



Research article

Effect of online and offline social network group clusters on life satisfaction across age groups

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ABSTRACT

Background: Positive social relationships are critical for better subjective well-being across ages. Future research will benefit from examining how to improve life satisfaction by utilizing social groups in new, ever-changing social and technological contexts. This study aimed to evaluate the effect of online and offline social network group clusters on life satisfaction across different age groups.

Methods: Data were derived from the Chinese Social Survey (CSS) (2019), which is a nationally representative survey. We adopted a K-mode cluster analysis algorithm to categorize participants into four clusters according to their online and offline social network groups. ANOVA and chi-square analysis were used to understand the associations among age groups, social network group clusters, and life satisfaction. Multiple linear regression was applied to identify the association between social network group clusters and life satisfaction across age groups.

Results: Younger and older adults had higher life satisfaction than middle-aged adults. Individuals who joined diverse social network groups had the highest life satisfaction, followed by those who joined personal and working social groups, while those who joined restricted social groups had the lowest life satisfaction ($F = 81.19$, $p < 0.001$). According to the results of multiple linear regression, individuals who belonged to diverse social groups had higher life satisfaction than those who belonged to restricted social groups among adults aged 18–59 years, except students ($p < 0.05$). Individuals who joined personal and working social groups had higher life satisfaction than those who joined restricted social groups among adults aged 18–29 and 45–59 years ($\beta = 2.15$, $p < 0.01$; $\beta = 1.45$, $p < 0.01$).

Conclusions: Interventions to promote participation in diverse social network groups among adults aged 18–59 years, except for students, are highly recommended to improve life satisfaction. Health practitioners could provide interventions to encourage young and middle-aged adults to join both personal and working social groups.

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1. Introduction

Life satisfaction is a central component of subjective well-being. It can measure how individuals evaluate their life as a whole rather than simply evaluating their current feelings. Improvement in life satisfaction has received increasing attention from psychologists, sociologists, and policy-makers. Social relationships are the most consistent predictors of life satisfaction across the lifespan [5,69]. Previous studies have discussed the effect of social networks on health, including depressive symptoms, subjective well-being, and self-rated health [22,74,75,118]. Social networks develop within social groups. A social group consists of two or more individuals who interact based on mutual expectations and share a common identity. Social groups can create a sense of belonging, and these groups can also influence and shape behavior and personality. Some scholars support the idea that membership in social network groups (such as family, friend, religious, and interest groups) can satisfy a core human need [106]. Perceived emotional support can provide resiliency against life problems and negative life events, and promote positive feelings [26]. It is easier to develop interventions by focusing on joining social groups than by maintaining and developing social networks. Future research would benefit from examining how to improve life satisfaction through social groups in new, ever-changing social and technological contexts.

Several sociodemographic characteristics (such as age, income, education level, marital status, and age group) have a significant impact on life satisfaction [50]; H. J [76]. Extensive research has focused on age differences in life satisfaction, and discussed the influencing factors of life satisfaction in adults across different age groups [56,57,60]. Adolescents are at the beginning of their maturation process, while adults have experienced several milestones and turning points. Older adults reap benefits in the process of growth and development. Previous studies have provided complicated (and sometimes contradictory) evidence about the changing patterns of life satisfaction across the lifespan [7,32,42]. Life satisfaction differs across age groups, and individual differences in the subjective well-being of young, middle-aged, and older adults are mainly accounted for by social relationships [95]. While some scholars have discussed the relationships between social network group clusters and life satisfaction among seniors or students in China, few studies have sought to understand this link among different age groups.

2. Relevant literature and theoretical foundations

2.1. Social capital theory

Social capital is described as the value of social norms, networks, and trust in individuals and society [27,92,93]. Social capital is considered a necessary and sufficient condition for sustainable community development and enables societies to function by creating networks of individuals who live in a particular community [31,110]. According to social capital theory, social capital resources are embedded in the social network of groups and can be obtained through the social network. The concept of social capital is a central feature of civil society. Many previous studies have discussed the relationships between social capital and life satisfaction, and social capital can be considered a crucial factor in overall well-being in Chinese society [25,28,49,90]. Social capital is a multidimensional concept and takes many different but interrelated forms. Social capital can be further divided into cognitive social capital and structural social capital. Social group participation is often used to measure structural social capital [84]. Normative social capital includes norms, trust, reciprocity, civic engagement, and group values. Trust, social harmony, and perceived fairness are treated as key indicators of cognitive social capital and are generated from groups based on social networks and associations [1,33]. The study of social capital involves network-based processes that generate beneficial outcomes through norms and trust [73]. Social networks, trust, social justice, and social tolerance are frequently discussed in the literature on social capital [79,88].

2.2. Social network

Social networks are considered to be structural social capital that relates to systems of social relations between individuals. According to social network theory, social networks deal with social groups like a net full of nodes and links, and “focus on the characteristic patterns of ties between actors in a social system rather than on characteristics of the individual actors themselves and use these descriptions to study how these social structures constrain network member’s behavior” [45]. Social groups are the foundation of social networks. When an individual belongs to many different types of groups (e.g., a religious group, an ethnic group, a workplace colleague group, a sports team), social groups emerge. Subsequently, individuals have the opportunity to interact with other members of social groups with social ties or communication links [113] and form a social network (both online and offline). The more social groups a person participates in, the more communication links or ties within each communication network they will have and the more social networks they will follow. Social networks have been widely studied regarding their association with health outcomes [10,14,39,97,117]. Previous studies have highlighted that social networks are related to life satisfaction [23,41,91]. Therefore, focusing on social groups may be the simplest or most fundamental intervention for social networks to improve life satisfaction.

2.3. Social network groups and life satisfaction

According to the social cure hypothesis, social group memberships can drive the development and consolidation of social support and social relationships, thereby improving social cures [48]. Many scholars have highlighted that belonging to a social group improves health benefits, and well-being [53]. However, there is mixed evidence about the relationship between belonging to multiple social groups and well-being. The number of group memberships is important for psychological and physical well-being [51,52,64,98], and being an active member of two or more social groups is associated with higher life satisfaction [99,104]. Belonging to a larger

number of social groups is more beneficial for psychological well-being than belonging to fewer social groups, and the diversity of social networks is negatively associated with depression [29,52,65,100]. However, some scholars hold that individuals may obtain diverse well-being benefits through social networks due to different cultural contexts [18]. In addition to the number of communication links, the closeness of nodes can influence social networks. Personal social networks (including family members, friends, and other close confidants) are more likely to influence health behavior than other social networks such as work-related social networks (A [61,67,68]. The associations between social network groups and life satisfaction need to be further clarified.

With the development of social and internet technological contexts, online social network groups provide various avenues for social contact, and social media groups (e.g. WeChat groups) are critical for engaging and building relationships (H. U [62,72]. Online social interaction is very important for improving individuals' perceived social support and enhancing their psychological well-being and life satisfaction [85]. Online and offline social capital significantly increase an individual's life satisfaction [58]; Kong et al., 2019), and the frequency of online social interactions affects an individual's level of social support [30]. The internet penetration rate in China has reached 73.0% [105]. The effect of online and offline social network group memberships and frequent online social interaction on life satisfaction in China needs to be more closely considered.

2.4. Characteristics of social network groups among different age groups

According to two major theories socioemotional selectivity theory [16] and social convoy theory [59], social networks differ across age groups. Overall, social networks increase during adolescence and young adulthood, plateau in the mid-20s and early 30s, and continue to decline throughout adulthood and old age, except for family social networks, which tend to be stable [116]. In particular, older adults have smaller online social networks but a higher percentage of actual friends than younger adults, reflecting lower rates of social isolation and loneliness [19]. The present study aimed to explore the associations between the characteristics of social network group participation and life satisfaction across different age groups.

2.5. Trust, tolerance, and justice

High levels of cognitive social capital are associated with better social trust, reciprocity, and perceived fairness [33,78]. Trust is cognitive social capital that is related to shared norms, values, attitudes, and beliefs that contribute to cooperation [109]. Trust plays an important role in personal relationships, and is central to the concept of social capital. Interpersonal trust is a strong, deep, or close association or acquaintance between two or more individuals and often refers to a dyadic relationship involving reciprocity between friends and family [114]. A high level of trust in one's living environment is beneficial to the development of stable social relationship structures [2]. A person with high levels of interpersonal trust has more instrumental and affective returns, is able to meet life demands and even achieve life goals, and has increased life satisfaction [112]. Social tolerance is the extent of the recognition and acceptance of differences, willingness to grant equal rights, and abstention from openly intolerant attitudes [89]. Social tolerance affects the evolution of cooperation and the resulting cooperative networks [21]. Tolerance and openness affect not only individuals but also institutions and the community as a whole. Improved economic conditions and trust and less intolerance may affect civil society, which in turn may increase espoused social tolerance [89]. Social tolerance is an important component of social capital, and reductions in prejudice produce more positive relationships among diverse groups [55]. Social justice is related to a subject's right to be treated with positive regard or affectionate care. Social justice thrives when members see themselves as participants who exercise their name, place, and value. Social capital relates to the process by which social justice can be demonstrated. A culture of trust, tolerance and justice with extensive social networks is vital for flourishing societies in European countries [28,35]. It is necessary to further discuss the generalizability of this concept to the Chinese context, which is characterized by high collectivism.

2.6. Current study

Most individuals interact with family members, coworkers, and friends and have several group memberships. These social group memberships can be categorized into different types. Cluster analysis can be used to identify various units, such as individuals, groups, or societies, based on common characteristics. These clusters include diverse, family-focused, friend-focused, and restricted types. Social networks can also be clustered into several types according to the characteristics of online and offline social group memberships. Research on different social group types has more theoretical and practical significance than considering each social group individually. Few studies have focused on the effect of membership in different types of social network groups on life satisfaction. Thus, in this study, cluster analysis was used to determine specific features of latent groups of individuals who belong to online and offline social network groups. Many individuals join both online and offline social groups, so we did not cluster online and offline social groups separately.

How does membership in social groups differ among participants in different age groups? What is the relationship between social network group clusters and life satisfaction among adults in different age groups? According to social capital theory, it is necessary to consider the impact of social justice, trust, and tolerance when discussing the issue of social networks. Some research has shown that social justice, trust, and tolerance are associated with life satisfaction [70,120]. In this study, we aimed to understand the effect of social network group clusters on life satisfaction across age groups using a nationally representative survey. Based on the literature and theories, our hypotheses were as follows.

Hypothesis 1. Younger and older adults have higher life satisfaction than middle-aged adults.

Hypothesis 2. The characteristics of social participation differ across age groups.

Hypothesis 3. Individuals who join diverse social groups have higher life satisfaction than those who join restricted social groups.

Hypothesis 4. Social justice, trust, and tolerance are positively associated with life satisfaction.

3. Materials and methods

3.1. Data sources and participants

The Chinese Social Survey (CSS) is a nationwide large-scale continuous sample survey project that was initiated by the Institute of Sociology, Chinese Academy of Social Sciences in 2005. The CSS focuses on understanding public employment, family and social life, social attitudes, etc., in China. This survey is conducted approximately every 2 years by a probability sampling household interview method. The CSS was conducted in eight periods in 2006, 2008, 2011, 2013, 2015, 2017, 2019, and 2021. More detailed information can be found in the additional information. The data in this study were derived from the 2019 CSS, which was the latest release. This survey area covered 31 provinces/autonomous regions/municipalities across the country, including 151 districts, cities, and counties, and 596 villages/neighborhood committees. Map address sampling was used in this study to cover more internal migrants. Approximately 11,000 urban and rural households were visited. This study recruited Chinese citizens aged 18–69 years who lived in the urban and rural areas of 31 provinces/autonomous regions in China. A total of 10,283 questionnaires were collected, and one was deleted due to missing data. Therefore, the sample size in this study was 10,282. We classified the participants into five age groups: students (aged 18–29 years), citizens aged 18–29 years (except students), citizens aged 30–44 years, citizens aged 45–59 years, and citizens aged 60–69 years. Students have unique characteristics and contexts that may be different from those of young adults [6]. For example, students aged 18–29 years may participate in parties and weekend socializing, whereas the majority of nonstudent young adults may relax and interact with others after work. Many previous studies have explored health and development issues in young adult students

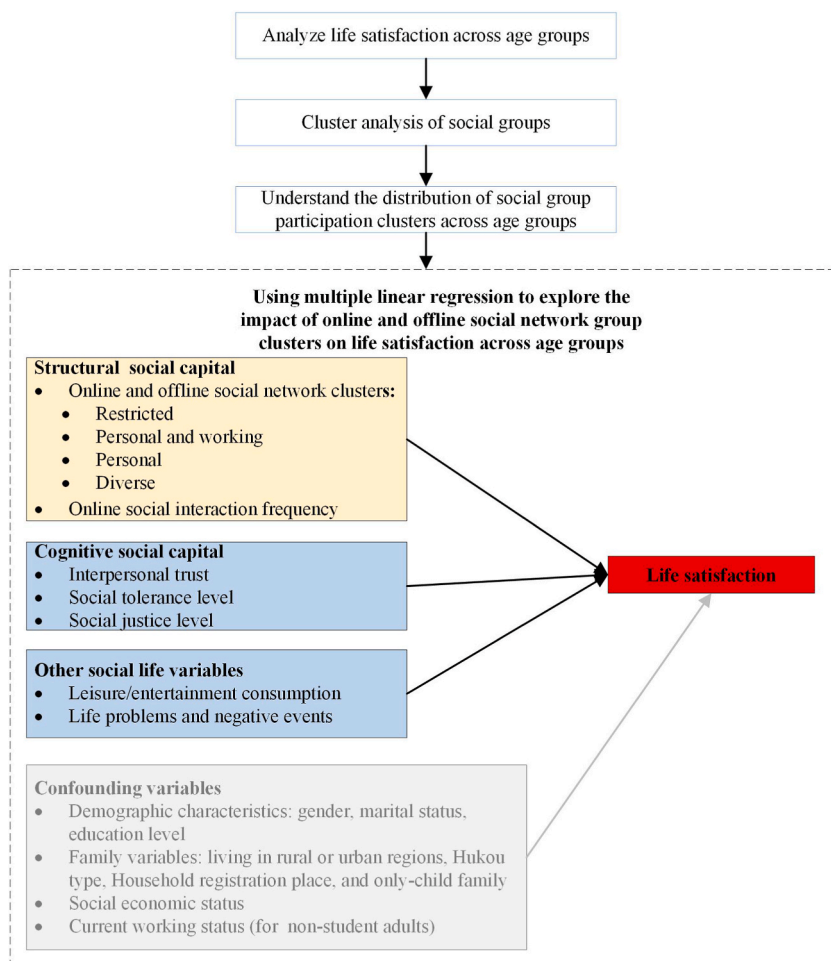


Fig. 1. Research framework.

and nonstudents and analyzed the difference in physical and mental health between these two groups (McManus & Gunnell, 2020; Mitchell & Syed, 2015). Some scholars have indicated that the relationship between trait emotional intelligence and life satisfaction differs between students and nonstudents (Kong & Zhao, 2013). Thus, this study distinguished student groups from other young adults aged 18–29 years. The sample sizes of these five age groups were 518, 1090, 2606, 3787, and 2281, respectively.

3.2. Variables and instruments

In this analysis, the outcome of interest was individual life satisfaction. The research framework for this study (Fig. 1) incorporated several variables, including structural social capital (online and offline social group clusters and online social interaction frequency), cognitive social capital (social tolerance level, social justice level, interpersonal trust), other social life variables (leisure/entertainment consumption and negative life events), and confounding variables.

3.2.1. Life satisfaction

Life satisfaction can reliably reflect subjective well-being [34]. Life satisfaction was obtained in this study by respondents' subjective evaluations of family relationships, family economic status, education level, leisure/entertainment/cultural activities, social interactions, and general satisfaction with life. The response options for each item of the six-item scale ranged from "very dissatisfied" = 1 to "very satisfied" = 10. Cronbach's alpha value for the present study was 0.80. All six-item responses were summed to generate a single continuous item (6–60), and higher means were associated with higher levels of life satisfaction.

3.2.2. Online and offline social network groups

Online and offline social network groups were measured by two questions "Which of the following online social groups have you joined in the past 2 years?" and "Which of the following offline social groups have you joined in the past 2 years?" The online social network groups included relatives, friends, classmates/alumni, neighbors, fellow villagers, colleagues, professional organizations/unions, interests and hobbies, nonprofits, religion, human rights protection, and other online social groups. The offline social network groups include alumni associations, fellow villagers, professional organizations, interest and hobbies, nonprofits, religious groups, and other offline social groups. Response options were recoded as 0 or 1 for no or yes, respectively.

3.2.3. The frequency of online social interactions

The frequency of online social interactions was measured by the frequency of online chatting and making friends (i.e., WeChat chatting and other dating activities) [30]. We reversed the response options as an ordered scale from 1 to 6, namely, from 1 = never to 6 = every day. Higher scores indicated a higher frequency of social interaction.

3.2.4. Interpersonal trust, tolerance, and justice

In the theoretical section, we argued that there are four independent components of social capital: social networks, trust, justice, and tolerance. To understand the relationship between social network groups and life satisfaction, this study also considered three other aspects of social capital. Interpersonal trust is accepted as an indicator of cognitive social capital, and trust is the foundation of most personal relationships. The measurement of interpersonal trust by a single-item is common in social network studies [15,40,46]. The question for trust, "Generally speaking, would you say that most people can be trusted?", has been frequently used in the measurement of trust [82]. The interpersonal trust level in this study was also measured by the item, "Please use 1–10 points to express your evaluation of the current interpersonal trust level" (a 10-point scale from 1 = very distrusted to 10 = very trusted).

Social justice refers to a fair and equitable division of wealth, commodities, resources, opportunities, and privileges in society [8]. Social capital relates to the process by which social justice can be demonstrated [37]. This study assessed the level of social justice by the item, "Please use 1–10 points to express your evaluation of the overall fairness and justice of the current society" (a 10-point Likert scale from "1 = very unfair" to "10 = very fair"). The measurement of the perception of social justice was similar to that in a previous study [Z 77].

Social tolerance refers to an individual's "recognition and acceptance of differences" and is viewed as a synergistic effect of the features of both the individual and the socioeconomic environment [36,119]. Social tolerance may reduce the conflict and tension caused by the distribution of limited social resources [63]. The attitude of social tolerance is driven by underlying psychological predispositions and ideological beliefs. For the measurement of individuals' perception of social tolerance level, participants responded to the item, "Please use 1–10 points to express your evaluation of the tolerance level of the current society" on a 10-point Likert scale ("1 = very intolerant" to "10 = very tolerant"). The measurement of the perception of social tolerance was supported by a previous study [36].

3.2.5. Leisure/entertainment consumption and negative life events

Based on the results of previous studies [9]; P. J. [20], we also considered several influencing factors of life satisfaction, including the percentage of leisure and entertainment consumption of the total family expenditure and the number of life problems and negative events. The variables of leisure and entertainment consumption were measured by the ratio of the whole family's expenditure on culture, entertainment, and tourism to the total living consumption in the last year. Negative events may have an impact on social capital and life satisfaction [90,107]. Negative life events were measured by the adapted version of the Negative Life Events Questionnaire [66]. Life problems and negative events were reflected in the question, "In the past 12 months, which of the following life problems or negative events have you or your family experienced?", including poor housing conditions, high and unbearable child

education costs, poor family relationships, large and unbearable medical expenses, rising prices affecting the quality of life, low family income and economic difficulty, unemployment or job instability, heavy burdens of caring for elderly individuals, high and unaffordable human interest expenditure, encountering criminal incidents (being cheated, robbed, etc.), serious environmental pollution of residential areas and other aspects of life pressure and difficulties. Response options were scored as 0 or 1 if absent or present, respectively. We calculated response scores as a single continuous item (0–12) to represent the number of life problems and negative events.

3.2.6. Confounding variables

A large body of existing work confirms that individual and socioeconomic characteristics, such as sex, income level, marital status, education level, urbanization, migration, and employment status, are important for explaining an individual’s life satisfaction levels [38,101]. This study controlled for several individual and socioeconomic characteristics to understand the relationships between social network group clusters and life satisfaction. The confounding factors included sex (male, female), marital status (married, unmarried), educational level (uneducated, elementary school, primarily middle school, high middle school, college/undergraduate, and postgraduate), living in rural or urban regions, hukou type (0 = agricultural residence, 1 = nonagricultural residence, also including resident accounts and other), local residence status, living in an only-child family, and current socioeconomic status (1 = lower level, 2 = lower-middle level, 3 = medium level, 4 = upper-middle level, and 5 = upper level). For nonstudent adults, this study also controlled for current working status (yes or no).

3.3. Statistical analysis

We used frequency distributions, percentages, means and standard deviations to understand the demographic and

Table 1
Distribution of demographic and sociopsychological characteristics.

Variables	Total (n = 10,282)		Students (18–29 years) (n = 518)		18–29 years (except students) (n = 1090)		30–44 years (n = 2606)		45–59 years (n = 3787)		60–69 years (n = 2281)	
	n	%	n	%	n	%	n	%	N	%	n	%
Gender												
Male	4413	42.92	260	50.19	465	42.66	988	37.91	1616	42.67	1084	47.52
Female	5869	57.08	258	49.81	625	57.34	1618	62.09	2171	57.33	1197	52.48
Married	8260	80.33	2	0.39	537	49.27	2366	90.79	3430	90.57	1925	84.39
Education level												
Uneducated	972	9.45	0	0.00	7	0.64	85	3.26	381	10.06	499	21.88
Elementary school	2292	22.29	0	0.00	47	4.31	410	15.73	1094	28.89	741	32.49
Primary middle school	3219	31.31	2	0.39	310	28.44	924	35.46	1371	36.20	612	26.83
High middle school	1907	18.55	162	31.27	241	22.11	502	19.26	653	17.24	349	15.30
College/Undergraduate	1794	17.45	338	65.25	465	42.66	645	24.75	275	7.26	71	3.11
Postgraduate	79	0.77	15	2.90	19	1.74	36	1.38	9	0.24	0	0.00
Missing	19	0.18	1	0.19	1	0.09	4	0.15	4	0.11	9	0.39
Residence												
Rural	4481	43.58	169	32.63	370	33.94	917	35.19	1865	49.25	1160	50.85
Urban	5801	56.42	349	67.37	720	66.06	1689	64.81	1922	50.75	1121	49.15
Hukou type												
Nonagricultural	3251	31.62	209	40.35	308	28.26	875	33.58	1130	29.84	729	31.96
Agricultural	7031	68.38	309	59.65	782	71.74	1731	66.42	2657	70.16	1552	68.04
Local residence	9011	87.64	455	87.84	807	74.04	2147	82.39	3460	91.37	2142	93.91
Only-child family	2707	26.33	333	64.29	559	51.28	939	36.03	565	14.92	311	13.63
Socioeconomic status												
Lower level	2310	22.47	100	19.31	224	20.55	525	20.15	955	25.22	506	22.18
Lower-middle level	2879	28.00	128	24.71	352	32.29	819	31.43	1008	26.62	572	25.08
Medium level	4210	40.95	224	43.24	419	38.44	1079	41.40	1529	40.37	959	42.04
Upper-middle level	648	6.30	35	6.76	71	6.51	150	5.76	215	5.68	177	7.76
Upper level	87	0.85	4	0.77	5	0.46	8	0.31	38	1.00	32	1.40
Missing	148	1.44	27	5.21	19	1.74	25	0.96	42	1.11	35	1.53
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Online social interaction frequency [1–6]	3.58	2.25	5.51	0.97	5.38	1.20	4.56	1.89	3.13	2.21	1.91	1.79
Leisure/entertainment consumption ^a (%)	1.89	5.40	3.06	5.56	3.55	7.30	2.06	4.40	1.34	4.93	1.59	5.91
Life problems and negative events ^b [0–11]	3.01	2.51	1.92	1.96	2.30	2.21	2.94	2.42	3.36	2.60	3.08	2.55
Social tolerance level [1–10]	6.81	2.01	6.79	1.52	6.49	1.77	6.68	1.87	6.84	2.09	7.07	2.21
Social justice level [1–10]	6.69	2.09	6.85	1.44	6.47	1.72	6.56	1.93	6.63	2.19	7.01	2.32
Interpersonal trust [1–10]	6.33	2.12	6.69	1.60	6.14	1.93	6.26	2.00	6.28	2.21	6.48	2.28

Note: The minimum score and maximum score of each sociopsychological variable are presented in brackets.

^a The percentages of leisure and entertainment consumption of total family expenditure.

^b The number of life problems and negative events in the past 12 months.

sociopsychological characteristics of the participants.

The K-means clustering algorithm is an iterative algorithm that partitions a dataset into K predefined nonoverlapping distinct clusters or subgroups according to its features. K-means uses the mean value in each cluster as the center point, while K-modes use the mode in each cluster as the center point. The K-mode method is a clustering method for clustering categorical data. We adopted a K-mode cluster analysis algorithm to categorize participants according to their online and offline social network group participation. This study used the elbow method to determine the number of categories, and the silhouette method was the fit indicator to evaluate the clustering effect. The elbow method calculates the sum of squared distances from each point to its assigned center by the Hamming distance. Where the function created “an elbow”, we chose the value for the cluster number. The silhouette score is calculated by the Hamming distance from points in one cluster to the other clusters. The silhouette score falls within the range $[-1, 1]$. A silhouette score of 1 means that the cluster is dense and well separated. A score near 0 indicates overlapping clusters. A score less than 0 means that data belonging to clusters may be incorrect. The silhouette score was also used to evaluate the performance of the K-mode clustering algorithm. The clustering process was implemented using the K-modes in Python 3.

We then divided the online and offline social network groups into three groups (personal, working, and other social network groups). Personal social network groups included relatives, friends, classmates, alumni, neighbors, and fellow villager groups. Working social network groups included colleague, and professional organization/union groups. Other social network groups represented other types of online and offline social groups except for personal and working groups, including interests, hobbies, commonweal, religious groups, and human rights protection groups. To evaluate the differences in participant features among social network group clusters, we used chi-square statistical analysis. In addition, ANOVA, Scheffe’s post hoc tests, and chi-square analysis were used to understand the associations among age groups, online and offline social network group clusters, and life satisfaction. Multiple linear regression was applied to identify the effects of online and offline social network group clusters and other influencing factors on life satisfaction among the age groups, after controlling for confounding variables. We used SAS 9.4 to perform reliability tests, descriptive analysis, correlations, and regression analysis.

4. Results

Table 1 shows the results for demographic and sociopsychological characteristics. Most of the respondents were female (57.08%), and 80.33% were married. Approximately 68.07% of the participants had completed secondary education (primarily middle school or above). Of these participants, 56.42% lived in urban areas, 68.38% owned agricultural hukou, and 87.64% were local residents. Only 26.33% of families were only-child families, and 40.95% could be considered to have a medium-level socioeconomic status. The participants spent an average of 1.89% of the total family expenditure on leisure and entertainment consumption. The average number of life problems and negative events reported in the past 12 months was 3.01. The average levels of online social interaction frequency, social tolerance, social fairness, and interpersonal trust were 3.58 (SD = 2.25), 6.81 (SD = 2.01), 6.69 (SD = 2.09), and 6.33 (SD = 2.12), respectively. Among students aged 18–29 years, only 0.39% were married, 99.42% had completed high middle school and above, and 64.29% were from only-child family. Adults aged 18–44 years tended to have a higher frequency of online social interactions, higher percentages of leisure and entertainment consumption, and fewer life problems and negative events in the past 12 months. Less than 15% of middle-old and older people aged 45–69 years were from an only child families (14.92% of those aged 45–59

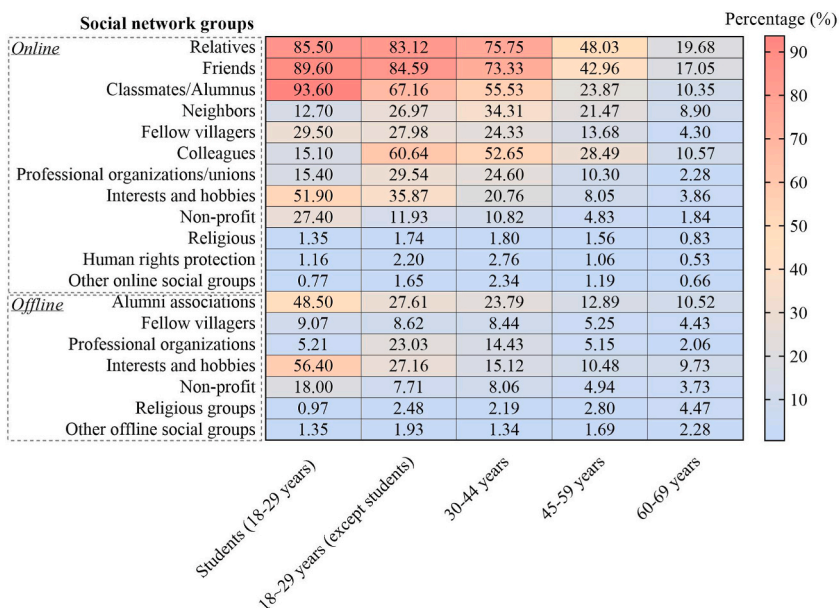


Fig. 2. Online and offline social network groups across age groups.

years and 13.63% of those aged 60–69 years), and they had a low frequency of online social interactions (mean = 3.13, SD = 2.21; mean = 1.91, SD = 1.79), low percentages of leisure and entertainment consumption (mean = 1.34, SD = 4.93; mean = 1.59, SD = 5.91), and high average numbers of life problems and negative events (mean = 3.36, SD = 2.60; mean = 3.08, SD = 2.55).

Life satisfaction among students aged 18–29 years was higher than that among other groups, and early young adults aged 18–29 years and older adults aged 60–69 years had higher life satisfaction than those aged 30–59 years ($F = 35.58, p < 0.01$). **Hypothesis 1** was thus supported.

As shown in **Fig. 2**, almost all relative, friend, and classmate/alumni online social network groups were popular in each age group, while the percentages for religious and human rights protection groups were relatively low. Approximately 51.90% of students aged 18–29 years joined interest and hobby groups, and 27.40% joined nonprofit social groups. Most individuals who lived off campus were aged 18–44 years and joined colleague social groups (60.64% of adults aged 18–29 years, and 52.65% of those aged 30–44 years). For offline social groups, alumni associations and hobby social groups were the more popular social groups, while the percentages for fellow villager and religious social group joiners were relatively low in each age group. Approximately 23.03% of 18- to 29-year-olds, except students, joined professional organization groups; this percentage was 14.43% for those aged 30- to 44 years old. The percentages of each social group among older adults aged 60–69 years were relatively low, with the highest percentage of 19.68% for relative social groups.

This study used the K-mode method for cluster analysis and showed that the four cluster solution was the better model (silhouette coefficient = 0.42). When the number of clusters was 4, the elbow method was the end point of the segment with the decline, and the silhouette coefficient was better (**Fig. S1** in the additional information). The distribution of each type of online and offline social group in the 4 clusters was significantly different ($p < 0.001$). **Table 2** shows the distribution and characteristics of the four social network group types. In Cluster 1, the percentages of individuals who joined each social group were less than 10%. In Cluster 2, the percentages of individuals who joined relatives, friends, classmates or alumni, neighbors, colleagues, and professional online social groups were 42.26%, 96.30%, 67.85%, 35.45%, 100.00%, and 25.23%, respectively. The percentages of individuals who joined offline alumni association and professional organization groups were 23.93%, and 16.97%, respectively. In Cluster 3, the top three most popular online social network groups were friends (2,022, 93.14%), classmates/alumni (1,316, 60.62%), and relative groups (2,066, 36.95%), while no participants joined online colleague social groups. The top three most popular offline social network groups were alumni associations (522, 24.04%), interest and hobby groups (440, 20.27%), and nonprofit groups (157, 7.23%). In Cluster 4, most of the online and offline social network groups had high percentages of individuals who joined.

Table 2
The distribution and characteristics of the four social network group types.

Variables	Cluster 1		Cluster 2		Cluster 3		Cluster 4		χ^2	p
	Restricted		Personal and working		Personal		Diverse			
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)				
Online social network										
Relatives	481	(8.60)	2363	(42.26)	2066	(36.95)	681	(12.18)	7701.09	***
Friends	237	(4.78)	2366	(96.30)	2022	(93.14)	688	(98.71)	8436.11	***
Classmates/alumni	172	(3.47)	1667	(67.85)	1316	(60.62)	649	(93.11)	4854.97	***
Neighbors	180	(3.63)	871	(35.45)	712	(32.80)	507	(72.74)	2420.74	***
Fellow villagers	139	(2.80)	558	(22.71)	531	(24.46)	480	(68.87)	2218.67	***
Colleagues	358	(7.22)	2457	(100.00)	0	(0.00)	616	(88.38)	8466.18	***
Professional organizations/unions	123	(2.48)	620	(25.23)	226	(10.41)	516	(74.03)	2836.97	***
Interests and hobbies	104	(2.10)	470	(19.13)	458	(21.10)	562	(80.63)	3013.43	***
Nonprofit	42	(0.85)	204	(8.30)	171	(7.88)	362	(51.94)	2281.44	***
Religious	24	(0.48)	49	(1.99)	52	(2.40)	26	(3.73)	75.41	***
Human rights protection	11	(0.22)	55	(2.24)	19	(0.88)	69	(9.90)	403.03	***
Other online social groups	33	(0.67)	44	(1.79)	50	(2.30)	16	(2.30)	39.20	***
Offline social network										
Alumni associations	308	(6.21)	588	(23.93)	522	(24.04)	482	(69.15)	1776.31	***
Fellow villagers	188	(3.79)	156	(6.35)	135	(6.22)	182	(26.11)	506.36	***
Professional organizations	137	(2.76)	417	(16.97)	82	(3.78)	260	(37.30)	1213.89	***
Interests and hobbies	318	(6.42)	388	(15.79)	440	(20.27)	455	(65.28)	1662.66	***
Nonprofit	142	(2.86)	158	(6.43)	157	(7.23)	202	(28.98)	698.30	***
Religious groups	162	(3.27)	52	(2.12)	59	(2.72)	24	(3.44)	8.76	***
Other offline social groups	91	(1.84)	46	(1.87)	26	(1.20)	16	(2.30)	5.51	***
Social network group type										
Personal-related ^a	1276	(25.74)	2457	(100.00)	2171	(100.00)	697	(100.00)	6159.34	***
Occupational-related ^b	502	(10.13)	2457	(100.00)	269	(12.39)	656	(94.12)	7195.82	***
Others ^c	749	(15.11)	1016	(41.35)	880	(40.53)	664	(95.27)	2096.87	***

^a Personal-related social network groups mean the percentage of individuals belonging to any type of personal online and offline social group, including relatives, friends, classmates, alumni groups or associations, neighbors, and fellow villagers.

^b Occupational-related social network groups represent the percentage of individuals belonging to any type of online and offline working group, including colleagues and professional organizations/unions.

^c Other social network groups mean the percentage of individuals joining other types of online and offline social groups except personal and working types, including interests, hobbies, nonprofit, religious, and human rights protection. *** $p < 0.001$.

To further identify and verify the features of the four clusters, we divided these online and offline social network groups into three categories: personal-related, occupational-related, and others. Personal-related social network groups included relative, friend, classmate, alumni or association, neighbor, and fellow villager groups. Occupational-related social network groups included any type of online and offline working group, including colleague and professional organization/union groups. Other social network groups included other types of online and offline social groups except for personal and working types, including groups for interests, hobbies, nonprofits, religion, and human rights protection. The distribution of the three categories in the four clusters was different ($p < 0.001$). Cluster 1 had low rates of personal-related social network groups, occupational-related social network groups, and other groups, so we named Cluster 1 the “restricted social network group”. Cluster 2 had 100% of individuals with membership in personal-related and occupational-related social network groups, so we named it the “personal and working social group”. One hundred percent of individuals joined personal-related social network groups while only 12.39% joined occupational-related social groups in Cluster 3, so we named this the “personal social group”. Since more than 94% of individuals joined groups in all three categories in Cluster 4, we named it the “diverse social network group”. Using ANOVA and Scheffe’s test, we compared life satisfaction among these four clusters. We found that the diverse social network groups had the highest life satisfaction, followed by the personal and working social groups and the personal social group clusters, while the restricted social groups had the lowest life satisfaction ($F = 81.19$, $p < 0.001$).

The distribution of the four social network group clusters among the five age groups was different ($\chi^2 = 3175.24$, $p < 0.001$). Fig. 3 shows that older adults were likely to join restricted social network groups. Early young adults tended to join personal social network groups, and the features of the social network group among adults aged 23–44 years were personal and work-focused. In addition, less than 22% of individuals in each age group belonged to the diverse social network groups, with a decreasing trend with age. Hypothesis 2 was supported.

Table 3 shows the multiple linear regression results of the effect of online and offline social network group clusters on life satisfaction among the five participation groups. All of the models controlled for variables including gender, marital status, educational level, living in rural or urban regions, hukou type, local residence status, being from an only child family, and current socioeconomic status.

Among students aged 18–29 years, compared with the restricted social group (Cluster 1), the personal and working (Cluster 2), personal (Cluster 3), and diverse social groups (Cluster 4) had similar life satisfaction ($p > 0.05$) after controlling for demographic characteristics and life status. We found that students had higher life satisfaction with fewer life problems and negative events ($\beta = -1.00$, $p < 0.001$), as well as higher levels of social justice ($\beta = 0.97$, $p < 0.001$) and interpersonal trust ($\beta = 1.15$, $p < 0.001$). In addition, the personal and working social group (Cluster 2) and the diverse social group (Cluster 4) had more benefits from life satisfaction than the restricted social group (Cluster 1) among adults aged 18–29 years, except for students ($p < 0.05$). Online social interaction frequency, leisure/entertainment consumption, the social tolerance level, the social justice level, and interpersonal trust were positively correlated with life satisfaction ($p < 0.001$), while the numbers of life problems and negative events were significantly correlated with lower levels of life satisfaction ($p < 0.001$).

Among adults aged 30–44 years, the diverse social group (Cluster 4) had higher life satisfaction than the restricted social group (Cluster 1) ($\beta = 1.48$, $p < 0.05$). In addition, online social interaction frequency, leisure/entertainment consumption, the social tolerance level, the social justice level, and interpersonal trust were positively correlated with life satisfaction ($p < 0.01$), while the numbers of life problems and negative events displayed were significantly correlated with lower levels of life satisfaction ($p < 0.001$).

Among adults aged 45–59 years, those belonging to the personal and working (Cluster 2) and diverse social groups (Cluster 4) had higher life satisfaction than those belonging to the restricted social group (Cluster 1) ($p < 0.01$). Moreover, individuals with higher frequencies of online social interaction, proportions of leisure/entertainment consumption, the social tolerance levels, the social justice levels, and interpersonal trust displayed significantly higher levels of life satisfaction ($p < 0.001$), while the number of life problems and negative events was negatively correlated with life satisfaction ($p < 0.001$).

Among individuals aged 60–69 years, only fewer life problems and negative events, and a friendly social atmosphere (higher social tolerance level, social justice level, and interpersonal trust) were beneficial for life satisfaction ($p < 0.001$). Hypothesis 3 and Hypothesis 4 were partially supported.

5. Discussion

This study adds to a growing body of research by highlighting the benefits of online and offline social network groups on life satisfaction using cluster analysis and multiple linear regression based on a nationally representative sample survey. This study

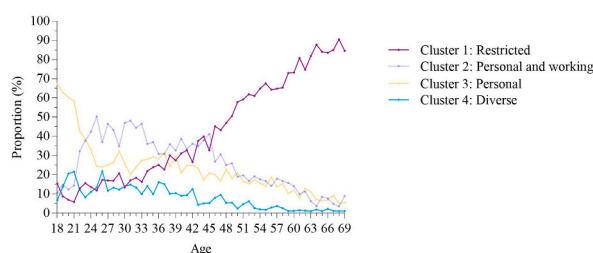


Fig. 3. The proportions of four social network groups clustered across age groups.

Table 3

The multiple linear regression results of online and offline social network group clusters on life satisfaction across age groups.

	M1: Students (18–29 years)		M2: 18–29 years (except students)		M3: 30–44 years		M4: 45–59 years		M5: 60–69 years	
	β	<i>p</i>	β	<i>p</i>	β	<i>p</i>	β	<i>p</i>	β	<i>p</i>
Online and offline social network clusters										
Cluster 2 vs. Cluster 1	0.83		2.15	**	0.31		1.45	**	–0.53	
Cluster 3 vs. Cluster 1	–0.23		0.88		–0.72		0.36		–0.70	
Cluster 4 vs. Cluster 1	–0.12		2.33	*	1.48	*	3.01	***	2.85	
Online social interaction frequency	0.23		0.72	**	0.30	**	0.04		0.26	
Leisure/entertainment consumption	0.04		0.09	**	0.13	***	0.10	***	0.04	
Life problems and negative events	–1.00	***	–1.20	***	–0.74	***	–0.65	***	–0.72	***
Social tolerance level	0.44		0.65	***	0.67	***	0.81	***	0.69	***
Social justice level	0.97	***	0.83	***	0.77	***	0.71	***	0.89	***
Interpersonal trust	1.15	***	0.59	***	0.89	***	0.83	***	0.74	***

Note: M1–M5 represent Model 1–Model 5. Cluster 1 means restricted social network group joiners, and cluster 2 means personal and working social network group joiners. Cluster 3 represents those individuals who prefer to join personal social groups, and cluster 4 means the diverse social group joiners. Leisure/entertainment consumption means the percentage of leisure and entertainment consumption of total family expenditure. All models are adjusted for demographic characteristics and life status, including gender, marital status, education level, residence, hukou type, household registration place, and only-child family, and socioeconomic status. Models 2–5 are also adjusted for work status. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

revealed that younger adults and older adults had higher life satisfaction levels, while middle-aged adults aged 30–59 years had lower life satisfaction levels, which was consistent with some literature [12,44]. Students aged 18–29 years had higher life satisfaction than the other age groups. Social network group participation also differed across age groups. Thus, this study focused on examining the relationships between social participation characteristics and life satisfaction across age groups.

5.1. The characteristics of social participation across age groups

The characteristics of social network groups were different across age groups. Young adults with weak family ties may be involved in multiple social organizations. This study also revealed that younger adults preferred to join personal relationship groups and working groups, and the proportion of younger adults who belonged to restricted groups was low. The personal and working group cluster was the primary social network type for adults aged 23–29 years. In addition, most older individuals aged 60–69 years belonged to the restricted social network group type in this study, which was not consistent with some scholars' findings [71,118]. The reason may be related to the measurement instruments of social network groups and the participants; some research has identified social network clusters in certain regions or certain elderly populations [22]. This study focused on several online and offline social networking groups. With the increase in the aging population in China, many elderly adults play a pivotal role in providing care for grandchildren, which may incite role conflicts between grandchild care and social participation. The Asian culture and Chinese tradition highly value multigenerational co-residence as an ideal living arrangement. Some elderly individuals may not connect with their families and friends through social networking groups. In addition, elderly individuals in China may experience a deterioration of their physical functions, and a social dilemma in the internet era, which may reduce their opportunities to join online and offline social network groups.

5.2. The benefits of joining diverse social groups for improving life satisfaction

Belonging to diverse social groups enhances life satisfaction for most young and middle-aged adults. This study showed that there was a positive relationship between membership in diverse social network groups and life satisfaction among adults aged 18–59 years, except students. Joining diverse social network groups is the foundation for developing diverse social relationships. A growing body of evidence suggests that a diversified social network structure is positively associated with well-being and health behaviors [24]. Membership in multiple groups could increase access to multiple psychological support resources and reduce negative emotions [13]. Restricted social networks may be reflective of social isolation, which is negatively associated with mental health and life satisfaction [47]. Therefore, this study provides evidence that diverse social group membership types may have important practical implications for improving life satisfaction among young and middle-aged populations aged 18–59 years.

5.3. Membership in work-related social groups is associated with increased life satisfaction among individuals aged 18–29 and 45–59 years

Adults aged 18–29 and 45–59 years should participate in both working and personal relationships. Membership in personal and working groups was more beneficial for the life satisfaction of individuals aged 18–29 and 45–59 years than restricted group membership. Working networking groups may be invaluable for business development, peer interaction, knowledge expansion, and personal development and may help individuals meet their social and self-actualization needs. Individuals who mainly belong to personal groups have a life satisfaction improvement effect that is similar to that of individuals in the restricted group. However, individuals with personal and working groups may strike a balance between personal and work life, which is important for increasing life

satisfaction for both men and women [83]. Good working relationships with coworkers and peers are a positive influencing factor in job satisfaction and improved quality of life [4,80]. Thus, health practitioners can provide interventions to encourage young and middle-aged adults to join both personal and working groups.

5.4. Strategies for improving life satisfaction among early middle-aged adults

Notably, early middle-aged adults between 30 and 44 years of age tend to have a low level of life satisfaction. A previous study indicated that the standard of living and family life were the most powerful predictors of life satisfaction among adults aged 35–44 years [81]. A prominent feature of this age group involves the notions of attainment and viewing this time as one of considerable stress. They may face life stress upon achievement in terms of economic and family life, and they may take care of children and parents, juggle work and family demands, face partner crises, and feel unsatisfied with their initial jobs. Financial and life stress significantly affect well-being, especially satisfaction with one's partner, and early middle-aged adults experience the decline of both parents [102,121]. Joining personal and working social groups does not meet the need for life satisfaction improvement. Diverse social groups include social groups such as hobby and nonprofit organization groups and leisure/entertainment consumption, which were found to be beneficial for the improvement of life satisfaction [11]. The findings have practical significance for health agencies. Interventions should focus on joining diverse social groups, increasing leisure/entertainment activities, reducing negative life events, and improving cognitive social capital among early middle-aged adults aged 30–44 years.

5.5. Cognitive social capital can be relied upon to improve life satisfaction among elderly adults

The results of this study showed that the effect of membership in diverse social groups or personal and working social groups on life satisfaction, was not better than that of restricted social group membership among elderly adults, which was inconsistent with some literature that used several continuous social network variables to measure social network size, social activities and the frequency of contact and support [22,86,87,118]. Older adults engage in fewer social comparisons overall and tend to passively join social groups. The frequency of contact and support through those social network groups, and the structural and functional properties of social groups may impact the effect of social network groups on life satisfaction. In addition, qualitative social networks are stronger predictors of life satisfaction than structural social networks [59]. Group membership increased psychological satisfaction more strongly when the groups were valued and liked. The importance of social relationships on elderly adults' opinions may impact the efficacy of social groups on life satisfaction. Further studies should take into consideration the frequency of social interaction, shared identity, and the personalities of elderly adults when evaluating how to improve life satisfaction from the perspective of social group membership. Generally, elderly individuals may be afraid of becoming a burden to their friends and loved ones. Other social capital components including trust, tolerance, and justice, are more important for increasing life satisfaction in elderly individuals. High levels of cognitive social capital (such as trust, tolerance, and justice) could lead to better self-evaluation of the availability of socially supportive resources in society, which could contribute to better life satisfaction. We recommend that policy-makers consider solving livelihood problems for elderly individuals and creating an age-friendly social atmosphere to improve elderly individuals' life satisfaction.

5.6. Social group participation is insufficient for improving the life satisfaction of students

The improvement of life satisfaction among students should focus on the construction of social values and overcoming life adversity. Students may tend to join personal social groups (e.g., family, friends, and classmates). However, previous studies have revealed that university student contact is not related to satisfaction with life and that belonging to multiple social group memberships may confer fewer well-being benefits for Asian students than for Western students [18]; P. J [20,96,111]. This study also showed that membership in personal and diverse social network groups did not have positive associations with life satisfaction among students aged 18–29 years. The academic usage of social networking sites was beneficial to students' mental health, while entertainment usage was positively correlated with anxiety [3]. The relationships between the frequency of online social interactions (e.g., WeChat) and life satisfaction were also not statistically significant in this group. Individuals who join social network groups may encounter social benefits and social overload [94]. Social benefits are positively associated with life satisfaction, while social overload may negatively affect life satisfaction [94]. In addition, according to social identity theory, social groups or social connectedness have the capacity to predict well-being when individuals perceive that they share an identity with their social groups [54,103]. Social support and a shared sense of identity may influence the link between social groups and life satisfaction [108]. To clarify the relationships between social interaction and life satisfaction, further research should analyze the effect of the quality of social relationships, interactions among members, social identity, and the role of social networking groups in students' learning performance on the link between social group belonging and life satisfaction. Regardless, the findings of this study suggest that policy-makers should be aware of the importance of factors other than social groups, including reducing life problems and negative events and improving social justice and trust levels, to improve the life satisfaction of students aged 18–29 years.

6. Strengths and limitations

This study focused on analyzing the associations between participation in different social network groups and life satisfaction among different age groups. Unlike previous network studies, in this study, social network group types were shaped by membership in

different social groups by K-mode clustering analysis. The cluster analysis of online and offline social group participation produces a valid and evidence-based classification structure for the characteristics of social participation. This study also examined life satisfaction and the characteristics of social participation and analyzed the relationships between social network group clusters and life satisfaction across age groups, which could provide evidence for social workers and health education practitioners to develop targeted intervention strategies to promote life satisfaction among different age groups. Finally, the use of nationwide data could provide essential implications for policymakers and community health management to develop opportunities to increase participation in diverse social groups, and cognitive social capital could aid in improving public life satisfaction.

The present study complements and extends the literature by investigating the effects of participation in different online and offline social network groups on life satisfaction across age groups. However, there are also several limitations. First, the cross-sectional design of the study limits any causal inferences among the variables of interest. In further studies, first-hand longitudinal data or group-based social participation interventions could be used to provide practical insights into the associations between diverse characteristics of social group participation and life satisfaction. Second, this study focused on analyzing the associations between online and offline social network group participation and life satisfaction. According to social identity theory, membership in multiple group memberships is positively associated with the need to belong and with identity [115]. Some psychological resources (such as a sense of meaning, purpose, and positive orientation toward others) are derived from shared social identities [17]. Further studies could explore the roles of social identification and the efficacy of group memberships in life satisfaction across age groups. Third, this study focused on the benefits of online and offline social group participation for individuals' life satisfaction. The quality of social connections, frequency of offline social interaction, and ability to socialize may have an impact on the relationship between social group participation and life satisfaction. The mechanism of how social network group participation impacts life satisfaction across age groups requires further research.

7. Theory and practical implications

In this study, we analyzed the characteristics of social participation among different age groups and explored the effect of different characteristics of social participation on life satisfaction across age groups. Based on social capital theory, we clustered social network groups and outlined the characteristics of social group participation across age groups, which influences individuals' life satisfaction. These findings add to previous research that has investigated the impact of structural and cognitive social capital on life satisfaction across age groups and provided cross-cultural evidence for theories. Further studies could explore the reasons for the diverse characteristics of social participation among different age groups. More evidence-based practice educational intervention studies could be conducted to improve life satisfaction from the perspective of the characteristics of social group participation across age groups could be conducted.

This study also has practical implications for health practitioners and social workers. In this study, we identified a helpful connection between individuals' social group participation and their life satisfaction. Our findings suggest that health practitioners should recognize the potential benefits of membership in diverse online and offline social groups for life satisfaction among adults aged 18–59 years, except students, and should encourage individuals aged 18–29 and 45–59 years to join personal and working social groups. Our study supports the importance of reducing life problems and negative events and increasing cognitive social capital (such as social justice levels and interpersonal trust) for improving life satisfaction in each age group. Social capital is a set of shared values that allows individuals to work together in a group to effectively achieve a common purpose. By developing an atmosphere of justice and trust in society, adults' life satisfaction levels can be increased. Social workers may contribute by providing training and development programs for individuals to increase their self-competence to cope with negative events.

8. Conclusions

This study analyzed the relationships between online and offline social network group clusters and life satisfaction across age groups through a nationwide sample survey in 2019 in China. Younger adults and older adults have higher life satisfaction than middle-aged adults aged 30–59 years. Younger nonstudent adults aged 18–29 years and 45- to 59-year-old middle-aged adults, could have higher life satisfaction if they join personal and working social network groups, and diverse social groups. For individuals aged 30–44 years, social workers could strive to promote membership in diverse social groups. These findings are of great practical and theoretical significance for developing targeted life satisfaction improvement strategies from the perspective of the characteristics of social network group participation. In addition, according to social capital theory, the frequency of online social interactions, the social tolerance, social justice level, and interpersonal trust are important influencing factors of life satisfaction. This study provides new evidence from the Chinese context to support and expand the application of a social capital framework. We also propose important policy and intervention implications in terms of social network participation and life satisfaction for Chinese adults.

Author contribution statement

Meijie Chu: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Honghao Ma: Contributed reagents, materials, analysis tools or data; Wrote the paper.

Chun-Yang Lee: Contributed reagents, materials, analysis tools or data; Analyzed and interpreted the data.

Zeyu Zhao: Contributed reagents, materials, analysis tools or data; Analyzed and interpreted the data.

Tianmu Chen: Analyzed and interpreted the data.

Shuoxun Zhang: Contributed reagents, materials, analysis tools or data.

Yi-Chen Chiang: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data.

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Data availability statement

These data were derived from the following resources available in the public domain: Chinese social survey (CSS) (<https://www.chinaldrk.org.cn/wjw/#/home>). The raw data of this study in excel format was included in the additional information.

Ethical statement

The data we used were derived from a project based on the Chinese social survey. Therefore, this study didn't receive ethical committee approval. This study followed the guidelines issued in the Declaration of Helsinki where applicable.

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.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.heliyon.2023.e16176>.

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