The Association between Sleep Quality and Loneliness in Rural Elderly Individuals: A Cross-Sectional Study in Shandong Province, China

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Abstract
Background: There is evidence of negative associations between loneliness and sleep quality in older adults. However, little is known regarding the relationship between loneliness and sleep quality among Chinese rural elderly. This study examined the associations of loneliness and sleep quality in a cross-sectional study of older adults.

Methods: A face-to-face questionnaire survey was conducted among 1,568 rural elderly people in Shandong Province, China. Loneliness was assessed using the University of California at Los Angeles Loneliness Scale. Sleep quality was assessed using the Pittsburgh Sleep Quality Index. Ordinal logistic regression was conducted to examine the association of loneliness and sleep quality after adjusting for multiple confounding variables.

Results: After controlling for variables such as age, marriage, education, occupation, economic income, family relationships, living arrangement, smoking, drinking, chronic diseases, quality of life in a multivariable analysis, poor sleep quality still indicates loneliness in the rural elderly population.

Conclusion: This finding implied an adverse effect of sleep quality on the loneliness of older adults. Poor sleep quality was associated with the increased odds of loneliness in Chinese rural older adults. Sleep-based interventions should be developed to prevent loneliness in rural older adults in China.

Background
The loneliness experience of elderly individuals is an important aspect of the mental health of the elderly population[1]. Loneliness is also an important indicator for measuring the subjective well-being of the elderly population[2]. Surveys have shown that loneliness has become one of the prominent problems threatening the quality of life and personal happiness of elderly individuals[3].

The ageing process of China's population is obviously faster than that of other middle- and low-income countries. By 2040, the proportion of people aged 60 and over will rise to 28% from 12.4% in 2010. The life expectancy of women is higher than that of men, and the proportion of elderly people in rural areas is higher than that in the urban population (2016 National Assessment Report on Aging and Health in China).

According to a survey conducted by the China Aging Science Research Center, more than 1/3 of the
elderly population in rural areas often feel severely lonely. In particular, the psychological impact of empty nests on the elderly and the psychological problems of this population need to be addressed and solved[4, 5]. Peplau et al. began to study the loneliness of adults in the 1970s[6]. They have proposed that loneliness is a bad emotional experienced by an individual when their social network is insufficient, including the inadequacy and low quality and quantity of their social relationships[7, 8]. In the past ten years, American scholar Dr. Cacioppo and his colleagues have developed a study of loneliness. They have proposed a theory that an individual’s genes determine their loneliness level[9]. He also suggests that loneliness will spread similar to an infectious disease[10]. The prevalence of loneliness in the Chinese elderly population varies greatly due to the differences in research[4, 11]. Many factors have been indicated to be associated with loneliness. These factors include demographic characteristics, such as gender, age, education level [12], marriage and economic status, social interaction[13, 14], race[15], stress, depression[16, 17], poor lifestyle[18], being solitary, malnutrition, relationships with family members[19], life satisfaction[20], drinking[21], smoking, quality of life, non-communicable diseases (NCDs),[22] and psychological problems[23].

Loneliness is associated with poor health outcomes including depression, sleep quality, heart disease and all-cause mortality [24]. Among the psychological and behavioural problems experienced by lonely people, poor sleep quality has received considerable attention in recent years[25]. Studies have suggested that loneliness causes poor sleep quality and insomnia. In the evolutionary theory of loneliness (ETL), Cassiop[26] has proposed that loneliness leads to poor sleep quality and insomnia (and other results) because it signals that one exists in an environment where others are likely to behave selfishly. This triggers a physiological response to the perceived possibility of a social threat (even if there is no threat), including increased cortisol secretion, a common substance secreted when one is awake, which can have a negative impact on sleep initiation and is not conducive to high-quality sleep[27]. This theory was supported by Matthews[28], who found that the link between loneliness and sleep quality was particularly significant in young people who had experienced trauma, such as violence / neglect.

Loneliness and poor sleep quality are common phenomena in advanced age and are not conducive to
physical and mental health. Although it may be difficult to intervene in loneliness, there may be some adjustable related factors, such as sleep. If sleep disorders are relieved, the impact of loneliness on the health of the elderly population can be reduced. McHugh [29] found that the effect of loneliness, especially emotional loneliness, on the sleep quality of elderly individuals was partly mediated by perceived stress. The research results on loneliness and sleep quality in the elderly population are mixed. A large sample study of the elderly population in China shows that compared with elderly individuals with an empty nest, elderly individuals who live with their spouse or family members have good sleep quality [30]. The study also found that loneliness indicates the decline of the subjective sleep quality of elderly individuals. Another study found that loneliness did not affect sleep duration and subjective sleep quality [31]. Wakefield’s research suggests that loneliness has been proven to be an important predictor of depression and sleep deprivation, but the variables that may predict loneliness have not been fully studied [27].

A study by Chris Segrin was conducted among 255 couples in the United States, indicating an association between loneliness and sleep quality [25]. The relationship between loneliness and sleep quality was also explored among American college students [24]. Another study showed that loneliness in young adults could affect their sleep quality [28]. However, most of the above studies have focused on young people or college students.

A survey of 447 elderly individuals in an urban Irish community showed the effect of emotional loneliness on the quality of sleep, but the study used the De Jong Gierveld Loneliness Scale with a small sample size [29]. A current longitudinal study of a sample in Taiwan does not reveal an association between loneliness and sleep quality in elderly people [32]. In view of the uncertainty of the above findings and the frequent use of a small sample size, it is necessary to conduct a large sample study on the relationship between loneliness and sleep quality.

Therefore, we conducted a large sample of rural areas in Shandong Province, China, to study the association between loneliness and sleep quality in the elderly population. To this end, we have established the following specific objectives. First, we identified the prevalence of loneliness among the elderly population in Shandong Province, China. Then, we studied the relationship between
loneliness and sleep quality in the elderly population.

Methods

**Settings and participants**

A village-based cross-sectional study was conducted among 1,568 elderly people over 60 years of age in five cities in Shandong Province. The participants were selected by three-stage cluster sampling. First, according to the geographical location of Shandong Province, each district and county was divided into five groups: east, south, west, north and middle. Second, we chose one city from each group, and the five selected cities were Yantai (east), Jining (south), Liaocheng (west), Binzhou (north) and Zibo (middle). Similarly, four towns were sampled from each sample city according to geographical location. Finally, one village was sampled from each town, and all the elderly individuals in these 20 villages were included in this study. The average number of people in each village was 90, the response rate was 94.27%, and the effective rate was 97.82%.

**Data collection**

The entire survey was conducted from December 2016 to February 2017. All of the older adults were interviewed face-to-face by trained investigators who were undergraduates from Binzhou Medical University School of Public Health and Management. Information on demographics, loneliness, sleep quality, quality of life, health-related behaviours, diseases and symptoms was collected by a structured questionnaire. To ensure quality, inspectors checked each completed questionnaire daily and supplemented and corrected errors in a timely manner.

**Measures**

**Sociodemographic variables**

Sociodemographic characteristics, such as sex, age, economic status (economic sources and income), marital status, education, and occupation, were investigated. The ages of the participants was categorized as follows: 60-69, 70-79 and 80+ years old. Other demographic characteristics were classified as follows: sex (male vs. female), economic income (<1000 yuan, 1000-3000 yuan, 3000-5000 yuan, and ≥5000 yuan), economic resources (farming income vs. support from children and others), marital status (couple vs. others), education (primary school or below, junior school, senior
high school and above), occupation (manual labour vs. mental labour), number of children (0, 1, 2, 3+), relationship with family members (good vs. bad), and empty nester (yes vs. no).

**Health-related behaviours**

Smoking and drinking statuses were assessed by asking the participants whether they had smoked or consumed alcohol in the past 6 months[33].

**Diseases and symptoms**

Self-reported non-communicable diseases (NCDs) were also investigated, especially NCDs in the past year (yes vs. no). Weight and height were measured in this study, and body mass index (BMI) was calculated as weight (kg) divided by height (m) divided by height (m) again. Participants were divided into 3 categories (lean, normal and overweight+) according to the Chinese standard.

**Quality of life scale**

The Medical Outcomes Study 36-item Short-Form Health Survey (SF-36) is a generic tool for assessing health-related quality of life[34]. The results are evaluated by assigning scores for each question and then transforming the scores into a scale from 0 to 100, with a higher score reflecting better perceived health[35]. The Cronbach’s α is 0.825 in this study.

**Loneliness assessment**

The University of California at Los Angeles (UCLA) Loneliness Scale (version 3) compiled by Russell et al. was applied to all groups[36]. The advantage of the third scale is the anti-order scoring item, which prevents the appearance of a false answer. The UCLA Loneliness Scale contains 20 items, and each item has a 4-point rating scale in which 1 = never and 4 = always. The UCLA scores are summed to produce a total score, with potential scores ranging from 20 to 80. Higher scores indicate a higher level of perceived loneliness. The scale is the most commonly used tool for assessing loneliness[37, 38], and the Cronbach’s α is 0.860 in this study. According to Perry's loneliness classification scheme[39], a score of 20-34 is classified as a low loneliness experience, 35-49 is classified as moderate loneliness experience, and a score of over 50 is classified as high loneliness experience. The test-retest reliability of the scale is relatively high, which makes it suitable to measure the loneliness of the elderly sample[40].
Sleep quality assessment

We used the Pittsburgh Sleep Quality Index (PSQI) scale, which is used worldwide, to evaluate the sleep quality of the elderly sample[41]. The scale includes the following 7 dimensions: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction[42]. Each dimension ranges from 0 to 3 points. The sum of the 7 dimensions is the total score of the PSQI scale (range of 0-21)[43]. The Cronbach’s $\alpha$ of sleep quality in this study is 0.840. Referring to Li J’s research on the analysis of sleep quality characteristics and related factors of the elderly population in rural China, when 7 was cut off point, the sensitivity and specificity were 98.3% and 90.2%, respectively[44]. The threshold for sleep quality was seven, with higher scores indicating poorer sleep quality[45].

Statistical analysis

EpiData version 3.1(The EpiData Association, Odense, Denmark) was used for data entry and verification. SPSS version 22.0 (IBM Corp., Armonk, NY) statistical software was used for statistical analysis. The differences in the loneliness scores between the levels of factors were examined using independent sample $t$-tests or analysis of variance (ANOVA). An ordinal logistic regression model was employed to assess the association between sleep quality and loneliness. Three models were fitted for the outcome. An adjusted model (Model 1) was constructed first to examine the effects of different demographic variables on loneliness. A fully adjusted model (Model 2) was constructed to examine the associations between sleep quality and loneliness by controlling for sociodemographic variables, health-related behaviours, quality of life variables and NCDs. Model 3 was constructed by adding all seven dimensions of sleep quality and loneliness into the fully adjusted model. A sensitivity analysis was conducted by excluding participants with 1 or 0 children. Leanness or obesity are considered to be the main risk factors for poor sleep quality, which can lead to experiencing poor sleep quality. Therefore, subjects with BMI $\geq 24$ and BMI $< 18.5$ were excluded from the second sensitivity analysis, and those with a poor quality of life were excluded from the third sensitivity analysis. All reported CIs were calculated at the 95% level. Statistical significance was assessed at the 5% level.

Results
Basic information of the participants

Table 1 shows the basic information collected from the 1,658 participants. The average age of the respondents was 70.41 years old (SD 7.63). The loneliness scores in the survey ranged between 21 and 80. A total of 31 (18.4%), 924 (55.7 %), and 429 (25.9%) of the respondents were assessed as having low, moderate, and high levels of loneliness, respectively, and the mean overall score for the participants was 43.17±9.46. Of all the participants, 50.7% were female, and 15.2% were over 80 years of age. Individuals who were part of a couple accounted for 69.8% of the respondents, and 31.1% of the participants reported less than 1000 yuan in economic income. A total of 62.1% reported that their income comes from their children, 69.1% had a primary school education or below, 63.0% worked in manual labour, 30.9% reported smoking, 46.1% reported consuming alcohol, 94.7% had good relationships with their family members, 30.2% reported being an empty nester, 17.3% reported having either 1 child or 0 children, and 32.8% reported having a chronic diseases.

Comparison of loneliness scores

There were significant differences in the loneliness scores among older adults with different characteristics, mainly including age (p<0.001), marital status (p=0.001), occupation (p<0.001), education (p<0.001), economic sources (p<0.001), economic income (p=0.002), smoking (p<0.001), drinking (p<0.001), relationships with family members (p=0.045), being an empty nester (p<0.001), the number of children (p<0.001) and having a NCD (p<0.001). The average score of an elderly individual with poor sleep quality was 45.04±8.86, which was significantly higher than that of an elderly individual with good sleep quality (41.66± 9.65) (t=7.742, p< 0.001).

Comparison of the PSQI scale and its component scores

The mean score for sleep quality was 6.673.42. Among the 1658 participants with a global score greater than 7, which accounted for 44.9% of the sample, the prevalence rate of poor sleep quality was 44.9% in rural elderly people in Shandong Province. As shown in Table 2, the average scores for sleep quality, subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction were 6.67±3.42, 1.14±0.76, 1.24±0.90, 0.61±0.84, 0.84±1.04, 1.34±0.67, 0.36±0.76 and 1.15±0.78, respectively. There was a
statistically significant difference between the score of sleep quality and 5 PSQI scale dimensions (all except subjective sleep quality and habitual sleep efficiency) between the different levels of loneliness (p <0.05).

**Contour analysis of average scores of PSQI for different levels of loneliness**

A contour analysis of the average scores of the PSQI scale for different levels of loneliness in rural elderly people was conducted. The profile of the seniors who experienced loneliness in rural areas is not parallel to each other among the low group, the moderate group or the high group ($F=12.000$, $p=0.000$), and the contours of the high group were higher than those of the moderate and low group. For a horizontal profile analysis, the average scores of 7 factors, namely, subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication and daytime dysfunction, were different ($F = 38.103$, $p=0.000$), as shown in Figure 1.

**Association between sleep quality and loneliness**

The classification of loneliness in the rural elderly population was used as the dependent variable ($Y=0$, low level of loneliness, $Y=1$, moderate level of loneliness, $Y=2$, high level of loneliness), the sleep quality score was used as the independent variable, and age, marital status, occupation, economic income, relationships with family members, empty nester, number of children, smoking, drinking, BMI, chronic disease and quality of life were used as control variables. The relationship between the sleep quality and loneliness of elderly people was analysed by three ordinal regression models. Even after controlling for marital status, drinking, relationships with family members, occupation, economic income, chronic disease and quality of life, an increase in the odds of loneliness was associated with an increase in the sleep quality score (adjusted odds ratio [aOR] = 1.111, 95% confidence interval [95% CI] = 1.078-1.145). The worse the quality of sleep, the higher the degree of loneliness in the elderly sample. Scores in subjective sleep quality (aOR = 0.765, 95% CI = 0.649-0.902), sleep latency (aOR = 1.346, 95% CI = 1.178-1.537), sleep duration (aOR = 1.316, 95% CI = 1.139-1.522), use of sleeping medication (aOR = 1.175, 95% CI = 1.005-1.372), and daytime dysfunction (aOR = 1.267, 95% CI = 1.079-1.487) were significantly different between older adults with high levels of loneliness and those with moderate and low levels of loneliness. Older adults with
higher PSQI scale scores in these 5 components had a higher risk of loneliness. Although older adults with higher scores in habitual sleep efficiency and sleep disturbances had a higher risk for loneliness, these differences were not statistically significant, as shown in Table 3.

**Sensitivity analysis**

A sensitivity analysis that excluded participants with either one child or no children (n = 287) yielded a similar result to that of Model 2 (OR 1.102; 95% CI 1.064–1.141; \( p = 0.000 \)). The second sensitivity analysis that excluded participants whose BMI ≥ 24 and BMI<18.5 (n = 882) also yielded a result similar to that of Model 2 (OR 1.113; 95% CI 1.063–1.164; \( p = 0.000 \)). The third sensitivity analysis that excluded participants with poor quality of life (n = 160) also yielded a result similar to that of Model 2 (OR 1.105; 95% CI 1.070–1.141; \( p = 0.000 \)).

**Discussion**

The overall score of loneliness in the Shandong Province rural elderly population was 43.17 ± 9.46, and 25.9% of the study population had a strong sense of loneliness. This percentage is higher than the 11.6% reported for a population of English-speaking U.S. residents aged more than 65 years [20]. It is also higher than the 10.5% reported for the general population in Germany[23]. However, the percentage is lower than the 38.22% reported in a study of elderly individuals with similar ages in urban communities of Xiamen, China[43]. Differences in socioeconomic development might explain the variations between our study and those carried out in the U.S. and Germany[45]. The acceleration of rural urbanization caused by socioeconomic development in China has led to the rapid increase of empty nesters, which eventually leads to social isolation and an increase in psychological problems for rural elderly individuals who are not accompanied by their children. The difference between the results from our research and those from the study of urban Xiamen may be due to differences in geographical location. Our research was conducted in rural Shandong Province, while the study from Xiamen was conducted in urban areas. In addition, the differences between our research and the study from Xiamen can be explained by the use of different investigative tools. We used a universal scale to evaluate loneliness. However, in the Xiamen study, only 1 question was used to test loneliness.
The main factors affecting loneliness in this study were age, marriage, education, occupation, economic source and income, family relations, being an empty nester, number of children, smoking, drinking, NCDs and so on, which were consistent with the findings of previous studies[46]. Many studies believe that social and economic factors play an important role in the development of loneliness of elderly individuals in rural areas[47]. Among these factors, the empty nest phenomenon is the most obvious social factor in China's rural areas. Since the 1980s, a large portion of the rural labour force has been continuously imported into the city, which intensifies the empty nest trend of the rural elderly population. In this study, the loneliness level of elderly empty nesters is significantly higher than that of non-empty nest elderly individuals, which is consistent with previous studies. Chronic diseases lead to the decline of the health status of elderly individuals, which makes social communication difficult. The social support of children for elderly individuals decreases when children move away from home and the individuals become empty nesters. Widowhood also reduces the social support of elderly individuals, further promoting the loneliness of the elderly population[48]. The influence of the number of children (a specifically added variable) on the loneliness of elderly individuals showed that having no children or only 1 child was lonelier than having 2 or more children, which further demonstrates the importance of the companionship of children for elderly individuals. Research shows that deficiencies in the quantity and quality of sleep can predict some health problems[49, 50]. This is consistent with previous studies in different populations that have found a negative correlation between loneliness and sleep quality. Matthews et al.[28] found this result in young people, and Wakefield[27] also found this result in a group of individuals aged 18-76 years old. Although the research populations are different, these findings are consistent with the theory of evolution of loneliness[26] tested by Matthews et al. Because loneliness promotes social threats, there is a negative correlation between loneliness and sleep quality. This in turn triggers physiological reactions, such as cortisol production, which can disrupt sleep attempts. This may be one of the reasons why loneliness is negatively related to sleep. McHugh[29] believes that emotional loneliness in the elderly population may lead to an increase in perceived stress, which in turn affects sleep quality. Although some reasons have been given for the relationship between loneliness and sleep, it
seems to be easier and more effective to improve the quality of life of elderly individuals from the perspective of sleep intervention.

This study attempted to explore whether loneliness affects the sleep quality of rural elderly people. To eliminate the accidental association between loneliness and sleep caused by mixed bias, our study further excluded other factors related to loneliness. When controlling for covariates such as age, marital status, education, occupation, economic status, family relationship, lifestyle, smoking, drinking, BMI, NCDs and quality of life, the PSQI scale score of the elderly sample was higher and the loneliness experience was improved[51]. Our results are consistent with those of studies by Matthews et al. on the relationship between sleep quality and loneliness in young people, suggesting that poor sleep quality increases the risk of loneliness even after controlling for many other factors [28, 31, 52, 53]. Our findings are not consistent with previous studies in older adults in the Taiwan area [32]. The difference between our study and the study of Yu B et al., in addition to geographical differences, may also be related to the use of different survey tools for evaluating loneliness. In the research on Taiwan, loneliness was only evaluated by one question, whereas we used the UCLA Loneliness Scale to evaluate it. Some physiological processes may also explain the association between loneliness and sleep quality. Dream disturbances are associated with greater stress and anxiety[54] and may represent a further manifestation of emotional distress in lonely individuals[28].

Our study also showed that 5 dimensions, including scores on subjective sleep quality, sleep latency, sleep duration, use of sleeping medication, and daytime dysfunction, were associated with loneliness. In previous studies of loneliness and sleep in young adults, only subjective sleep quality and daytime dysfunction were associated with loneliness[28, 31]; however, the study of the elderly population in Taiwan did not explore the dimensions of the PSQI scale. A study of 95 young people showed that loneliness was related to sleep quality, but no relationship between loneliness and sleep duration was found[52]. Older people with poorer subjective sleep quality are more likely to become restless than are those with no subjective sleep quality[55]. Poor subjective sleep quality is harmful to a person's physical and mental health. Studies have shown that physical and mental health are related to loneliness [18]. These negative effects may in turn lead to the further escalation of loneliness. The
influence of the PSQI scale's dimensions on loneliness should be further studied. Based on the findings in this sample, the relationship between sleep quality and loneliness is very close in the elderly population of China. Previous studies have also shown a relationship between loneliness and sleep quality, as loneliness affects sleep, and sleep also affects loneliness[53, 56]. The connection between the two is exacerbated by stress [25]. Whether there are intermediate variables between loneliness and sleep quality and how these intermediate variables function need to be explored in a later study; however, it is undeniable that the relationship between the loneliness and sleep quality of the elderly population in rural areas is self-evident and should be important to decision makers. Psychological interventions to improve the loneliness of the elderly or measures to improve their quality of sleep will ultimately improve the quality of life for the elderly population.

Our study has some limitations that must be appreciated when interpreting the findings. First, loneliness and sleep quality were measured cross-sectionally, and no conclusions can be drawn about the directionality of the associations. Second, both loneliness and sleep quality were based on self-reported measures that can cause reporting bias. Third, unknown variables are not involved in the designed questionnaire, which may lead to some deviations in the results. For example, the weakening of the social communication ability of the elderly is significant to their feeling of loneliness[57], but it was not involved as a confounding factor in this study. This exclusion may affect the validity of our findings.

Conclusion
In summary, our study demonstrated that sleep quality was significantly associated with loneliness in the rural elderly population in China. We also found that several variables, such as subjective sleep quality, sleep latency, sleep duration, use of sleeping medication, and daytime dysfunction, were significantly different between participants with high levels of loneliness and those with moderate/low levels of loneliness. Interventions should be developed to help older individuals with sleep disorders improve their sleep quality so that high levels of loneliness are prevented in the senior population in China. Therefore, corresponding intervention measures should be formulated to reduce the loneliness of elderly individuals and improve the quality of sleep in the elderly population.
Abbreviations
BMI: Body mass index; PSQI: Pittsburgh Sleep Quality Index; CI: Confidence Interval; OR: Odds ratio; SD: Standard deviation; SPSS: Statistical package for the social sciences; NCDs: non-communicable diseases

Declarations

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Availability of data and materials
The datasets used and/or analysed during the article are available on reasonable request at jiagzh221@163.com.

Author’s contributions
PY were responsible for study concept and design. GJ performed the statistical analyses and wrote the first draft of the manuscript. GJ and PY were responsible for critical revision of the manuscript. All authors approved the final manuscript.

Ethical approval and consent to participate
The study design was approved by the Ethical Committee of Binzhou medical college (NO. ytsk2013-070). All the elderly gave oral informed consent before conducting a house-to-house survey.

Consent to publish
All participants provided signed consent prior to objective assessment which included use of data for publication.

Conflict of interest
The authors declare that they have no competing interests.

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**References**

1. Zhao M, Gao J, Li M, Wang K. Relationship Between Loneliness and Frailty Among Older Adults in Nursing Homes: The Mediating Role of Activity Engagement. Journal of the American Medical Directors Association. 2019; 20(6):759-64.

2. Domenech-Abella J, Mundo J, Haro JM, Rubio-Valera M. Anxiety, depression, loneliness and social network in the elderly: Longitudinal associations from The Irish Longitudinal Study on Ageing (TILDA). Journal of affective disorders. 2018;246:82-8.

3. Lim LL, Kua EH. Living alone, loneliness, and psychological well-being of older persons in singapore. Current gerontology and geriatrics research. 2011;2011:673181.

4. Guojun Wang, Mi Hu, Shui-yuan Xiao, Zhou L. Loneliness and depression among rural empty-nest elderly adults in Liuyang, China: a cross-sectional study. BMJ open. 2017; (7):e016-91.

5. Cheng P, Jin Y, Sun H, Tang Z, Zhang C, Chen Y, Zhang Q, Zhang Q, Huang F. Disparities in prevalence and risk indicators of loneliness between rural empty nest and non-empty nest older adults in Chizhou, China. Geriatrics & gerontology international. 2015; 15(3):356-64.

6. Michela JL, Peplau LA, Weeks DG. Perceived Dimensions of Attributions for Loneliness. Journal of Personality and Social Psychology. 1982;43(5):929-36.

7. Bragg DGWJLMLAPME. Relation Between Loneliness and Depression: A Structural Equation Analysis. Journal of Personality and Social Psychology. 1980; 39(6):1238-44.
8. Louise C. Hawkley, Mary Elizabeth Hughes, Linda J. Waite, Christopher M. Masi R, A. Thisted, Cacioppo JT. From Social Structural Factors to Perceptions of Relationship Quality and Loneliness: The Chicago Health, Aging, and Social Relations Study. J Gerontol B Psychol Sci Soc Sci. 2008;63(6): S375–84.

9. Boomsma DI, Willemsen G, Dolan CV, Hawkley LC, Cacioppo JT. Genetic and environmental contributions to loneliness in adults: the Netherlands twin register study. Behavior genetics. 2005; 35(6):745-52.

10. Cacioppo JT, Fowler JH, Christakis NA. Alone in the crowd: the structure and spread of loneliness in a large social network. J Pers Soc Psychol. 2009;97(6):977-91.

11. Wang G, Zhang X, Wang K, Li Y, Shen Q, Ge X, Hang W. Loneliness among the rural older people in Anhui, China: prevalence and associated factors. International journal of geriatric psychiatry. 2011; 26(11):1162-8.

12. Hacihasanoglu R, Yildirim A, Karakurt P. Loneliness in elderly individuals, level of dependence in activities of daily living (ADL) and influential factors. Archives of gerontology and geriatrics. 2012; 54(1):61-6.

13. Dahlberg L, Andersson L, Lennartsson C. Long-term predictors of loneliness in old age: results of a 20-year national study. Aging & mental health. 2018; 22(2):190-6.

14. Aanes MM, Hetland J, Pallesen S, Mittelmark MB. Does loneliness mediate the stress-sleep quality relation? The Hordaland Health Study. International psychogeriatrics. 2011; 23(6):994-1002.

15. Visser MA, El Fakiri F. The prevalence and impact of risk factors for ethnic differences in loneliness. The European Journal of Public Health. 2016; 26(6):977-83.

16. Aylaz R, Akturk U, Erci B, Ozturk H, Aslan H. Relationship between depression and loneliness in elderly and examination of influential factors. Archives of gerontology and geriatrics. 2012;55(3):548-54.
17. Lisa M. Jaremka, Rebecca R. Andridge, Fagundes CP. Supplemental Material for Pain, Depression, and Fatigue: Loneliness as a Longitudinal Risk Factor. Health Psychology. 2014; 33(9):948-57.

18. Richard A, Rohrmann S, Vandeleur CL, Schmid M, Barth J, Eichholzer M. Loneliness is adversely associated with physical and mental health and lifestyle factors: Results from a Swiss national survey. PloS one. 2017;12(7):e0181442.

19. Yang K. Longitudinal Loneliness and Its Risk Factors among Older People in England. Canadian journal on aging = La revue canadienne du vieillissement. 2018;37(1):12-21.

20. Tomstad S, Dale B, Sundsli K, Saevareid HI, Söderhamn U. Who often feels lonely? A cross-sectional study about loneliness and its related factors among older home-dwelling people. International Journal of Older People Nursing. 2017; 12(4):e12162.

21. Arpin SN, Mohr CD, Brannan D. Having friends and feeling lonely: a daily process examination of transient loneliness, socialization, and drinking behavior. Personality & social psychology bulletin. 2015; 41(5):615-28.

22. Zhu Y LJ, Qu B. Quality of life, loneliness and health-related characteristics among older people in Liaoning province, China: a cross-sectional study. BMJ open. 2018; 8(11):e0211822.

23. Beutel ME, Klein EM, Brähler E, Reiner I, Jünger C, Michal M, Wiltink J, Wild PS, Münzel T, Lackner KJ et al. Loneliness in the general population: prevalence, determinants and relations to mental health. BMC Psychiatry. 2017; 17(1):97.

24. Zawadzki MJ, Graham JE, Gerin W. Rumination and anxiety mediate the effect of loneliness on depressed mood and sleep quality in college students. Health psychology : official journal of the Division of Health Psychology, American Psychological Association. 2013;32(2):212-22.
25. Segrin C, Burke TJ. Loneliness and sleep quality: dyadic effects and stress effects. Behavioral sleep medicine. 2015;13(3):241-54.

26. Cacioppo JT, & Cacioppo, S. Loneliness in the modern age: An evolutionary theory of loneliness (ETL). Advances in Experimental Social Psychology. 2018; 58:127-97.

27. Wakefield JRH, Bowe M, Kellezi B, Butcher A, Groeger JA. Longitudinal associations between family identification, loneliness, depression, and sleep quality. British journal of health psychology. 2019;():1-16.

28. Matthews T, Danese A, Gregory AM, Caspi A, Moffitt TE, Arseneault L. Sleeping with one eye open: loneliness and sleep quality in young adults. Psychological medicine. 2017;47(12):2177-86.

29. McHugh JE, Lawlor BA. Perceived stress mediates the relationship between emotional loneliness and sleep quality over time in older adults. British journal of health psychology. 2013;18(3):546-55.

30. Gu D SJ, Pipkin R. Sociodemographic and health correlates of sleep quality and duration among very old Chinese. Sleep medicine reviews. 2010;33(5):601-10.

31. Hawkley LC, Preacher KJ, Cacioppo JT. Loneliness impairs daytime functioning but not sleep duration. Health psychology : official journal of the Division of Health Psychology, American Psychological Association. 2010; 29(2):124-9.

32. Yu B, Steptoe A, Niu K, Ku PW, Chen LJ. Prospective associations of social isolation and loneliness with poor sleep quality in older adults. Quality of life research : an international journal of quality of life aspects of treatment, care and rehabilitation. 2018;27(3):683-91.

33. Hu W, Lu J. Associations of chronic conditions, APOE4 allele, stress factors, and health behaviors with self-rated health. BMC geriatrics. 2015;15:137.

34. John E. Ware J, Sherbourne CD. The MOS 36-item Short-Form Health Survey (SF36): I.
Conceptual framework and item selection. Medical Care. 1992; 30(6):473-83.

35. Arslantaş H AF, Abacigil Ergin F, Kayar D, Acar G. Loneliness in Elderly People, Associated Factors and Its Correlation with Quality of Life: A Field Study from Western Turkey. Iran J Public Health. 2015; 44(1):43-50.

36. Russell DW. UCLA Loneliness Scale (Version 3): reliability, validity, and factor structure. J Pers Assess. 1996; 66(1):20-40.

37. Ponizovsky AM, Ritsner MS. Patterns of loneliness in an immigrant population. Comprehensive psychiatry. 2004; 45(5):408-14.

38. Heinrich LM, Gullone E. The clinical significance of loneliness: a literature review. Clinical psychology review. 2006; 26(6):695-718.

39. Perry GR. Loneliness and coping among tertiary-level adult cancer patients in the home. Cancer Nurs. 1990; 13(5):293-302.

40. Chen Y, Hicks A, While AE. Loneliness and social support of older people living alone in a county of Shanghai, China. Health & social care in the community. 2014; 22(4):429-38.

41. Buysse. DJ, Charles F. Reynolds III, Timothy H. Monk, Susan R. Berman, Kupfer DJ. The Pittsburgh sleep quality index: A new instrument for psychiatric practice and research. Psychiatry research. 1989; 28(2):193-213.

42. Zhang HS, Xu YM, Zhu JH, Zhong BL. Poor sleep quality is significantly associated with low sexual satisfaction in Chinese methadone-maintained patients. Medicine. 2017; 96(39):e8214.

43. Fangya, Chao HS, ding z. Interaction and joint influence of living style and loneliness on self-rated health of the elderly. Chinese Journal of Gerontology. 2016; 36(10):2502-5.

44. Li J, Yao Y-s, Dong Q, Dong Y-h, Liu J-j, Yang L-s, Huang F. Characterization and
factors associated with sleep quality among rural elderly in China. Archives of gerontology and geriatrics. 2013;56(1):237-43.

45. Nyqvist F, Cattan M, Conradsson M, Näsman M, Gustafsson Y. Prevalence of loneliness over ten years among the oldest old. Scandinavian Journal of Public Health. 2017;45(4):411-8.

46. Hawkley LC, Kocherginsky M. Transitions in Loneliness Among Older Adults: A 5-Year Follow-Up in the National Social Life, Health, and Aging Project. Research on Aging. 2017;40(4):365-87.

47. Cacioppo JT, Hughes ME, Waite LJ, Hawkley LC, Thisted RA. Loneliness as a specific risk factor for depressive symptoms: cross-sectional and longitudinal analyses. Psychol Aging. 2006;21(1):140-51.

48. Liu LJ, Guo Q: Loneliness and health-related quality of life for the empty nest elderly in the rural area of a mountainous county in China. Quality of life research . an international journal of quality of life aspects of treatment, care and rehabilitation. 2007;16(8):1275-80.

49. Gangwisch JE, Heymsfield SB, Boden-Albala B, Buijs RM, Kreier F, Pickering TG, Rundle AG, Zammit GK, Malaspina D. Short sleep duration as a risk factor for hypertension: analyses of the first National Health and Nutrition Examination Survey. Hypertension. 2006;47(5):833-9.

50. Patel SR, Hu FB. Short sleep duration and weight gain: a systematic review. Obesity. 2008;16(3):643-53.

51. Qian Y, Sun L, Zhou C, Ge D, Zhang L. The association between suicidal ideation and sleep quality in elderly individuals: A cross-sectional study in Shandong, China. Psychiatry research. 2017;256:453-7.

52. Kurina LM, Knutson KL, Hawkley LC, Cacioppo JT, Lauderdale DS, Ober C. Loneliness
is associated with sleep fragmentation in a communal society. Sleep. 2011;34(11):1519-26.

53. Cacioppo JT, Hawkley LC, Berntson GG, Ernst JM, Gibbs AC, Stickgold R, Hobson JA. Do lonely days invade the nights? Potential social modulation of sleep efficiency. Psychological science. 2002;13(4):384-7.

54. Levin R, Nielsen TA. Disturbed dreaming, posttraumatic stress disorder, and affect distress: a review and neurocognitive model. Psychological bulletin. 2007;133(3):482-528.

55. Smith SS, Kozak N, Sullivan KA. An investigation of the relationship between subjective sleep quality, loneliness and mood in an Australian sample: can daily routine explain the links? The International journal of social psychiatry. 2012;58(2):166-71.

56. Segrin C, Domschke T. Social support, loneliness, recuperative processes, and their direct and indirect effects on health. Health communication. 2011;26(3):221-32.

57. Chopik WJ. The Benefits of Social Technology Use Among Older Adults Are Mediated by Reduced Loneliness. Cyberpsychology, behavior and social networking. 2016;19(9):551-6.

Tables

Table 1 Comparison of Loneliness Scores among Rural Elderly with Different Characteristics(Mean ± SD)

| Variables        | N(%) | Loneliness score | F/t  | P   |
|------------------|------|------------------|------|-----|
|                  |      |                  |      |     |
| **Sex:**         |      |                  |      |     |
| Male             | 818(49.3) | 42.81±9.54 | -1.531 | 0.126 |
| Female           | 840(50.7)  | 43.52±9.37 |      |      |
| **Age:**         |      |                  |      |     |
| 60–69            | 840(50.7)  | 42.24±9.47 | 10.781 | 0.000 |
| 70–79            | 566(34.1)  | 43.64±9.50 |      |      |
| 80+ years older  | 252(15.2)  | 45.21±8.94 |      |      |
| Marital status:                | 1158(69.8) | 42.65±9.40 | -3.431 | 0.001 |
|--------------------------------|------------|------------|--------|-------|
| Couple                         | 1158(69.8) | 42.65±9.40 | -3.431 | 0.001 |
| Others*                        | 500(30.2)  | 44.38±9.49 |        |       |
| Occupation:                    |            |            |        |       |
| Manual labour                  | 1045(63.0) | 41.37±9.34 | -10.588| 0.000 |
| Mental labour                  | 613(37.0)  | 46.24±8.86 |        |       |
| Degree of education:           |            |            |        |       |
| Primary school or below        | 1145(69.1) | 42.06±9.48 | 26.500 | 0.000 |
| Junior school                  | 266(16.0)  | 45.82±9.13 |        |       |
| High school and above          | 247(14.9)  | 45.47±8.72 |        |       |
| Economic sources:              |            |            |        |       |
| Farming income                 | 628(37.9)  | 40.44±9.63 | -9.244 | 0.000 |
| Support from children and others | 1030(62.1)| 44.83±8.96 |        |       |
| Economic income(yuan):         |            |            |        |       |
| <1000                          | 516(31.1)  | 42.66±9.54 | 4.852  | 0.002 |
| 1000~3000                      | 401(24.2)  | 42.71±9.00 |        |       |
| 3000~5000                      | 415(25.0)  | 42.86±9.42 |        |       |
| ≥5000                          | 326(19.7)  | 44.95±9.75 |        |       |
| Smoking:                       |            |            |        |       |
| Yes                            | 512(30.9)  | 41.92±9.88 | -3.515 | 0.000 |
| No                             | 1146(69.1) | 43.73±9.21 |        |       |
| Drinking:                      |            |            |        |       |
| Yes                            | 765(46.1)  | 42.14±9.45 | -4.134 | 0.000 |
| No                             | 893(53.9)  | 44.05±9.38 |        |       |
| Relationship with family members: |        |            |        |       |
| Good                           | 1570(94.7) | 43.06±9.42 | -2.007 | 0.045 |
| Bad                            | 88( 5.3)   | 45.14±9.89 |        |       |
| Empty nester:                  |            |            |        |       |
| Yes                            | 501(30.2)  | 45.77±8.91 | 56.299 | 0.000 |
| No                             | 1157(69.8) | 42.04±9.47 |        |       |
| Number of children:            |            |            |        |       |
| 0                              | 36( 2.2)   | 44.64±7.45 | 17.162 | 0.000 |
| 1                              | 251(15.1)  | 46.76±9.08 |        |       |
| 2                              | 453(27.3)  | 43.34±9.58 |        |       |
| 3+                             | 918(55.4)  | 42.05±9.32 |        |       |
| BMI:                           |            |            |        |       |
| Lean                           | 146( 8.8)  | 42.95±9.57 | 1.980  | 0.138 |
| Normal                         | 776(46.8)  | 42.73±9.63 |        |       |
| Overweight+                    | 736(44.4)  | 43.68±9.22 |        |       |
NCDs:

|   | Yes       | No        |
|---|-----------|-----------|
|   | 668(32.8) | 990(67.2) |
|   | 44.80±8.93| 42.07±9.65|
|   | 33.769    | 0.000     |

\(^a\) others means those who are unmarried (1.7\%), divorced (6.5\%), widowed (22.0\%).

Table 2 Comparison of the psqi and its component scores with different levels of loneliness in Shandong, China (2016) (mean±s)

| PSQI                  | Total score | Different levels of loneliness |    |      |    |
|-----------------------|-------------|--------------------------------|----|------|----|
|                       |             | Low                           | Moderate | High | F  | P   |
| Sleep quality         | 6.67±3.42   | 5.36±2.83                     | 6.69±3.23 | 7.55±3.89 | 38.104 | 0.000 |
| Subjective sleep quality | 1.14±0.76   | 1.06±0.64                     | 1.17±0.72 | 1.11±0.91 | 2.680   | 0.069 |
| Sleep latency         | 1.24±0.90   | 0.90±0.83                     | 1.23±0.91 | 1.48±0.86 | 38.583   | 0.000 |
| Sleep duration        | 0.61±0.84   | 0.30±0.62                     | 0.58±0.83 | 0.88±0.91 | 45.337   | 0.000 |
| Habitual sleep efficiency | 0.84±1.04   | 0.78±1.01                     | 0.85±1.05 | 0.87±1.05 | 0.840   | 0.432 |
| Sleep disturbances    | 1.34±0.67   | 1.21±0.50                     | 1.36±0.61 | 1.38±0.86 | 6.667    | 0.001 |
| Use of sleeping medication | 0.36±0.76   | 0.17±0.52                     | 0.32±0.69 | 0.59±0.96 | 32.302   | 0.000 |
| Daytime dysfunction   | 1.15±0.78   | 0.94±0.63                     | 1.17±0.71 | 1.23±0.99 | 13.317   | 0.000 |

Table 3 Associations between sleep quality and loneliness in the rural elderly individuals in Shandong, China (2016)

| Variables               | Loneliness          | Model 1 | Model 2 | Model 3 |
|-------------------------|----------------------|---------|---------|---------|
|                         | OR95% CI             | p       | OR95% CI| p       | OR95% CI| p       |
| Age:                    |                      |         |         |         |
| 60’s                    | 1                    | 1       | 1       | 1       |
| 70’s                    | 1.950(1.448-2.627)   | 0.000   | 1.465(1.167-1.839) | 0.013 | 1.443(1.148-1.815) | 0.002 |
| 80+                     | 1.470(0.172-1.840)   | 0.001   | 1.866(1.382-2.519) | 0.000 | 1.795(1.324-2.433) | 0.000 |
| Sex:                    |                      |         |         |         |
| Female                  | 1                    | 1       | 1       | 1       |
|                          | Male               | 0.885(0.72-1.085) | 0.241 | 0.898(0.732-1.102) | 0.304 | 0.904(0.736-1.112) | 0.340 |
|------------------------|--------------------|-------------------|-------|-------------------|-------|-------------------|-------|
| Marital status:        |                    |                   |       |                   |       |                   |       |
| Othersa                | 1                  | 1                 | 1     |                   |       |                   |       |
| Couple                 | 1.148(0.91-1.438)  | 0.231             | 1.191(0.949-1.495) | 0.131 | 1.172(0.933-1.473) | 0.172 |
| Degree of education:   |                    |                   |       |                   |       |                   |       |
| Primary school or      | 1                  | 1                 | 1     |                   |       |                   |       |
| below                  | 1.752(1.30-2.351)  | 0.000             | 1.749(1.300-2.351) | 0.000 | 1.664(1.234-2.243) | 0.001 |
| Junior school          | 0.937(0.66-1.319)  | 0.901             | 1.040(0.638-1.271) | 0.552 | 0.876(0.620-1.239) | 0.455 |
| High school and above  |                    |                   |       |                   |       |                   |       |
| Occupation:            |                    |                   |       |                   |       |                   |       |
| Mental labour          | 1                  | 1                 | 1     |                   |       |                   |       |
| Manual labour          | 0.478(0.36-0.619)  | 0.000             | 0.491(0.379-0.637) | 0.000 | 0.552(0.422-0.722) | 0.000 |
| Economic income:       |                    |                   |       |                   |       |                   |       |
| (RMB)                  | less than 1000      | 1                 | 1     |                   |       |                   |       |
| 1000~3000              | 1.169(0.98-1.786)  | 0.245             | 1.220(0.937-1.589) | 0.140 | 1.225(0.939-1.598) | 0.134 |
| 3000~5000              | 0.923(0.70-1.214)  | 0.565             | 0.980(0.744-1.292) | 0.887 | 0.982(0.744-1.296) | 0.897 |
| 5000and above          | 1.324(0.98-1.786)  | 0.066             | 1.201(0.890-1.632) | 0.226 | 1.115(0.820-1.517) | 0.488 |
| Family relationship:   |                    |                   |       |                   |       |                   |       |
| Good                   | 1                  | 1                 | 1     |                   |       |                   |       |
| Bad                    | 1.517(0.98-2.333)  | 0.058             | 1.543(1.002-2.425) | 0.049 | 1.547(1.001-2.387) | 0.049 |
| Empty nester:          |                    |                   |       |                   |       |                   |       |
| No                     | 1                  | 1                 | 1     |                   |       |                   |       |
| Yes                    | 1.519(1.20-1.912)  | 0.000             | 1.553(1.231-1.958) | 0.000 | 1.514(1.198-1.912) | 0.000 |
| Number of children:    |                    |                   |       |                   |       |                   |       |
| 3+                     | 1                  | 1                 | 1     |                   |       |                   |       |
| 2                      | 1.132(0.89-1.433)  | 0.301             | 1.126(0.890-1.428) | 0.322 | 1.065(0.839-1.351) | 0.607 |
| 1                      | 1.950(1.42-2.678)  | 0.000             | 1.946(1.415-2.680) | 0.000 | 1.833(1.327-2.529) | 0.000 |
| 0                      | 1.235(0.62-2.428)  | 0.540             | 1.150(0.583-2.270) | 0.687 | 1.041(0.525-2.063) | 0.910 |
| Smoking:               |                    |                   |       |                   |       |                   |       |
| NO                     | 1                  | 1                 | 1     |                   |       |                   |       |
| Yes                    | 0.746(0.59-2.039)  | 0.013             | 0.855(0.676-1.081) | 0.190 | 0.890(0.715-1.131) | 0.342 |
| Drinking:              |                    |                   |       |                   |       |                   |       |
| NO                     | 1                  | 1                 | 1     |                   |       |                   |       |
| Yes                    | 0.992(0.80-1.228)  | 0.944             | 0.949(0.766-1.176) | 0.634 | 1.022(0.819-1.276) | 0.847 |
| BMI:                   |                    |                   |       |                   |       |                   |       |
| Normal                 | 1                  | 1                 | 1     |                   |       |                   |       |
| Lean                   | 1.206(0.84-1.714)  | 0.295             | 1.212(0.850-1.725) | 0.288 | 1.158(0.811-1.652) | 0.418 |
Figures

Fig. 1 Profile chart of mean of the PSQI scores for different levels of loneliness in rural elderly people
