

Contrary to H1, OSI was negatively associated with life satisfaction in the bivariate models (M1–M2;  $\beta = -0.005$ ,  $p < 0.05$ ), but the coefficient shrank to near zero and lost significance after adding time-varying controls (M3;  $\beta = -0.002$ ,  $p = 0.375$ ). The attenuation points to selection on time-invariant characteristics rather than a within-person effect of offline networking. H1 was not supported.

Meanwhile, H2 fared better. Relative to non-users, both SCI = 1 and SCI = 2 were positively associated with life satisfaction. In M2, the coefficients were sizable (SCI = 1:  $\beta = 0.202$ ,  $p < 0.01$ ; SCI = 2:  $\beta = 0.170$ ,  $p < 0.001$ ) and remained significant after adding controls (M3: SCI = 1:  $\beta = 0.131$ ,  $p = 0.047$ ; SCI = 2:  $\beta = 0.053$ ,  $p = 0.031$ ). Within individuals, transitioning into internet use—especially

**Table 1. Descriptive statistics of key variables by survey year**

| Variable                                            | Full sample<br>(N = 34,200) | 2018<br>(n = 11,306) | 2020<br>(n = 11,304) | 2023<br>(n = 11,590) |
|-----------------------------------------------------|-----------------------------|----------------------|----------------------|----------------------|
| Life satisfaction (1–5)                             | 3.783 (0.843)               | 3.776 (0.871)        | 3.723 (0.892)        | 3.847 (0.758)        |
| Offline social networking index                     | 0.000 (4.654)               | −0.315 (4.867)       | 0.043 (4.589)        | 0.265 (4.484)        |
| Family member contact                               | 2.662 (1.063)               | 2.659 (1.129)        | 2.640 (1.055)        | 2.686 (1.003)        |
| Emotional support of family members                 | 2.265 (1.026)               | 2.193 (1.064)        | 2.271 (1.009)        | 2.330 (0.999)        |
| Instrumental support of family members              | 2.519 (1.086)               | 2.510 (1.105)        | 2.532 (1.107)        | 2.515 (1.045)        |
| Friend contact                                      | 2.450 (1.217)               | 2.356 (1.275)        | 2.466 (1.214)        | 2.525 (1.154)        |
| Emotional support of friends                        | 2.100 (1.123)               | 1.998 (1.150)        | 2.107 (1.134)        | 2.194 (1.078)        |
| Instrumental support of friends                     | 2.096 (1.200)               | 2.016 (1.242)        | 2.129 (1.196)        | 2.141 (1.159)        |
| Age (years)                                         | 71.4 (6.6)                  | 71.4 (7.4)           | 71.6 (6.6)           | 71.3 (5.9)           |
| Self-rated health (1–5)                             | 3.425 (0.871)               | 3.319 (0.894)        | 3.372 (0.898)        | 3.580 (0.796)        |
| Chronic diseases (count)                            | 1.181 (1.150)               | 1.069 (1.126)        | 1.197 (1.109)        | 1.276 (1.202)        |
| Activities of daily living                          | 9.368 (1.434)               | 9.383 (1.504)        | 9.436 (1.548)        | 9.286 (1.229)        |
| Self-rated economic status (2020–2023) <sup>a</sup> | 2.053 (0.493)               | -                    | 2.066 (0.540)        | 2.041 (0.441)        |
| Social-communicative internet use                   |                             |                      |                      |                      |
| No internet use                                     | 66.9%                       | 81.6%                | 72.5%                | 47.0%                |
| Internet use without social communication           | 2.1%                        | 2.4%                 | 1.8%                 | 2.2%                 |
| Social-communicative internet use                   | 31.0%                       | 16.0%                | 25.7%                | 50.8%                |
| Education                                           |                             |                      |                      |                      |
| No formal education                                 | 22.4%                       | 26.5%                | 23.6%                | 17.3%                |
| Primary school                                      | 40.6%                       | 40.7%                | 40.8%                | 40.3%                |
| Junior high school                                  | 25.2%                       | 23.1%                | 24.7%                | 27.8%                |
| Senior high school and above                        | 11.8%                       | 9.7%                 | 10.9%                | 14.7%                |
| Gender                                              |                             |                      |                      |                      |
| Male                                                | 50.9%                       | 50.4%                | 50.5%                | 51.9%                |
| Female                                              | 49.1%                       | 49.6%                | 49.5%                | 48.1%                |
| Marital status                                      |                             |                      |                      |                      |
| Without spouse                                      | 24.0%                       | 30.6%                | 24.5%                | 16.9%                |
| With spouse (married)                               | 76.0%                       | 69.4%                | 75.5%                | 83.1%                |
| Living arrangement                                  |                             |                      |                      |                      |
| Co-residing                                         | 89.9%                       | 87.8%                | 89.8%                | 91.9%                |
| Living alone                                        | 10.1%                       | 12.2%                | 10.2%                | 8.1%                 |
| Household registration ( <i>hukou</i> )             |                             |                      |                      |                      |
| Rural (agricultural)                                | 57.4%                       | 57.0%                | 57.6%                | 57.5%                |
| Non-agricultural                                    | 42.6%                       | 43.0%                | 42.4%                | 42.5%                |

Notes: Values are means (standard deviations) for continuous variables and percentages (%) for categorical variables. The offline social networking index is standardized (mean = 0 in the full sample). <sup>a</sup> Self-rated economic status not collected in 2018.

**Table 2. Estimates of offline and online social networking on life satisfaction based on a two-way fixed effects model**

| Parameter                        | M1                 | M2                  | M3                   | M4                   |
|----------------------------------|--------------------|---------------------|----------------------|----------------------|
| OSI (offline)                    | −0.005*<br>(0.002) | −0.005*<br>(0.002)  | −0.002<br>(0.002)    | −0.006*<br>(0.003)   |
| SCI = 1 (Online, no social chat) | -                  | 0.202**<br>(0.070)  | 0.131*<br>(0.066)    | 0.143*<br>(0.069)    |
| SCI = 2 (Online social chat)     | -                  | 0.170***<br>(0.026) | 0.053*<br>(0.025)    | 0.049*<br>(0.025)    |
| OSI × [SCI = 1]                  | -                  | -                   | -                    | 0.012<br>(0.013)     |
| OSI × [SCI = 2]                  | -                  | -                   | -                    | 0.011*<br>(0.004)    |
| Married                          | -                  | -                   | 0.080*<br>(0.036)    | 0.080*<br>(0.036)    |
| Living alone                     | -                  | -                   | −0.028<br>(0.042)    | −0.029<br>(0.042)    |
| Self-rated health                | -                  | -                   | 0.361***<br>(0.013)  | 0.361***<br>(0.013)  |
| Chronic diseases                 | -                  | -                   | −0.004<br>(0.009)    | −0.005<br>(0.009)    |
| ADL limitations                  | -                  | -                   | −0.055***<br>(0.009) | −0.055***<br>(0.009) |
| Individual FE                    | Yes                | Yes                 | Yes                  | Yes                  |
| Year FE                          | Yes                | Yes                 | Yes                  | Yes                  |
| <i>n</i> (person-year)           | 26,576             | 26,576              | 26,543               | 26,543               |
| <i>R</i> <sup>2</sup> (within)   | 0.0007             | 0.0074              | 0.1498               | 0.1506               |

Notes: Coefficients with standard errors clustered at the individual level in parentheses. All models include individual and year fixed effects. M3 and M4 also include controls for marital status, living arrangement, self-rated health, chronic diseases, and ADL limitations. OSI is mean-centered. SCI = 0 (non-internet users) is the reference category. M4 adds OSI × SCI interaction terms. \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ .

Abbreviations: ADL: Activities of daily living; FE: Fixed effect; OSI: Offline social networking index; SCI: Social-communicative internet use.

for social communication—was associated with modest gains in life satisfaction. H2 was supported. The larger coefficient for SCI = 1 than SCI = 2 in M3 was somewhat counterintuitive; a likely explanation is that the well-being return to social-communicative use is more fully realized in conjunction with offline social resources, as M4 shows.

The M4 adds OSI × SCI interaction terms. The interaction for SCI = 1 was positive but non-significant ( $\beta = 0.012$ ,  $p = 0.372$ ); for SCI = 2, it was positive and significant ( $\beta = 0.011$ ,  $p = 0.012$ ). The well-being association of offline networking is thus amplified among those who use the internet for social communication, consistent with the complementarity hypothesis.

Put differently, the marginal effect of OSI on life satisfaction was more positive when individuals use the internet socially than when they do not, pointing to mutual reinforcement rather than substitution. Adding

the interaction terms rose within- $R^2$  modestly (0.1498 to 0.1506). H3a was supported; H3b was not.

### 3.3. Heterogeneity analysis

Table 3 presents estimates from the subgroup two-way fixed-effects model by age group, gender, and living arrangement. The OSI × SCI interaction varied substantially across subgroups. By age, the OSI × SCI = 2 interaction was significant among the young-old (60–69;  $\beta = 0.017$ ,  $p = 0.012$ ), marginally significant among the oldest-old (80+;  $\beta = 0.052$ ,  $p = 0.063$ ), but absent among those aged 70–79 ( $\beta = 0.009$ ,  $p = 0.338$ ). The 80+ estimate was imprecise given the small subsample. Complementarity was more pronounced among younger older adults.

For SCI main effects, a significant positive association with life satisfaction was found only among those aged 70–79 ( $\beta = 0.104$ ,  $p = 0.022$ ); no such effect emerged in the other age groups.

Table 3. Heterogeneity analysis: Subgroup two-way fixed effects model estimates

| Parameter                        | 60–69              | 70–79              | 80+               | Male               | Female            | Alone             | Co-residing         |
|----------------------------------|--------------------|--------------------|-------------------|--------------------|-------------------|-------------------|---------------------|
| OSI (offline)                    | –0.011*<br>(0.005) | –0.008†<br>(0.004) | 0.002<br>(0.007)  | –0.009*<br>(0.004) | –0.002<br>(0.004) | –0.005<br>(0.011) | –0.008**<br>(0.003) |
| SCI = 1 (Online, no social chat) | 0.129<br>(0.098)   | 0.139<br>(0.153)   | 0.083<br>(0.297)  | 0.182*<br>(0.089)  | 0.132<br>(0.114)  | 0.660<br>(0.404)  | 0.153*<br>(0.074)   |
| SCI = 2 (Online social chat)     | 0.026<br>(0.036)   | 0.104*<br>(0.045)  | 0.178<br>(0.133)  | 0.050<br>(0.035)   | 0.050<br>(0.036)  | –0.088<br>(0.147) | 0.046†<br>(0.026)   |
| OSI × [SCI = 1]                  | 0.013<br>(0.017)   | 0.061<br>(0.038)   | –0.018<br>(0.053) | –0.005<br>(0.015)  | 0.038<br>(0.025)  | 0.115<br>(0.081)  | 0.011<br>(0.014)    |
| OSI × [SCI = 2]                  | 0.017*<br>(0.007)  | 0.009<br>(0.009)   | 0.052†<br>(0.028) | 0.018**<br>(0.006) | 0.004<br>(0.007)  | –0.018<br>(0.029) | 0.014**<br>(0.005)  |
| <i>n</i>                         | 10,643             | 8,639              | 2,264             | 13,378             | 13,165            | 2,208             | 23,366              |
| Controls                         | Yes                | Yes                | Yes               | Yes                | Yes               | Yes               | Yes                 |
| Individual & year fixed effects  | Yes                | Yes                | Yes               | Yes                | Yes               | Yes               | Yes                 |
| R <sup>2</sup> (within)          | 0.1475             | 0.1665             | 0.2121            | 0.1555             | 0.1478            | 0.0993            | 0.1592              |

Notes: Coefficients with standard errors clustered at the individual level in parentheses. All subgroup models include the same controls as Table 2, M4. †  $p < 0.10$ , \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ .

Abbreviations: OSI: Offline social networking index; SCI: Social-communicative internet use.

The offline–online complementarity was gender-specific: the OSI × SCI = 2 interaction was positive and significant for males ( $\beta = 0.018$ ,  $p = 0.003$ ), but not for females ( $\beta = 0.004$ ,  $p = 0.518$ ). SCI = 2 main effects were positive for both genders, but did not reach statistical significance.

Third, by living arrangement, the interaction was positive and statistically significant among co-residing older adults ( $\beta = 0.014$ ,  $p = 0.004$ ), but not among those living alone ( $\beta = -0.018$ ,  $p = 0.525$ ). The main effect of SCI = 2 was marginally significant only among co-residing individuals ( $\beta = 0.046$ ,  $p = 0.078$ ). For older adults living alone, neither offline nor online social networking showed a statistically significant within-person association with life satisfaction, although this may partly reflect limited statistical power in the smaller subsample.

The complementarity between offline and online networking was more pronounced among younger older adults, men, and co-residing individuals, a pattern of heterogeneity consistent with H4.

### 3.4. Robustness checks

Table 4 reports four robustness checks. Across specifications, the complementarity finding held up reasonably well.

First, using a binary indicator of life satisfaction (R1) yielded results consistent with the main specification.

The coefficient on OSI remained negative and statistically significant, and the interaction between OSI and SCI = 2 remained positive and significant ( $\beta = 0.006$ ,  $p = 0.018$ ), indicating that the complementarity pattern is not driven by treating the dependent variable as continuous.

Second, using internet use frequency as an alternative online measure (R2) yielded similar results. Daily use was positively associated with life satisfaction ( $\beta = 0.067$ ,  $p = 0.012$ ); occasional use was not. The interaction between OSI and daily internet use remained positive and significant ( $\beta = 0.015$ ,  $p = 0.003$ ), consistent with the main complementarity finding.

Third, adding self-rated economic status to the 2020–2023 subsample (R3) attenuated the SCI main effect to non-significance, and the interaction also became small and insignificant. This result partly reflects the much smaller sample, and economic status may be capturing financial circumstances that confound the online networking–well-being relationship.

Finally, adding home internet access as a control (R4) left the main results unchanged: SCI = 2 ( $\beta = 0.076$ ,  $p = 0.006$ ) and the OSI × SCI = 2 interaction ( $\beta = 0.010$ ,  $p = 0.020$ ) remained positive and significant. Home internet access per se carried a negative coefficient ( $\beta = -0.050$ ,  $p = 0.027$ ), consistent with the idea that mere connectivity, absent social use, does not translate into well-being gains.

The main findings thus hold across most alternative specifications, though the economic status model (R3) warrants caution given the reduced sample.

**Table 4. Robustness checks**

| Parameter                                 | R1                  | R2                 | R3                | R4                 |
|-------------------------------------------|---------------------|--------------------|-------------------|--------------------|
| Offline (OSI)                             | −0.005**<br>(0.002) | −0.006*<br>(0.003) | 0.009*<br>(0.004) | −0.005†<br>(0.003) |
| SCI = 1 (Online, no social chat)          | 0.048<br>(0.041)    | -                  | 0.015<br>(0.107)  | 0.161*<br>(0.069)  |
| SCI = 2 (Online social chat)              | 0.017<br>(0.014)    | -                  | 0.050<br>(0.035)  | 0.076**<br>(0.027) |
| Internet use frequency = 1 (Occasionally) | -                   | 0.039<br>(0.034)   | -                 | -                  |
| Internet use frequency = 2 (Daily)        | -                   | 0.067*<br>(0.027)  | -                 | -                  |
| OSI × [SCI = 1] (or proxy)                | 0.014†<br>(0.008)   | 0.002<br>(0.007)   | −0.019<br>(0.020) | 0.011<br>(0.013)   |
| OSI × [SCI = 2] (or proxy)                | 0.006*<br>(0.003)   | 0.015**<br>(0.005) | −0.006<br>(0.006) | 0.010*<br>(0.004)  |
| Home internet access = 1 (yes)            | -                   | -                  | -                 | −0.050*<br>(0.023) |
| Controls                                  | Yes                 | Yes                | +SES              | Yes                |
| Individual & year fixed effects           | Yes                 | Yes                | Yes               | Yes                |
| <i>n</i>                                  | 26,543              | 26,543             | 13,896            | 26,543             |

Notes: Coefficients with standard errors clustered at the individual level in parentheses. R1 uses a binary outcome as the dependent variable with a linear probability model. R2 uses internet use frequency (three categories: 0 = never, 1 = occasionally, 2 = daily) as the alternative online measure. R3 adds SES (available 2020–2023 only). R4 includes household internet access as an additional control.

†  $p < 0.10$ , \*  $p < 0.05$ , \*\*  $p < 0.01$ .

Abbreviations: OSI: Offline social networking index; SCI: Social-communicative internet use; SES: Self-rated economic status.

## 4. Discussion

This study provides longitudinal evidence on how offline and online networking are jointly associated with life satisfaction among older adults in China. Three main findings emerge. First, SCI is positively associated with life satisfaction within individuals, whereas offline social networking does not exhibit a significant within-person association. Second, offline and online networking exhibit a complementary relationship: the association between offline social networking and life satisfaction is more positive among individuals who engage in SCI. Third, this complementarity varies across subgroups, being more evident among younger older adults, men, and those living with others.

The absence of a positive, within-person association for

offline social networking suggests that increases in network size or contact frequency do not necessarily translate into improvements in life satisfaction in later life. Consistent with SST (Charles, 2020; Gu, Wang, *et al.*, 2025), older adults proactively narrow their social networks to prioritize emotionally meaningful relationships, rendering changes in network breadth weakly linked to well-being. Moreover, life events such as health shocks or family transitions may simultaneously drive network contraction and declines in well-being, thereby obscuring any independent effect of offline networking. By contrast, online social networking may provide more accessible and flexible channels for maintaining emotionally salient ties. From a uses and gratifications perspective (Gu, Feng, Wang, *et al.*, 2025), older adults actively engage in SCI and select platforms that satisfy emotional and relational needs, which more directly translate into well-being gains.

More importantly, the findings support the social enhancement hypothesis (Gu, Wang, *et al.*, 2025): rather than substituting for offline ties, SCI reinforces them, with individuals deriving greater well-being benefits from offline networking when they are also engaged in online social communication. This pattern aligns with prior arguments that digital communication supplements rather than displaces offline social life (Chu *et al.*, 2023; Hampton & Wellman, 2003; Wellman *et al.*, 2001). In the Chinese context, multifunctional platforms such as WeChat may further strengthen this complementarity by facilitating both the maintenance of existing ties and the coordination of offline interactions.

The heterogeneity analysis further suggests that this complementary relationship is not uniform across the older population. It is more pronounced among younger cohorts of older adults, consistent with activity theory (Gu, Wang, *et al.*, 2025), which predicts that individuals who maintain higher levels of social engagement are better positioned to leverage digital tools as part of an integrated social repertoire. Gender differences indicate that older men may benefit more from the integration of online and offline networking, possibly because men's social convoys tend to be more spouse- and family-centered and less diverse (Cohn-Schwartz & Schmitz, 2024; Cornwell & Schafer, 2016; Fuller & Ajrouch, 2020), making online channels particularly effective for maintaining their core emotional ties. In addition, the complementarity is evident primarily among co-residing older adults, which aligns with the Social Enhancement hypothesis (Gu, Wang, *et al.*, 2025): those with richer existing offline social resources may derive greater additional benefits from online engagement, rather than using it as compensation for social deficits.

At the same time, the robustness analysis indicates some sensitivity of the results to the inclusion of economic status, highlighting the potential role of socioeconomic resources in shaping access to and effective use of digital platforms (CNNIC, 2024; Gu, Feng, Wang, *et al.*, 2025). This suggests that the benefits of integrating online and offline social networking may be unevenly distributed, pointing to a stratified pattern of digital aging in which those with greater economic resources are better positioned to reap the well-being gains of digital engagement.

Taken together, these findings contribute to the literature by highlighting that the relationship between internet use and well-being in later life cannot be understood in isolation from offline social contexts. Instead, digital engagement operates as part of a broader social system, in which online and offline interactions are interdependent and jointly shape well-being outcomes.

The findings also carry policy implications. Promoting digital inclusion among older adults may enhance not only access to information but also subjective well-being. However, the results indicate that digital engagement is most beneficial when it complements rather than substitutes for offline social relationships. Policies that integrate digital literacy initiatives with investments in community-based social infrastructure may therefore be more effective than those focusing on access alone. At the same time, targeted support remains important for vulnerable groups—particularly the oldest-old and those living alone—for whom such complementarity appears weaker.

Several limitations warrant consideration. First, the measure of online social networking is relatively coarse and does not capture variation in platforms, intensity, or quality of use (Gu, Feng, Yang, *et al.*, 2025). Second, although the fixed-effects approach accounts for time-invariant heterogeneity, time-varying confounding cannot be fully ruled out (Angrist & Pischke, 2009; Piper, 2023). Third, limited information on economic status constrains certain specifications (CNNIC, 2024; Gu, Feng, Wang, *et al.*, 2025). Finally, as the analysis is grounded in the Chinese context, the findings may not generalize to other institutional and cultural settings (Iwasa *et al.*, 2025; Saha, 2024). Future research could incorporate more granular measures of digital behavior, examine underlying mechanisms in greater depth, and extend the analysis to comparative contexts.

## 5. Conclusion

This study examined four hypotheses concerning the associations between social networking and life satisfaction

among older adults in China. H1, which posited a positive association between offline social networking and life satisfaction, was not supported, as no significant within-person effect was identified after controlling for time-varying covariates. In contrast, H2 was supported: SCI was positively associated with life satisfaction at the within-individual level. With respect to their joint effects, the results supported H3a (complementarity) but not H3b (substitution), as evidenced by a positive interaction indicating that offline and online networking mutually reinforce one another. Finally, H4 was supported, with subgroup analyses showing that the complementary pattern was more pronounced among the younger-old, men, and individuals living with others.

These findings make three contributions to the literature. First, by leveraging panel data and within-individual estimation, the study moves beyond cross-sectional evidence and provides stronger support for the relationship between digital engagement and well-being in later life. Second, it advances the debate on complementarity versus substitution by showing that, in the Chinese context, SCI tends to reinforce rather than replace offline social ties. Third, it demonstrates that the integration of online and offline social networking is socially stratified, varying systematically across demographic and living arrangement contexts.

Notwithstanding limitations in the measurement of online social networking, potential time-varying confounding, and the China-specific context, the findings provide a theoretically grounded and empirically robust account of how offline and online social networking jointly shape well-being in later life. Future research could build on this framework by incorporating more granular measures of digital behavior, examining underlying mechanisms in greater depth, and extending the analysis to cross-national comparative settings.

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## Conflict of interest

The author declares no conflict of interest.

## Author contributions

This is a single-authored article.

## Ethics approval and consent to participate

Ethics approval is not required, as this study is based on a publicly available dataset (China Longitudinal Aging Social Survey, CLASS). The author obtained permission to use the data in accordance with the data provider's requirements. All data used in this study are anonymized, and no identifiable personal information is involved.

## Consent for publication

Not applicable.

## Availability of data

The data that support the findings of this study are from the China Longitudinal Aging Social Survey (CLASS), conducted by Renmin University of China. The dataset is available from the data provider upon application and approval. Restrictions apply to the availability of these data, which were used under license for the current study.

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