

# Sociodemographic, health-related, and social predictors of subjective well-being among Chinese oldest-old: a national community-based cohort study

Gang Cheng

Central South University Xiangya School of Public Health

Yan Yan (✉ [yanyan802394@126.com](mailto:yanyan802394@126.com))

Central South University Xiangya School of Public Health <https://orcid.org/0000-0001-7479-637X>

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## Research article

**Keywords:** subjective well-being, multifactor analysis, Chinese oldest-old, large and representative sample

**Posted Date:** August 24th, 2020

**DOI:** <https://doi.org/10.21203/rs.3.rs-60248/v1>

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**Version of Record:** A version of this preprint was published on February 16th, 2021. See the published version at <https://doi.org/10.1186/s12877-021-02071-7>.

# Abstract

**Background:** There is still a lack of a systematic and comprehensive multifactor analysis of subjective well-being (SWB) among Chinese oldest-old. This study aimed to explore sociodemographic, health-related, and social predictors of SWB among Chinese oldest-old using a large and representative sample.

**Methods:** The study included 49,069 individuals aged 80 and older from the Chinese Longitudinal Healthy Longevity Survey, a prospective, nationwide, community-based study conducted from 1998 to 2014. SWB was measured by eight items covering life satisfaction, positive affect (optimism, happiness, personal control, and conscientiousness) and negative affect (anxiety, loneliness, and uselessness). Generalized estimating equation models were used to explore the predictors of SWB.

**Results:** We found that age, gender, ethnic group, education, primary occupation before retirement, current marital status, and place of residence were sociodemographic predictors of SWB among the Chinese oldest-old. The health-related predictors included self-rated health, visual function, hearing function, diet quality, smoking status, and exercise status. SWB was influenced by some social factors, such as co-residence, number of biological siblings, number of children, leisure activities, financial independence, and access to adequate medical service. In particular, self-rated health, access to adequate medical services, exercise status, and place of residence exert a stronger effect than other factors.

**Conclusions:** SWB in the oldest-old is influenced by a large number of complex sociodemographic, health-related, and social factors. Special attention should be paid to the mental health of centenarians, women, rural residents, widowed, physically disabled, and childless oldest-old people. Relevant agencies can improve physical activities, leisure activities, financial support, and medical services to promote the well-being of the oldest-old.

## 1. Background

The world's population is rapidly aging. The population aged 60 years and older is expected to rise to 2 billion by 2050 [1]. People worldwide are living longer, and now the oldest-old (aged 80 and older) are the fastest-growing age group globally [1]. The number of the oldest-old will have quadrupled between 2000 and 2050 to 434 million [1]. China is one of the fastest aging countries and has the largest oldest-old population in the world [2]. There is growing evidence that a person's dynamic psychological aspects might be related to long-term survival [3, 4]. Substantial evidence indicates that subjective well-being (SWB) as an important predictor of longevity was associated with a decreased risk of all-cause mortality [5, 6].

There are two recognized theoretical perspectives in well-being research: SWB emphasizes hedonism or happiness, and psychological well-being (PWB) focuses on eudaemonia or self-realization [7]. Although SWB is highly correlated to PWB, they belong to different constructs in terms of positive psychological function [8]. SWB is defined as the cognitive and affective evaluations of one's life [9]. The cognitive aspect usually refers to one's judgments regarding life satisfaction [9, 10]. The affective aspect typically refers to one's moods, emotions, and feelings [9], which is measured by the frequency and intensity of positive affect and negative affect [11]. In brief, SWB involves three components: life satisfaction, positive affect, and negative affect. PWB is considered to be a process of realizing values that make us feel alive and real, give us a sense of life, and seek to develop personal potential and to achieve full function [7, 12, 13]. PWB was composed of self-acceptance, autonomy, purpose in life, personal growth, positive relationships, and environmental mastery [13]. To some extent, it is difficult to

distinguish between SWB and PWB. In previous studies, more focused on PWB than on SWB, and some mistook SWB for PWB [14, 15]. Our study explores the predictors of SWB from the real meaning of it.

In recent years, psychologists have paid more attention to the SWB of the old people and its related factors [6]. However, most studies focused on SWB and its related factors among young-old people and seldom considered those among the oldest-old [6, 10, 16]. The oldest-old are the population with the most prominent characteristics of the older. They are generally unable to support themselves financially, have poor ability to take care of themselves, are weak and sick, and have lost their spouses. Previous researches have found a downward trend in the SWB level with increasing age in the old people [17]. There may be differences in the risk factors of SWB between the young-old and the oldest-old, so it is best not to generalize.

In the previous literature, Cho et al. found significant direct or indirect effects of physical health impairment, social resources, cognitive functioning, and education on positive aspects among oldest-old adults [18]. Nakagawa et al. reported that cognitive function, hearing problems, and activities of daily living (ADL) were strong predictors of well-being in Japan and American [19]. Etxeberria et al. suggested that SWB among the oldest old was mainly predicted by personality traits [20]. The limitations of these existing literature are that the sample size is too small (less than 350) and not representative enough.

There have been a few studies of the SWB among the oldest-old in developed countries, but the results should not be extended to developing countries or different cultures [6]. The Chinese Longitudinal Healthy Longevity Survey (CLHLS) is a dynamic, prospective, and national cohort of Chinese older people, which is the largest longitudinal study of the oldest-old in the world [2, 6]. Some studies have obtained related results about risk factors of SWB using CLHLS data. Zhang et al. reported that better intergenerational relations promote the older's positive affect and reduce their negative affect [21]. Chen et al. found that coresidence with spouse or children is associated with positive well-being [22]. Brown et al. reported a strong negative relationship between religious participation and SWB [23]. Li et al. observed that life satisfaction and affective aspect were both influenced by demographic variables and social supports [6]. One limitation of this study is that the analysis of variance was used to examine the influences without adjusting for any confounders. To sum up, there is still a lack of a systematic and comprehensive multifactor analysis for more robust and in-depth research on the SWB of the oldest-old in China.

To fill the gap in the existing research literature, we explore the predictors of SWB among oldest-old people using a large and representative population from CLHLS conducted from 1998 to 2014. In this study, potential predictors are categorized into three aspects: sociodemographic, health-related, and social factors. We took into account all the possible predictors measured in seven waves of the CLHLS from 1998 to 2014 unless the data of a single variable missed too much (more than 10%). We hope that our research findings will contribute to developing the improvement and promotion strategies of the oldest-old's well-being.

## **2. Methods**

### **2.1 Study population**

The CLHLS is a dynamic, community-based, and prospective cohort study to investigate the determinants of health and longevity of Chinese older people. More details can be found elsewhere [2, 24, 25]. It is a nationwide survey covering approximately 85% of the Chinese population. Half of the counties or cities in 22 provinces and 7 longevity areas in China are randomly selected as study sites. The CLHLS began in 1998, and follow-up visits are

carried out every 2–3 years. For the older who are dead and lost to follow-up, the samples were replenished nearby according to the same sex and age. The surveys were conducted by trained interviewers at the participants' homes with structured questionnaires. Family members or neighbors are interviewed when the participants are unable to answer questions, but the subjective questions, such as self-rated life satisfaction, affective aspects, and self-rated health, are answered by participants themselves. The current study was based on seven waves of the CLHLS from 1998 to 2014. From a total of 85,905 individuals, we included 51,774 who aged  $\geq 80$  years and completed SWB assessments. Then we excluded 2705 who was diagnosed with dementia and mental disease and screened as moderate to severe cognitive impairment by a Mini-Mental State Examination score of 20 or less. Finally, a sample size of 49,069 individuals or 30,317 participants was included in our analysis.

## **2.2 Measurements**

### **2.2.1 Outcome**

SWB was measured by eight items covering life satisfaction, positive affect (optimism, happiness, personal control, and conscientiousness) and negative affect (anxiety, loneliness, and uselessness) [6]. Life satisfaction was assessed by “how do you rate your life at present” with a five-point Likert scale ranging from 1 (very bad) to 5 (very good). For the affective aspects, participants responded to the questions “do you always look on the bright side of things?” “are you as happy as when you were younger?” “can you make your own decisions concerning your personal affairs?” “do you like to keep your belongings neat and clean?” “do you often feel fearful or anxious?” “do you often feel lonely and isolated?” “do you feel the older you get, the more useless you are?” on a five-point Likert scale ranging from 1 (always) to 5 (never). The SWB score was constructed from the sum of the eight-item scores and was divided by quartile (Q1 = 0–26, Q2 = 27–29, Q3 = 30–32, and Q4 = 33–40) [6, 15]. We reversed the coding of negative affect, so that the higher the score, the more positive the SWB. If the score was within the range of Q4, the participants were classified as having a better SWB, if not, the participants were classified as having a worse SWB [26]. The internal consistency of the scale was acceptable (Cronbach's  $\alpha = 0.68$ ).

### **2.2.2 Predictors**

Based on previous research [26–28], we divide the potential predictors into three categories: sociodemographic, health-related, and social factors. The sociodemographic factors included age (80–89/90–99/ $\geq 100$  years), gender (men/women), ethnic group (Han nationality/others), education (no schooling/ $\geq 1$  year of schooling), primary occupation before retirement (white-collar workers/others), current marital status (never married/married and not separated/separated/divorced/widowed), have been widowed (yes/no), and place of residence (city/town/rural areas). Health-related factors included ADL score, ADL disability (yes/no), self-rated health (very good/good/fair/bad/very bad), number of natural teeth, visual function (blind/vision loss/normal), hearing function (deaf/hearing loss/normal), systolic blood pressure, diastolic blood pressure, pulse pressure, heart rate, self-reported diseases (yes/no), comorbidity of self-reported diseases (yes/no), food frequency score, smoking status (never/past/current), drinking status (never/past/current), and exercise status (never/past/current). Social factors included co-residence (living alone/in an institution/with family members), number of cohabitants, number of biological siblings, siblings at death (yes/no), number of children, children at death (yes/no), leisure activities score, financial independence (primary financial source from retirement wages or own work/other sources), caregiver when sick (nobody/live-in caregiver/social services/friends or neighbors/family members), and access to adequate medical service (yes/no).

ADL was measured according to whether the interviewees need any assistance in six basic daily activities (bathing, dressing, going to the toilet, indoor transfer, continence, and eating). "Without assistance", "one part assistance", and "more than one part assistance" were respectively scored 1, 2, and 3. These six items were summed up to ADL scores ranging from 6 to 18 and the higher scores, more difficultly their ADL (Cronbach's  $\alpha = 0.82$ ). The interviewees were considered as ADL disability if they answered "more than one part of assistance" in performing one of the six basic daily activities. Self-rated health was assessed by "how do you rate your health at present?" with a five-point Likert scale ranging from 1 (very bad) to 5 (very good), thus a higher score indicated a better health status. Visual function was objectively examined by "can the interviewee see a break in the circle on the cardboard sheet when lit by a flashlight and distinguish where the break is located?". Hearing function was measured by "was the interviewee able to hear what you said?". After interviewees had rested for at least five minutes, interviewers used a mercury sphygmomanometer (upper arm type; Yuyue, Jiangsu, China) to measure blood pressure twice on the right arm. Korotkoff phase I was the systolic blood pressure and phase V was the diastolic blood pressure. For bedridden interviewees, blood pressure was measured in the recumbent position[29]. Pulse pressure was calculated as the difference between systolic and diastolic blood pressure. The heart rate was the pulse measured by the interviewer with two fingers at the radial artery of the interviewee's wrist within 1 minute.

Self-reported diseases were measured by asking the interviewee "are you suffering from hypertension, diabetes, heart disease, cerebrovascular disease, respiratory disease, and cancer?". Comorbidity of self-reported diseases means that the interviewee reported suffering from two or more diseases. Food frequency score was the sum of the frequency of eating fresh fruit, vegetables, meat, fish, eggs, and beans. "Rarely or never", "occasionally", and "always or often" were respectively scored 1, 2, and 3. The higher the score, the better the diet quality (Cronbach's  $\alpha = 0.60$ ). Interviewees also reported the frequency of eight leisure activities which they participated in with a five-point Likert scale ranging from 1 (never) to 5 (always). The eight leisure activities are housework, personal outdoor activities, garden work, reading newspapers or books, raising domestic animals, playing cards, watching TV or listening to the radio, and social activities. These leisure activities were summed to the leisure activities score ranging from 8 to 40, and the higher scores indicated the more frequent leisure activities (Cronbach's  $\alpha = 0.60$ ).

### 2.3 Statistical analyses

First, descriptive statistics of the basic characteristics of 30,317 participants at the initial survey were provided. Data are expressed as counts (percentages) because they are all categorical variables. Since SWB is an ordinal categorical outcome variable, the Wilcoxon rank-sum test and Kruskal-Wallis H test were used to compare the differences in better and worse SWB by covariates. Gender differences in the key variables were examined by chi-square tests. Second, Kendall's rank correlation coefficients were used to assess the inter-correlations between SWB, self-rated life satisfaction, positive affect, and negative affect, because they are all ordinal categorical variables. Third, generalized estimating equation models were used to estimate the effects of the potential predictors on the SWB of 49,069 individuals. We specified the covariance matrix as "a robust estimator", the working correlation matrix as "AR(1)", and the model type as "ordinal logistic". Overall, a small percentage of the data for the predictors were missing (1.51%), and we used multiple imputation methods to handle these missing data [30, 31]. A two-tailed  $p$ -value  $< 0.05$  was considered as statistically significant. All statistical analyses were performed with SPSS 22.0 statistical software (IBM SPSS Inc., New York, NY, USA).

## 3. Result

### 3.1 Participant characteristics

The basic characteristics of the study participants are shown in Table 1. Almost all the participants were of Han nationality (93.8%). Approximately 70% were illiterate, only 10% were white-collar workers. Most of the participants were widowed (77.0%) and rural residence (53.9%). Participants who were octogenarians, men, Han nationality, not illiterate, white-collar workers, married and not separated, and living in cities had better SWB. Besides, participants who rated their health as very good had better SWB. Conversely, participants who were considered as ADL disability and reported suffering from cerebrovascular disease and respiratory disease had worse SWB. Compared to older women, older men had a higher proportion of being octogenarians, white-collar workers, and living in cities. Moreover, older men were more likely to rate their health as very good and report suffering from cerebrovascular disease and respiratory disease. However, older women were more likely to be illiterate, widowed, and considered as ADL disability. The population with missing data and those estimated by multiple imputations had similar basic characteristics (see Additional file 1 Table S1).

Table 1

The basic characteristics of study participants of 30,317 Chinese oldest-old people at the initial survey

<b>Variables</b>	<b>Total (n = 30317)</b>	<b>Better SWB (n = 6512)</b>	<b>Worse SWB (n = 23805)</b>	<b>Women (n = 17663)</b>	<b>Men (n = 12654)</b>
<b>Age group</b>					
80–89 years	13419(44.3)	3309(24.7)	10110(75.3) <sup>****a</sup>	6567(37.2)	6852(54.1) <sup>***</sup>
90–99 years	9923(32.7)	1968(19.8)	7955(80.2)	5600(31.7)	4323(34.2)
≥ 100 years	6975(23.0)	1235(17.7)	5740(82.3)	5496(31.1)	1479(11.7)
<b>Gender</b>					
Women	17663(58.3)	3346(18.9)	14317(81.1) <sup>***</sup>		
Men	12654(41.7)	3166(25.0)	9488(75.0)		
<b>Ethnic group</b>					
Han nationality	28442(93.8)	6250(22.0)	22192(78.0) <sup>***</sup>	16532(93.6)	11910(94.1)
Ethnic minorities	1875(6.2)	262(14.0)	1613(86.0)	1131(6.4)	744(5.9)
<b>Education</b>					
No schooling	20317(67.0)	3691(18.2)	16626(81.8) <sup>***</sup>	2375(13.4)	7625(60.3) <sup>***</sup>
≥ 1 year of schooling	10000(33.0)	2821(28.2)	7179(71.8)	15288(86.6)	5029(39.7)
<b>Primary occupation before retirement</b>					
White-collar	2207(7.3)	866(39.2)	1341(60.8) <sup>***</sup>	400(2.3)	1807(14.3) <sup>***</sup>
Others	28110(92.7)	5646(20.1)	22464(79.9)	17263(97.7)	10847(85.7)
<b>Current marital status</b>					

<b>Variables</b>	<b>Total (n = 30317)</b>	<b>Better SWB (n = 6512)</b>	<b>Worse SWB (n = 23805)</b>	<b>Women (n = 17663)</b>	<b>Men (n = 12654)</b>
Married and not separated	6119(20.2)	1729(28.3)	4390(71.7)****a	1457(8.2)	4662(36.8)***
Separated	412(1.4)	77(18.7)	335(81.3)	106(0.6)	306(2.4)
Divorced	132(0.4)	24(18.2)	108(81.8)	50(0.3)	82(0.6)
Widowed	23332(77.0)	4619(19.8)	18713(80.2)	15954(90.3)	7378(58.3)
Never married	322(1.1)	63(19.6)	259(80.4)	96(0.5)	226(1.8)
<b>Place of residence</b>					
City	6866(22.6)	2153(31.4)	4713(68.6)****a	3731(21.1)	3135(24.8)***
Town	7116(23.5)	1513(21.3)	5603(78.7)	4110(23.3)	3006(23.8)
Rural areas	16335(53.9)	2846(17.4)	13489(82.6)	9822(55.6)	6513(51.5)
<b>ADL disability</b>					
Yes	4884(16.1)	791(16.2)	4093(83.8)***	3476(19.7)	1408(11.1)***
No	25433(83.9)	5721(22.5)	19712(77.5)	14187(80.3)	11246(88.9)
<b>Self-rated health</b>					
Very good	3692(12.2)	1981(53.7)	1711(46.3)****a	1946(11.0)	1746(13.8)***
Good	12678(41.8)	3020(23.8)	9658(76.2)	7295(41.3)	5383(42.5)
Fair	10288(33.9)	1261(12.3)	9027(87.7)	6135(34.7)	4153(32.8)
Bad	3390(11.2)	240(7.1)	3150(92.9)	2128(12.0)	1262(10.0)
Very bad	269(0.9)	10(3.7)	259(96.3)	159(0.9)	110(0.9)
<b>Hypertension</b>					
Yes	5252(17.3)	1088(20.7)	4164(79.3)	3073(17.4)	2179(17.2)

### 3.2 Inter-correlations between SWB, self-rated life satisfaction, and affective aspects

Table 2 shows the inter-correlations between SWB, self-rated life satisfaction, and affective aspect. Significant associations were found among the nine variables. SWB was positively correlated with self-rated life satisfaction and positive affect (optimism, happiness, personal control, and conscientiousness), but negatively correlated with negative affect (anxiety, loneliness, and uselessness). Self-rated life satisfaction and the positive affect were

positively related to each other but negatively correlated with the negative affect. The negative affect was also positively related to each other.

Table 2  
The inter-correlations between SWB, life satisfaction, positive affects and negative affects among 30,317 Chinese oldest-old people

Variables	1	2	3	4	5	6	7	8
1. SWB								
2. life satisfaction	0.330							
3. optimism	0.371	0.328						
4. happiness	0.428	0.245	0.248					
5. personal control	0.358	0.106	0.178	0.204				
6. conscientiousness	0.320	0.264	0.336	0.188	0.167			
7. anxiety	-0.407	-0.141	-0.234	-0.179	-0.145	-0.118		
8. loneliness	-0.432	-0.197	-0.241	-0.224	-0.131	-0.140	0.496	
9. uselessness	-0.389	-0.156	-0.182	-0.206	-0.085	-0.111	0.249	0.309
Data are expressed as Kendall's rank correlation coefficients. All the <i>p</i> -values were less than 0.001.								

### 3.3 Predictors of better SWB

Table 3 shows the odds ratio and 95% confidence interval of the predictors of better SWB. In the final multivariable-adjusted model (model 3), centenarians, Han nationality, receiving more than 1 year of schooling, white-collar workers, and living in cities or towns were significantly associated with a better SWB ( $p < 0.05$ ), compared to octogenarians, other ethnic groups, illiteracy, others workers, and living in rural areas. In terms of health-related factors, rating their health as very good or good, getting higher food frequency score, smoking at present or smoked in the past, and exercising at present or exercised in the past were significantly associated with a better SWB ( $p < 0.05$ ), compared to rating their life satisfaction and health as fair, getting lower food frequency score, never smoking, and never exercising. In terms of social factors, living in an institution, more biological siblings, more children, more frequent leisure activities, financial independence, and access to adequate medical services were significantly associated with a better SWB ( $p < 0.01$ ), compared to living with family members, fewer biological siblings, fewer children, less frequent leisure activities, financial dependence, and lack of adequate medical services. Besides, men, separated or widowed, rating their health as bad or very bad, blind or vision loss, and deaf or hearing loss respectively reduced the odds of better SWB by 11%, 21% or 16%, 33% or 56%, 22% or 30%, and 18% or 21% ( $p < 0.05$ ), compared to female, married and not separated, rating their health as fair, normal visual function, and normal hearing function.

Table 3

Odds ratio and 95% confidence interval of the predictors of better subjective well-being among 49,069 Chinese oldest-old people

Variables	Model 1	Model 2	Model 3
<b>Sociodemographic factors</b>			
Ages 90–99 (vs. 80–89)	0.80(0.76, 0.84) <sup>***</sup>	1.05(0.99, 1.11)	1.05(0.99, 1.11)
Ages ≥ 100 (vs. 80–89)	0.68(0.63, 0.72) <sup>***</sup>	1.15(1.06, 1.24) <sup>***</sup>	1.15(1.07, 1.24) <sup>***</sup>
Men (vs. women)	1.45(1.39, 1.52) <sup>***</sup>	0.88(0.83, 0.94) <sup>***</sup>	0.89(0.83, 0.95) <sup>***</sup>
Han nationality (vs. ethnic minorities)	1.69(1.52, 1.88) <sup>***</sup>	1.46(1.31, 1.63) <sup>***</sup>	1.45(1.30, 1.62) <sup>***</sup>
≥ 1 year of schooling (vs. no schooling)	1.78(1.70, 1.87) <sup>***</sup>	1.08(1.02, 1.15) <sup>*</sup>	1.08(1.02, 1.15) <sup>*</sup>
White-collar (vs. others)	2.54(2.37, 2.74) <sup>***</sup>	1.21(1.11, 1.33) <sup>***</sup>	1.30(1.05, 1.60) <sup>*</sup>
Separated (vs. married and not separated)	0.62(0.52, 0.76) <sup>***</sup>	0.79(0.64, 0.97) <sup>*</sup>	0.79(0.64, 0.98) <sup>*</sup>
Divorced (vs. married and not separated)	0.62(0.44, 0.88) <sup>**</sup>	0.70(0.48, 1.02)	0.71(0.48, 1.03)
Widowed (vs. married and not separated)	0.63(0.60, 0.67) <sup>***</sup>	0.81(0.73, 0.90) <sup>***</sup>	0.84(0.78, 0.89) <sup>***</sup>
Never married (vs. married and not separated)	0.66(0.52, 0.83) <sup>**</sup>	0.84(0.65, 1.09)	0.85(0.66, 1.11)
Have been widowed (vs. no)	0.72(0.68, 0.76) <sup>***</sup>	1.03(0.93, 1.14)	
City (vs. rural areas)	2.28(2.16, 2.41) <sup>***</sup>	1.51(1.42, 1.61) <sup>***</sup>	1.51(1.41, 1.60) <sup>***</sup>

Variables	Model 1	Model 2	Model 3
Town (vs. rural areas)	1.38(1.30, 1.45)***	1.19(1.12, 1.26)***	1.18(1.12, 1.25)***
<b>Health related factors</b>			
ADL score	0.89(0.87, 0.90)***	0.95(0.93, 0.98)***	
ADL disability (vs. no)	0.71(0.66, 0.75)***	1.44(1.29, 1.61)***	1.02(0.83, 1.25)
Self-rated health			
Very good (vs. fair)	7.76(7.25, 8.31)***	6.31(5.87, 6.78)***	6.34(5.88, 6.84)* **
Good (vs. fair)	2.20(2.08, 2.32)***	1.96(1.85, 2.08)***	2.01(1.89, 2.13)***
Bad (vs. fair)	0.57(0.52, 0.63)***	0.67(0.60, 0.74)***	0.67(0.60, 0.76)***
Very bad (vs. fair)	0.27(0.18, 0.41)***	0.39(0.25, 0.59)***	0.44(0.28, 0.70)***
Number of natural teeth	1.01(1.01, 1.02)***	1.00(1.00, 1.00)	
Blind (vs. normal)	0.44(0.41, 0.47)***	0.79(0.73, 0.85)***	0.78(0.73, 0.85)***
Vision loss (vs. normal)	0.47(0.45, 0.51)***	0.71(0.66, 0.76)***	0.70(0.66, 0.75)***
Deaf (vs. normal)	0.51(0.44, 0.58)***	0.83(0.71, 0.96)*	0.82(0.71, 0.95)*

## 4. Discussion

In this large prospective community-based cohort study in China, we found that age, gender, ethnic group, education, primary occupation before retirement, current marital status, and place of residence were sociodemographic predictors of SWB among the Chinese oldest-old. Then, the health-related predictors of SWB included self-rated health, visual function, hearing function, diet quality, smoking status, and exercise status. Moreover, SWB was influenced by some social factors, such as co-residence, number of biological siblings, the number of children, leisure activities, financial independence, and access to adequate medical service. In particular, after adjustment for possible interactions in the multivariable-adjusted model, self-rated health, access to adequate medical services, exercise status, and place of residence still exert a stronger effect on SWB among the Chinese oldest-old than other factors.

Two variables deserve attention in our study, that is, age and gender. Their promotive and inhibitory effects on SWB were reversed in unadjusted analysis and multivariate analysis. Combined with the basic characteristics (Table 1), we think that the unadjusted effect is correct. Maybe because one of the predictors is a moderator of the relationship between age or gender and SWB. Consistent with a previous study [32], our findings showed that relatively younger octogenarians have a better SWB than centenarians. Among old people aged 45 to 97 years, positive affect demonstrated a linear decline with advancing age, while negative affect decreased until approximately 70 years, and thereafter gradually increased [33]. To complement the previous study [32], our results highlight the need to distinguish the roles of differential health-related and social factors in determining SWB among octogenarians and centenarians. In line with other studies [6, 34, 35], we observed the gender difference in SWB among the oldest-old. Besides, there are significant gender differences in some predictors of

SWB among the oldest-old. Compared to older women, older men had a higher proportion of being octogenarians and white-collar workers. Instead, older women were more likely to be illiterate and widowed. It is well known that women live longer than men. That's why men are more likely to be octogenarian and women have lost their husbands. In traditional China, parents usually placed more emphasis on the education and development of their sons than of their daughters [27]. Our research is informative to gender-tailored interventions for a better SWB among the oldest-old.

The special cultural traditions, different values, and even strong religious beliefs of ethnic minorities may cause differences in SWB between ethnic minorities and Han nationality. Ethnicity also affects other key predictors of SWB, such as education, occupation, and place of residence. In agreement with previous studies [6, 11, 27, 34], older people with higher levels of education, white-collar work, and living in cities or towns have better SWB. Empirical evidence shows that education is positively related to psychological resilience, which can play a role in buffering various stressors [28, 36]. Primary occupation before retirement can reflect socioeconomic status to some extent, and it is also closely related to some predictive factors of SWB, such as financial independence, access to adequate medical service, and even diet quality. The accumulated savings, more pensions, and more social security can better support the life and psychological needs of the older. Widowed has been proved to be a predictor of loneliness and depression among the older [28, 37], as well as life satisfaction among the oldest-old [38]. The death of a spouse means the loss of some psychological support and companionship in daily life, instead of emotional sadness [28]. Our research recommended that the mental health of the widowed oldest-old need to be highly valued in the social support system. Compared to rural areas, the advantages of living in cities for better SWB are easy to explain. Residents in urban areas have easier access to better health care services and medical technologies [39], as well as a broader social network, more social activities, and more community services [27, 39].

Based on previous studies that reported the associations between self-rated health and one or more aspects of SWB [11, 34, 38, 40, 41], our study shows that self-rated health is a strong predictor of SWB among the oldest-old. However, the association of any kind of self-reported diseases and SWB among the oldest-old was weakened and became nonsignificant. Self-rated health measures something different from physician's ratings but depending upon one's hypothesis, which is 'subjective' or 'perceived' as opposed to 'objective' or 'actual' [42]. Self-rated health does not decline with increasing age, to the same extent as chronic diseases and disabilities increase [42, 43]. Old people usually more positively assess their health than the middle-aged [42, 44]. Published researches have illustrated that there is a causal relationship between self-rated health and a series of psychological factors, such as self-esteem [41], depression [34, 41, 45], and loneliness [27, 46]. The self-concept hypothesis provides evidence for the stability of self-rated health, and it reflects one's established beliefs about their health [40, 47]. Thus, our research advocates that social services should focus more on the oldest-old's subjective perception of their health.

Similar to related studies [19, 48], our findings suggest that visual and hearing impairment has a significant negative impact on SWB of the oldest-old. Visual and hearing disabilities will adversely affect the interpersonal communication and activity of the daily life of older people [49, 50]. These disabilities can also cause older people to be fearful of or anxious about the unknown world that they can't see or hear. Our research reminds us to pay more attention to the mental health of the disabled old people. Similar to our research, the previous study has observed that frequent consumption of vegetables and fruit is associated with greater life satisfaction [51]. Nutrition-related health problems include frailty, depression, visual function, chronic non-communicable diseases,

and so on [52]. Proper nutrition is a modifiable factor that ultimately improves health, prevents functional disability, and promotes one's well being [51]. To some extent, smoking can indeed make people relaxed and release some psychological stress. However, the damage of smoking to physical functions, such as increased risks of lung cancer, atherosclerosis, and stroke [53], makes it not recommended. Previous researches have indicated that physical activity is a significant and robust predictor of SWB among older adults [10, 17, 54]. Our study shows that this prediction is still applicable for the oldest-old. Physical activity is linked with the release of emotion-related neurotransmitters, including norepinephrine, dopamine, serotonin, and endorphins [10, 55]. Under the condition that the oldest-old physical function permits, close relatives and social workers should help them to participate in physical activities.

The present analysis was inconsistent with previous studies in that living alone was not predictive of SWB after controlling for confounding factors [54, 56]. That could be because the subjects in our study were aged 80 or older from China, not including the young-old (aged 65–79) or the persons from other countries. Instead, we found that living in institutions resulted in better SWB. Related study supported that participation in social activities reduced the negative well-being of older people living in institutions [56]. Siblings relationship is almost the longest lasting in a person's lives, which plays an important role in social and emotional support in old age [57, 58]. There is robust evidence indicating that the sibling relationship is significantly related to the depression, anxiety, loneliness, and life satisfaction of older adults [57–59]. As observed in a recent paper, children are related to better SWB and lack of depression among the older [16]. The roles of children in providing instrumental, emotional, and economic support for the older make them indispensable in the later stages of one's life. In agreement with published articles, our findings showed that engagement in leisure activities will contribute to better SWB [60, 61]. Through participating in leisure activities, the oldest-old can meet life values and needs, build social relationships, feel positive emotions, and therefore enhance the well-being [61].

One novel finding from our study is that the oldest-old with financial dependence more likely to face worse SWB than others with financial independence. Related research has revealed that receiving financial support from adult children considerably increased male old people's negative aspects [21]. It was guessed that financial independence probably means autonomy, which is directly related to their SWB. Besides, for the oldest-old, their children are mostly at or near retirement age, thus they can only get little financial support from their children. One finding which needs to be taken seriously is that access to adequate medical service makes a powerful impact on SWB of the oldest-old. The older in remote, poor, rural areas and those left behind cannot get adequate medical service. The social phenomenon of "the difficulty in seeing a doctor" among the older is prevalent in China. Because of travel inconvenience and medical procedures cumbersome, it is difficult for old people to timely and quick access to medical services. Medical treatment may become major mental distress of the older. Because of this, relevant departments should actively provide convenient, low-cost, and effective medical and health services for older people, especially the oldest-old.

There are several strengths to our study. First, to the best of our knowledge, the present study is the first to carry out a systematic and comprehensive multifactor analysis on the predictors of SWB among the oldest-old in China. Second, the current study included a large and representative sample of the Chinese oldest-old, allowing a robust assessment for the predictor of SWB among this group. Third, this article carried on a preliminary exploration of all available and possible sociodemographic, health-related, and social factors, which were obtained through face-to-face surveys. Fourth, our results confirmed that SWB was significantly correlated with self-rated life satisfaction, optimism, happiness, personal control, conscientiousness, anxiety, loneliness, and

uselessness. It is reasonable to infer that the predictors of SWB may have a similar effect on these dimensions. Finally, our findings may also apply to other populations in transition, particularly in East Asia and Southeast Asia (e.g. Malaysia, Nepal), where contextual background and cultures are similar to those in China, such as the breakdown of traditional family structures and the imperfection of social security systems [27].

This study has several limitations. First, those strong predictors of SWB among the oldest-old may interact with other variables, and we overestimate their effects on SWB by not adjusting the interactions. Continued efforts to explore these relevant interactions further will yield more robust and realistic predictive effects. Second, during the follow-up period from 1998 to 2014, great changes have taken place in China, such as the rise of the Internet and electronic information technology, the government's greater concern for people's livelihood, and the improvement of people's quality of life. These changes will more or less have an impact on the content of this study. Subsequent studies suggest that study populations with a small-time span be selected. Third, in our study, SWB was not measured by the Satisfaction with Life Scale and the Positive and Negative Affect Schedule, which was more valid and reliable. The Cronbach's  $\alpha$  of our SWB scale was only 0.68, thus the reliability of the scale was defective. Finally, because of massive missing data, the study did not explore other possible predictors, such as household income, instrumental activities of daily living, community services, and so on. The effects of these factors can be discussed in future studies.

## 5. Conclusions

In this cohort study of over 30,000 oldest-old people in China, we observed that SWB in the oldest-old is influenced by a large number of complex sociodemographic, health-related, and social factors, including age, gender, ethnic group, education, primary occupation before retirement, current marital status, place of residence, self-rated health, visual function, hearing function, diet quality, smoking status, exercise status, co-residence, number of biological siblings, the number of children, leisure activities, financial independence, and access to adequate medical service. Our research advocates that special attention should be paid to the mental health of centenarians, women, rural residents, widowed, physically disabled, and childless oldest-old people. Relevant agencies can improve physical activities, leisure activities, financial support, and medical services to promote the well-being of the oldest-old. Future study is expected to explore other social factors that can be intervened, such as community services and social support.

## Abbreviations

SWB: subjective well-being; PWB: psychological well-being; ADL: activities of daily living; CLHLS: the Chinese Longitudinal Healthy Longevity Survey

## Declarations

### Acknowledgments

We acknowledge the CLHLS research team for collecting high-quality, nationally representative data and for making the data public, which was managed by the Center for Healthy Aging and Development Studies, Peking University.

### Authors' contributions

GC designed the study question, performed the statistical analyses, and wrote the first draft. YY was responsible for the overall supervision of the study design and revised the manuscript. The authors read and approved the final manuscript.

## Funding

This study was supported by the National Natural Science Foundation of China [81973153, 81673276, and 81373101]. The funder had no role in study design, data collection and analysis, decision to publish, or reparation of the manuscript.

## Availability of data and materials

The datasets analyzed during the current study are available in the [<https://doi.org/10.18170/DVN/UWS2LR>].<sup>[25]</sup>

## Ethics approval and consent to participate

The CLHLS study was approved by the Biomedical Ethics Committee of Peking University, Beijing, China (IRB00001052-13074), and informed consent was obtained from all participants or their proxy respondents. Our team has acquired the administrative permissions to access the data used in our research.

## Consent for publication

Not applicable.

## Competing interests

The authors declare that they have no competing interests.

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