# BMJ Open

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| Journal: | *BMJ Open* |
|---|---|
| Manuscript ID | bmjopen-2017-016091 |
| Article Type: | Research |
| Date Submitted by the Author: | 31-Jan-2017 |
| Complete List of Authors: | Wang, Guojun; XiangYa School of Public Health, Central South University, Department of Social Medicine and Health Management<br>Hu, Mi; XiangYa School of Public Health, Central South University, Department of Social Medicine and Health Management<br>Xiao, Shuiyuan; Xiangya School of Public Health, Central South Uniiversity, Department of Social Medicine and Health Management<br>Zhou, Liang; Guangzhou Huiai Hospital |
| <b>Primary Subject Heading</b>: | Mental health |
| Secondary Subject Heading: | Public health |
| Keywords: | loneliness, Depression & mood disorders < PSYCHIATRY, Suicide & self-harm < PSYCHIATRY |

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Loneliness, depression and suicidal ideation among rural empty-nest elderly in Liuyang, China: A cross-sectional study

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**Abstract**

**Objective** To investigate loneliness, depressive symptom, major depressive episode, and suicidal ideation among older adults in rural areas in Liuyang county, Hunan, China.

**Methods** A cross-sectional multi-stage random cluster survey was conducted from Nov 2011 to Apr 2012 in Liuyang, China. A total of 839 rural elder residents aged 60 or above completed the survey (response rate = 97.6%). The feeling of loneliness, depressive symptom, and suicide ideation of rural elderly were assessed by the short-form UCLA- Loneliness Scale (ULS-6), the Geriatric Depression Scale (GDS), and one question inquiry regarding suicidal ideation, respectively. Major depressive episode was diagnosed by the Structured Clinical Interview for DSM-IV (SCID-I/P).

**Results** Significant differences were found between empty-nest and not-empty-nest older adults in loneliness ($16.19 \pm 3.90$ vs. $12.87 \pm 3.02$, Cohen D=0.97), depressive symptom ($8.50 \pm 6.26$ vs. $6.92 \pm 5.19$, Cohen D=0.28), and in the prevalence of major depressive episode (10.1% vs. 4.6%), all P values<0.05, while no significant difference was found in the prevalence of suicidal ideation (6.9% vs. 4.4%, *P*>0.05). After controlling for demographic characteristics and physical disease, the differences in loneliness, depressive symptom and major depressive episode remained significant. Path analysis showed that loneliness mediated the relationship between empty-nest and depressive symptoms and major depressive episode.

**Conclusion** Loneliness and depression are severer among empty-nest rural elderly than not-empty-nest ones. Loneliness was a mediating variable between empty-nest living situation and depression.

**Key words**: loneliness, depression, suicidal ideation, empty-nest elderly

Strengths and limitations of the study

Major depressive episode, suicidal ideation were accessed among empty-nest elderly in rural

China, which was rarely focused on among previous studies.

The relationship between living status and mental health status (loneliness, depressive

symptoms and major depressive episode) was explored by AMOS17.0, which was an

underdeveloped research area.

In this study, empty-nest elderly were the participants that all their children had lived out of

the township for at least 10 months in the past 12 months prior to the interview, while

operational definitions of empty-nest elderly of previous studies only considered the living

situation of elderly parents and adult children at the time of investigation.

The sample of this study is older adults (60 or above) in one county in Hunan, China, which is

not a nationally representative sample of rural elderly in China and does not provide

information in urban older adults.

This is a cross-sectional study, which only indicates the correlations between empty-nest and

loneliness, depressive symptoms, and major depressive episode, not aiming at

preventing/intervening depression in this population.

**Introduction**

China has stepped into an aging society at the end of the 20th century along with the rapid

economic development, extension of life expectancy, and further reduction of fertility. The

Sixth National Census in 2010 showed that 13.3% of the total population was aged 60 and

above, with an increase of 2.9% comparing to the Fifth National Census in 2000.[1] It was

estimated that the proportion of people aged 60 and above would reach one third by 2050 [1].

Such data describe an accelerated aging progress in China. During the process of rapid aging,

modernization and urbanization are also dramatic in China. Approximately 252 million rural

residents had moved to and lived in urban areas by the end of 2014, 78% of whom aged from

15 to 59 [2]. Therefore, a huge number of rural older adults are left behind. Traditionally,

elderly are taken care of by their family members, mainly spouses and adult children, in

China. The disorganization of extended family in recent years has put older adults in a

so-called 'empty-nest' situation that no adult children are available when they need help.

Mental health status of rural elderly, especially empty-nest rural elderly, has become a

serious concern in China [3-6]. There have been a number of studies focused on different

aspects of mental health in this population, mainly on loneliness and depressive symptoms.

Loneliness is a negative affective state, which is experienced when a person perceives them as

socially isolated, or has insufficient quality and/or quantity of social connection[7-9]. A

cross-sectional study in Anhui province showed that 78.1% of the aged population had

moderate to severe levels of loneliness (n=5652) [10]. In a population-based survey in Hubei

province, the authors reported 54.5% empty-nest group had moderate or high loneliness,

which was higher than 44.4% in the not-empty-nest group (n=590)[11]. A comparative study

in rural Hubei province reported that the feeling of loneliness and depressive symptoms were higher in empty-nest elderly than in not-empty-nest elderly ($35.93 \pm 9.37$ vs $34.08 \pm 9.30$, p=0.017; $8.81 \pm 6.50$ vs $7.66 \pm 6.09$, p=0.028, respectively) [12]. Depressive symptoms are also common in empty-nest elderly. A meta-analysis showed that depression affects 40.4% of empty-nest rural elderly in China (95% confidence interval [CI]: 28.6% to 52.2%). [11] In a study in Yongzhou city, the authors reported that the prevalence of depression (mild depression or above) of empty-nest elderly was higher than that of not-empty-nest (79.7% vs 67.9%, p=0.003) [13]. These studies consistently reported that empty-nest was correlated with worse mental health outcomes.

However, there are methodological limitations in these researches. The definitions of empty-nest elderly differed in different studies. For example, empty-nest elderly was defined as those who had children, but did not live with any of their children together [3]; as those who did not live with their children or did not have any children [14]; as those without children or those with children who had already left their care, and thus, these older adults live alone or with a spouse [15]. These operational definitions of empty-nest elderly only considered the living situation of elderly parents and adult children at the time of investigation. But in the real world, adult children may come back and forth between urban and rural areas. When they do not live with their parents in the same household, they may live nearby (for example, in the same village) that allows them to visit and take care of the parents conveniently. Therefore, empty-nest status of elderly should not be determined simply by asking if the elderly live with their children or nor at the time of investigation.

The purpose of this study was to compare the feeling of loneliness, depressive symptoms,

major depressive episode, and suicidal ideation between empty-nest and not-empty-nest older adults in a community-based survey in Liuyang city, Hunan province, China. We hypothesize that the empty-nest rural elderly aged 60 and above are more susceptible to major depressive episode, suicidal ideation, feeling of loneliness, and depressive symptoms compared with the not-empty-nest individuals. Furthermore, we hypothesize that loneliness is the mediating factor in the relations between empty-nest and depressive symptoms, major depressive episode, and suicidal ideation.

**Methods**

**Samples and sampling**

Multi-staged randomized cluster sampling method was used (Fig.1). Two out of thirty-three townships in Liuyang, Hunan, China, were randomly selected, then two villages were randomly selected from each township, and later, two village teams (the smallest rural community in China) were randomly selected from each village. Finally, a total of eight village teams were included.

The sample only involved adults aged 60 and above who were inhabitants in rural Liuyang. The inclusion criteria were: (1) age $\geq$ 60, (2) living in the survey site for at least half year, (3) being at home during the investigation period, and (4) being able to participate in the study. Of the 1,058 elderly in the survey site, 860 elderly met the inclusion criteria and 839 questionnaires were drawn back, with a response rate of 97.6%.

In this study, empty-nest elderly were the participants that all their children had lived out of the township for at least 10 months in the past 12 months prior to the interview. According to the definition of empty-nest, 25 participants who had no child were excluded, and the rest 814

elderly with at least one child were included for analysis.

### Instruments and measures

General information questionnaire

We used a self-designed questionnaire consisting of demographic data, including age, gender, marital status, educational level, annual income per household, physical disease, number of children, and residence status. Information about where each child of the participant lived and how long they lived there in the last 12 months prior to the interview were also collected.

University of California at Los Angeles (UCLA)-Loneliness Scale Short-form (ULS)

This scale was developed to determine the perception of loneliness degree. It consists of 8 questions which are scored from 1 to 4 points. [8] During the translation and validation of the Chinese version of ULS-8, two items were deleted. Therefore the scores of ULS-6 ranged from 4 to 24, while a higher score indicates more intense feeling of loneliness. This instrument showed satisfactory reliability and validity in previous study in China [16].

The Geriatric Depression Scale (GDS)

GDS was created by Brink (1982). Here its Chinese revision was used to assess the depression level. GDS has a retest reliability of 0.85 and a convergent validity of 0.82.[17] GDS is frequently used as special table to screen the elderly depression symptoms. Depression was measured by 30-item. Specifically, a subject was asked to express his/her feelings in the previous 2 weeks. Each item had two answers: ''yes'' or ''no''. Ten entries in 30-item were scored with inverse sequential (the negative answer means depression), and other 20 entries with positive sequence (the affirmative answer shows the existence of

depression), One answer that represents depression will be given one point. The scores ranged

from 0 to 30 and showed the depression degree as reported by the elderly. A higher score

indicates higher level of depression experienced by an older adult. Generally, the GDS scores

0–10, 11–20, and 21–30 are considered to be normal, minimal to mild depression, and

moderate to severe depression, respectively[18].

Structured Clinical Interview for DSM-IV Axis I Disorders-Non-Patient Edition

(SCID-I/NP)

The Chinese revision of SCID was used to screen and diagnose major depressive episode.

A major depressive episode is defined by the presence of 5 or more out of nine symptoms for

at least two weeks in the month prior to interview, and at least one of the two core symptoms

must present (i.e., a person suffering from a major depressive episode must have either a

depressed mood or loss of interest or pleasure in daily activities consistently).

Suicide Ideation

One single question was used to determine whether the participant had suicidal ideation:

Have you ever seriously considered suicide in the past year?

Physical disease

Participants were asked to report their physical diseases that were diagnosed by physicians.

**Procedures and quality control**

Face-to-face interviews were conducted to collect information from 23 Nov. 2011 to 20 Apr.

2012. Totally 12 interviewer including10 medical postgraduates and 2 medical undergraduates

were involved. They were divided into two groups and received a standardized training for

one week. After training, pilot studies were conducted in 2 sites. To improve the response rate

of household investigation, we selected some locals as guides who had a high reputation,

understood and supported our research, and communicated with the participants masterly.

Most of the interviews were conducted in private spaces of the households. Prior to an

interview, the participant was informed about the background and purpose of our research.

Both parties read and signed the informed consent forms detailing the right of interviews.

This study was approved by Central South University, Changsha, Hunan, China. Two

experienced investigators, one from each group of interviewers, were responsible for quality

control. Measures of quality control during the interviews included: observing and monitoring

the quality of interview, collecting all finished questionnaires every day, checking the logical

errors and missing items, and determining whether the investigator should re-interview the

respondent so as to obtain the missing items and correct the logical errors. During the survey,

we randomly selected 45 cases for re-tests one to two weeks after the initial interview, which

were conducted by one investigator who was blind to the results of the primary interviews.

The test-retest correlation coefficients of ULS-6 and GDS were 0.722 and 0.702, respectively.

### Statistical method

Statistical analyses were performed on SPSS 17.0 (SPSS/IBM, Chicago, IL). Demographic

characteristics of the 814 rural elderly were compared by Chi-square test or Wilcoxon rank

sum test. Scores of ULS-6 or GDS between empty-nest and not-empty-nest rural elderly were

compared by t-test. Suicide ideation or major depressive episode between empty-nest and

not-empty-nest rural elderly were compared via Chi-square test. The relationships between

living situation, loneliness and depressive symptom among rural elderly were studied via

multiple linear regressions by controlling age, gender, marital status, income, educational

level, and physical disease. The risk factor of suicide ideation and major depressive episode

was explored via binary logistic regression. The significance level was set at P<0.05. The

inclusion criterion and exclusion criterion were 0.05 and 0.10, respectively.

To examine the hypothesis that loneliness mediates the relations between empty-nest and

depression, path analysis was conducted using AMOS 17.0. Living situation (empty-nest or

not), loneliness, depression symptom, and major depressive episode were included in the

models. The minimum fit function chi-square (CMIN), CMIN/DF, comparative fit index

(CFI), the incremental fit index (IFI), and the root mean square error of approximation

(RMSEA) with 90% confidence intervals were used to estimate the model fit.

**Results**

**Demographic characteristics**

Among the included 814 rural elderly (426 men and 388 women), 335 (41.2%) were

empty-nest elderly and 479 (58.8%) were not-empty-nest elderly. The participants aged from

60 to 90 years (mean 69.1 ± 7.1) and the years of school educational ranged from 0 to 15

years (mean 3.5 ± 2.8). The comparison of demographic characteristics between empty-nest

and not-empty-nest groups was shown in Table 1. No significant differences between groups

were found in age, gender, marital status, educational level, annual income per household, and

physical disease (all *P*>0.05).

**Between-group comparison of loneliness, depressive symptom, major depressive episode**

**and suicidal ideation**

Between-group comparisons of ULS-6 score, GDS score, major depressive episode and

suicide ideation were shown in Table 2. The mean scores of loneliness and depressive

symptom, or prevalence of major depressive episode are significantly higher in the empty-nest group (all *p values* <0.05). The effect size of empty-nest on loneliness was high significant, while that on depressive symptoms was low significant (Cohen D=0.97, 0.28, respectively). No significant difference between the empty-nest and not-empty-nest groups was found in prevalence of suicide ideation (6.9% vs. 4.4%, *P*>0.05).

**Multivariate analysis**

The results of multiple linear regression of ULS-6 scores and GDS scores were shown in Table 3 and 4. The independent variables involved in the linear regression models were gender, age, marital status, annual income per household, educational level, physical disease, living situation (empty-nest or not-empty-nest). Those who were empty-nest elderly and who had unstable marital status and physical diseases had significantly higher scores of ULS-6. Those who were empty-nest elderly and who had lower education level and income, unstable marital status, and physical diseases showed significantly higher scores of GDS.

Using the same set of independent variables, logistic regression model was used to compare suicide ideation and major depressive episode between empty-nest and not-empty-nest elderly (table 5). Empty-nest situation was correlated to higher prevalence of major depressive episode (OR = 2.41, 95% CI = 1.34 - 4.34), but not to suicide ideation (OR=1.55, 95% CI = 0.83 - 2.92). Lower income and physical diseases were also risk factors of major depressive episode, while only physical disease was correlated to suicidal ideation.

**Path analysis**

Based on the results of regressive model, we established two path analysis models to explore the relationship between living situation, loneliness, depressive symptom and major

depressive episode (figure 2). In model 1, there are six hypotheses. The fit indexes were not satisfying for this model (CMIN=0, IFI=1, CFI=1, RMSEA=0.343).

We then removed the path between living situation and depressive symptom and the path between living situation and major depressive episode, and created model 2. In model 2, there are four hypotheses. The first one was that living situation had a direct effect on loneliness (0.43). The second one was that loneliness had direct effect on depressive symptom (0.42). The third one was that loneliness had direct effect on major depressive episode (0.32). Loneliness played a mediating role between living situation, depressive symptom and major depressive episode. The fit indexes were satisfying for this model (*CMIN=2.896, CMIN/DF*=1.448, p=0.235, IFI=0.998, CFI=0.998, RMSEA=0.023).

**Discussion**

We found that after controlling for demographic characteristics and physical diseases, empty-nest older adults had significantly higher level of feeling of loneliness and depressive symptoms, and higher prevalence of major depressive episode. Moreover, the relationships between empty-nest and depression were mediated by loneliness. However, there was no significant difference in the prevalence of suicidal ideation between empty-nest and not-empty-nest elderly. These results supported our hypothesis that the separation of rural elderly and their adult children may have negative impact on the mental health among rural elderly.

Empty-nest living situation is associated with elevated level of loneliness in rural elderly (*Cohen D=0.97*). After controlling for demographic variables and physical disease, the difference remained statistically significant. This is consistent with a previous study reporting

a higher loneliness rate in empty-nest elderly [3]. Other risk factors for loneliness include unstable marital status and physical condition. Loneliness is a subjective feeling related to low quantity and/or quality interpersonal relationship. Our results indicate that adult children and spouses are important resources of social support for rural elderly. Physical diseases may cause loneliness through limiting the ability of rural elderly to participate in social activities.

The GDS scores of empty-nest was higher than that of not-empty-nest in rural elderly (Cohen D=0.28). This result is consistent with a previous study reporting the mean score of GDS among rural elderly is 8.73[19]. The prevalence of major depressive episode is also significantly higher in empty-nest older adults (10.1% vs. 4.6%, *p<0.05*), both are higher than the prevalence of major depressive disorder reported among adults aged 15 and over in four provinces in China (3.2%).[20] Therefore, empty-nest rural elderly are more likely to suffer from both depressive symptoms and major depressive episode. Other risk factors of depressive symptoms include unstable marital status, lower education level, lower income, and physical diseases, while only lower income and physical diseases are correlated to major depressive episode. These results are consistent with previous studies that lower socio-economic status and physical diseases are risk factors for depression.[21]

The prevalence of suicide ideation among empty-nest and not-empty-nest rural elderly are 6.9% and 4.4%, respectively (p>0.05). The prevalence of suicide ideation among rural empty-nest elderly is lower than previously reported among rural elderly in Macheng city (7.3%)[22] and Heyang county (21.5%) [23], and lower than the pooled result among Chinese elderly (11.5%)[24] The lower prevalence of suicide ideation in our study might be attributed to the strict definition. However, our result is higher than that among urban elderly in

Beijing.[25] Despite being related to elevated level of loneliness, depressive mood, and major depressive episode, empty-nest is not related to suicide ideation among rural elderly, which need further investigation.

The path analysis shows that there are no significant direct effects of empty-nest on depression among rural elderly, and loneliness is the mediating factor between empty-nest and depression. Our findings may have important implications. Depression in rural elderly, particularly among those whose adult children have left them, might be prevented or intervened if we can alleviate the feeling of loneliness. Potential measures include facilitating video and/or audio communications between empty-nest rural elderly and their adult children who are living and working in urban areas[26]; encouraging or organizing local group activities to promote social integration and to increase social support among rural older adults[27]; providing peer support by identifying younger and capable older adults who are willing to help other elderly people voluntarily[28]. Loneliness is not only related to adverse mental health outcomes, but also to a variety of medical conditions, such as cardiovascular disease, diabetes, dementia, and all-cause mortality. [29-33] Therefore, it is important to develop and validate intervention approaches targeting social connections for elderly in rural China, as well as in other countries.

There are several limitations need to be considered when interpreting our results. First, the sample of this study is older adults (60 or above) in one county in Hunan, China. It is not a nationally representative sample of rural elderly in China and does not provide information in urban older adults. Empty-nest situation may differ in different parts of China. Rural residents in better developed rural communities, such as in the East and/or Coast areas, are probably

less likely to be migrant workers. Therefore, older adults in these areas are less likely to be

empty-nest. Second, this is a cross-sectional study. Our results only indicate the correlations

between empty-nest and loneliness, depressive symptoms, and major depressive episode.

Further intervention studies aiming at preventing/intervening depression in this population

through providing social connections and promoting social integration are warranted.

**Ethical and consent to participate statement**

This study was approved by the Ethical Review Committee of the School of Public Health of Central South University. Each participant has provided written informed consent prior to participating in the study.

**Acknowledgments**

The authors would like to thank village cadres for guiding us to visit each household in the rural regions of Liuyang county, Hunan province, China.

**Footnotes**

**Contributors**    LZ and SYX conceived and designed the study. GJW, MH, SYX collected the data. GJW and LZ analyzed and interpreted the data. GJW drafted the article, while LZ, MH and SYX critically revised it for intellectual consent. All the authors gave final approval to the version submitted for publication.

**Role of funding**    This work was supported by the National Science and Technology Support Program, China. (LZ, No.2009BAI77B03 and SYX, 2009BAI77B01)

**Source Conflict of interest**    All authors declare that they have no conflicts of interest.

**Patient consent**    Obtained.

**Ethics approval**    Ethical Review Committee of the XiangYa School of Public Health of Central South University.

**Provenance and peer review**    Not commissioned, externally peer review.

**Data sharing statement**    All data and materials related to the study can be obtained through contacting to the first author at guojun-wang@hotmail.com.

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Table1. Demographic characteristics

| Variables | not-empty-nest (n=479) | | Empty-nest (n=335) | | Total (n=814) | | $\chi^2$ /Z | $p$ |
|---|---|---|---|---|---|---|---|---|
| | N | % | N | % | N | % | | |
| Age(years) | | | | | | | | |
| 60~65 | 171 | 35.7 | 134 | 40.0 | 305 | 37.5 | 3.469 | 0.483 |
| 66-70 | 113 | 23.6 | 80 | 23.9 | 193 | 23.6 | | |
| 71~75 | 103 | 21.5 | 61 | 18.1 | 164 | 20.1 | | |
| 76~80 | 59 | 12.3 | 33 | 9.9 | 92 | 11.4 | | |
| 81~ | 33 | 6.9 | 27 | 8.1 | 60 | 7.4 | | |
| Gender | | | | | | | | |
| Male | 251 | 52.4 | 175 | 52.2 | 426 | 52.3 | 0.002 | 1.000 |
| Female | 228 | 47.6 | 160 | 47.8 | 388 | 47.7 | | |
| Marital status | | | | | | | | |
| Married | 370 | 77.2 | 239 | 71.3 | 609 | 74.8 | 3.643 | 0.059 |
| Divorced/separated/widowed /never married | 109 | 22.8 | 96 | 28.7 | 205 | 25.2 | | |
| Educational level | | | | | | | | |
| Below Primary school | 127 | 26.5 | 88 | 26.3 | 215 | 26.4 | 0.254 | 0.881 |
| Primary school | 291 | 60.8 | 208 | 62.1 | 499 | 61.3 | | |
| Middle school or above | 61 | 12.7 | 39 | 11.6 | 100 | 12.3 | | |
| Annual income per household (RMB) | | | | | | | | |
| 0~1800 | 183 | 38.2 | 132 | 39.4 | 315 | 38.7 | 0.145 | 0.930 |
| 1801~5000 | 186 | 38.8 | 129 | 38.5 | 315 | 38.7 | | |
| 5001~ | 110 | 23.0 | 74 | 22.1 | 184 | 22.6 | | |
| Physical disease | | | | | | | | |
| Yes | 280 | 58.5 | 197 | 58.8 | 477 | 58.6 | 0.010 | 0.942 |
| No | 199 | 41.5 | 138 | 41.2 | 337 | 41.4 | | |

Table2. Comparison of scores of ULS-6, scores of GDS, major depressive episode, and

suicidal ideation

| Variables | not-empty-nest (n=479) | Empty-nest (n=335) | $\chi^2$ / t | Cohen's d | p |
|---|---|---|---|---|---|
| Scores of ULS-6 (Mean±SD) | 12.87±3.02 | 16.19±3.90 | 13.08 | 0.97 | 0.000 |
| Scores of GDS (Mean±SD) | 6.92±5.19 | 8.50±6.26 | 3.80 | 0.28 | 0.000 |
| Major Depressive Episode (n, %) | 22 (4.6) | 34 (10.1) | 9.500 | --- | 0.003 |
| Suicidal ideation (n, %) | 21 (4.4) | 23 (6.9) | 2.374 | --- | 0.156 |

Cohen's d effect size: Low significance (0.2-0.5), Moderate significance (0.5-0.8), High

significance (>0.8).

Table 3. Multiple linear regression of ULS-6 score

| Independent variables | Coef | Std. coef | t | p |
|---|---|---|---|---|
| Gender | -0.377 | -0.050 | -1.506 | 0.133 |
| Age | 0.029 | 0.055 | 1.613 | 0.107 |
| Marital status | 1.275 | 0.147 | 4.382 | 0.000* |
| Annual income per household | 1.433E-5 | 0.026 | 0.828 | 0.408 |
| Educational level | -0.404 | -0.065 | -1.869 | 0.062 |
| Physical disease | -0.749 | -0.098 | -3.142 | 0.002* |
| Living situation (empty-nest or not-empty-nest) | 3.245 | 0.423 | 13.673 | 0.000* |

*significant at P=0.05

Table 4. Multiple linear regression of GDS score

| Independent variables | Coef | Std. coef | $t$ | $p$ |
|---|---|---|---|---|
| Gender | -0.368 | -0.032 | -0.914 | 0.361 |
| Age | 0.039 | 0.049 | 1.352 | 0.177 |
| Marital status | 1.200 | 0.091 | 2.566 | 0.010* |
| Annual income per household | -9.623E-5 | -0.117 | -3.460 | 0.001* |
| Educational level | -0.959 | -0.102 | -2.761 | 0.006* |
| Physical disease | -2.946 | -0.254 | -7.682 | 0.000* |
| Living situation (empty-nest or not-empty-nest) | 1.465 | 0.126 | 3.839 | 0.000* |

Table 5. Binary logistic regression of suicide ideation and major depressive episode

| Variables | | N | MDE | Suicidal ideation |
|---|---|---|---|---|
| | | | OR(95%CI) | OR(95%CI) |
| Total | | 814 | | |
| Gender | Male | 426 | ref | ref |
| | Female | 388 | 0.56(0.30, 1.04) | 0.54 (0.28, 1.08) |
| Age | 60-65 | 305 | Ref | ref |
| | 66-70 | 193 | 1.16(0.50, 2.69) | 1.26 (0.53, 3.02) |
| | 71-75 | 164 | 1.48(0.65, 3.37) | 1.22(0.50, 2.98) |
| | 75-80 | 92 | 1.84(0.70, 4.86) | 1.02(0.33, 3.22) |
| | 80- | 60 | 1.61(0.54, 4.85) | 1.49(0.46, 4.80) |
| Marital status | Married | 610 | Ref | ref |
| | Divorced/separated/ widowed/Never married | 204 | 1.26(0.67, 2.39) | 1.39(0.69, 2.78) |
| Educational level | Middle school | 215 | Ref | ref |
| | Primary school | 499 | 4.39(0.90,21.37) | 3.82(0.77, 18.83) |
| | Below Primary school | 100 | 2.64(0.60, 11.74) | 2.36(0.53, 10.45) |
| Annual income per household | >5000 | 315 | Ref | ref |
| | 1800~5000 | 315 | 7.54(1.74, 32.62) | 2.70(0.89, 8.15) |
| | <1800 | 184 | 6.01(1.38, 26.26) | 2.27(0.74, 6.94) |
| Physical disease | No | 280 | ref | ref |
| | Yes | 199 | 8.67(3.34, 22.47) | 4.90 (2.02, 11.91) |
| Living situation | Not-empty-nest | 335 | Ref | ref |
| | Empty-nest | 479 | 2.41(1.34, 4.34) | 1.55 (0.83, 2.92) |

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| 1228 aged 60 years and over |

→ 170 not living in the survey areas

| 1058 residents fit the Included criteria |

198 residents were excluded
117 unable to communicate due to serious physical or mental illness
81 absent for three consecutive visits

| 860 residents eligible |

21 did not complete the survey
15 refused
6 dropped out

| 839 completed survey |

Fig 1.Flow chart of participant's enrolment

175x186mm (300 x 300 DPI)

Model 1: Path hypothesis of living situation, loneliness, depressive symptom and major depressive episode.



Model 2: First path hypothesis of living situation, loneliness, depressive symptom and major depressive episode.

**Fig 2.A path diagram showing the observed direct effects between variables using path analysis**

173x186mm (300 x 300 DPI)

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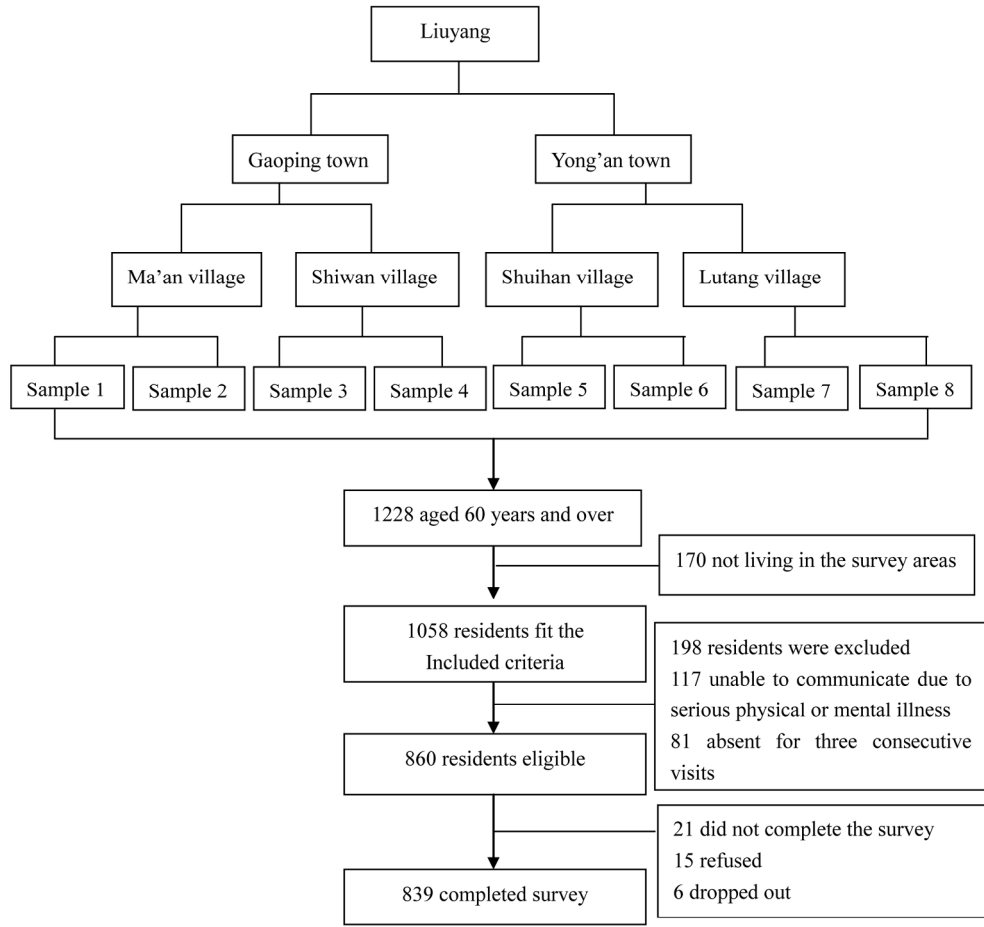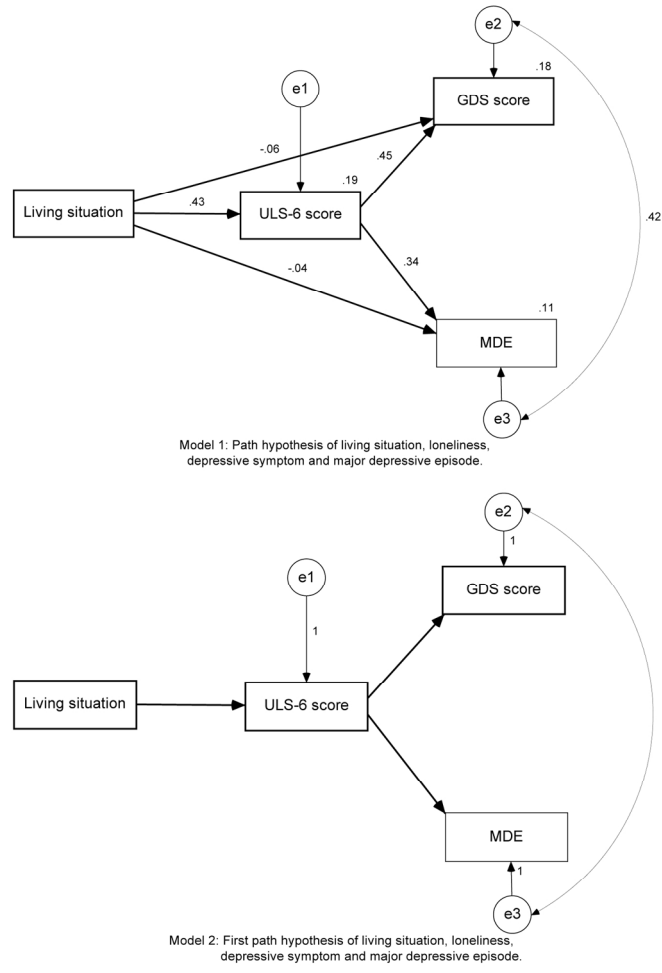**STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies***

| Section/Topic | Item # | Recommendation | Reported on page # |
|---|---|---|---|
| **Title and abstract** | 1 | (*a*) Indicate the study's design with a commonly used term in the title or the abstract | 1 |
| | | (*b*) Provide in the abstract an informative and balanced summary of what was done and what was found | 2 |
| **Introduction** | | | |
| Background/rationale | 2 | Explain the scientific background and rationale for the investigation being reported | 4 |
| Objectives | 3 | State specific objectives, including any prespecified hypotheses | 5-6 |
| **Methods** | | | |
| Study design | 4 | Present key elements of study design early in the paper | 6 |
| Setting | 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection | 6 |
| Participants | 6 | (*a*) Give the eligibility criteria, and the sources and methods of selection of participants | 6 |
| Variables | 7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable | 6,7,8 |
| Data sources/ measurement | 8* | For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group | 6,7,8,18 |
| Bias | 9 | Describe any efforts to address potential sources of bias | 8,9 |
| Study size | 10 | Explain how the study size was arrived at | 6,7,18 |
| Quantitative variables | 11 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why | 6,7,8 |
| Statistical methods | 12 | (*a*) Describe all statistical methods, including those used to control for confounding | 9,10 |
| | | (*b*) Describe any methods used to examine subgroups and interactions | No. |
| | | (*c*) Explain how missing data were addressed | 8 |
| | | (*d*) If applicable, describe analytical methods taking account of sampling strategy | 6,18 |
| | | (*e*) Describe any sensitivity analyses | No. |
| **Results** | | | |

| Participants | 13* | (a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed | 18 |
|---|---|---|---|
| | | (b) Give reasons for non-participation at each stage | 18 |
| | | (c) Consider use of a flow diagram | 18 |
| Descriptive data | 14* | (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders | 10,11,12,20 |
| | | (b) Indicate number of participants with missing data for each variable of interest | 20,21,22 |
| Outcome data | 15* | Report numbers of outcome events or summary measures | 21 |
| Main results | 16 | (*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included | 11,23 |
| | | (*b*) Report category boundaries when continuous variables were categorized | 20,23 |
| | | (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period | 23 |
| Other analyses | 17 | Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses | No. |
| **Discussion** | | | |
| Key results | 18 | Summarise key results with reference to study objectives | 12,13,14 |
| Limitations | 19 | Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias | 14,15 |
| Interpretation | 20 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence | 14,15 |
| Generalisability | 21 | Discuss the generalisability (external validity) of the study results | 14,15 |
| **Other information** | | | |
| Funding | 22 | Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based | 16 |

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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# Loneliness and depression among rural empty-nest elderly in Liuyang, China: A cross-sectional study

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Loneliness and depression among rural empty-nest elderly in Liuyang, China: A

cross-sectional study

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**Abstract**

**Objective** To compare loneliness, depressive symptom, and major depressive episode between empty-nest and non-empty-nest older adults in rural areas in Liuyang county, Hunan, China.

**Methods** A cross-sectional multi-stage random cluster survey was conducted from Nov 2011 to Apr 2012 in Liuyang, China. A total of 839 rural elder residents aged 60 or above completed the survey (response rate = 97.6%). According to the definition of empty-nest, 25 participants who had no child were excluded, and the rest 814 elderly with at least one child were included for analysis. The feeling of loneliness and depressive symptom of rural elderly were assessed by short-form UCLA- Loneliness Scale (ULS-6) and Geriatric Depression Scale (GDS). Major depressive episode was diagnosed using Structured Clinical Interview for DSM-IV (SCID-I).

**Results** Significant differences were found between empty-nest and not-empty-nest older adults in loneliness ($16.19\pm3.90$ vs. $12.87\pm3.02$, Cohen D=0.97), depressive symptom ($8.50\pm6.26$ vs. $6.92\pm5.19$, Cohen D=0.28), and in the prevalence of major depressive episode (10.1% vs. 4.6%), all P values<0.05. After controlling for demographic characteristics and physical disease, the differences in loneliness, depressive symptom and major depressive episode remained significant. Path analysis showed that loneliness mediated the relationship between empty-nest and depressive symptoms and major depressive episode.

**Conclusion** Loneliness and depression are severer among empty-nest rural elderly than not-empty-nest ones. Loneliness was a mediating variable between empty-nest living situation and depression.

**Key words**: loneliness, depression, empty-nest elderly

Strengths

The relationship between living status and mental health status (loneliness, depressive

symptoms and major depressive episode), and the mediating effect of loneliness in the

relationship between empty-nest and depression was an underdeveloped research area.

In this study, empty-nest elderly were the participants that all their children had lived out of

the original township for at least 10 months in the past 12 months prior to the interview, while

the operational definitions of empty-nest elderly of previous studies only considered the

living situation of elderly parents and adult children at the time of investigation.

Limitation:

The sample of this study is older adults (60 or above) in one county in Hunan, China. This is

not a nationally representative sample of rural elderly in China.

This is a cross-sectional study and can only indicate the correlations between empty-nest and

loneliness, depressive symptoms, and major depressive episode.

**Introduction**

China has stepped into an aging society at the end of the 20th century along with the rapid economic development, extension of life expectancy, and further reduction of fertility. The Sixth National Census in 2010 showed that 13.3% of the total population was aged 60 and above, with an increase of 2.9% comparing to the Fifth National Census in 2000.[1] It was estimated that the proportion of people aged 60 and above would reach one third by 2050.[1] Such data describe an accelerated aging progress in China. During the process of rapid aging, modernization and urbanization are also dramatic in China. Approximately 252 million rural residents had moved to and lived in urban areas by the end of 2014, 78% of whom aged from 15 to 59.[2] Therefore, a huge number of rural older adults are left behind. Traditionally, elderly are taken care of by their family members, mainly spouses and adult children, in China. The disorganization of extended family in recent years has put older adults in a so-called 'empty-nest' situation that no adult children are available when they need help. However, it seems that instrumental help is not the only important issue in empty-nest elderly. Previous study in non-immigrant Indian elderly parents indicated that despite they could get help from others and lived their lives independently, the leaving of adult children caused a deep feeling of loneliness in the parents.[3]

Mental health status of rural elderly, especially empty-nest rural elderly, has become a serious concern in China.[4-7] There have been a number of studies focused on different aspects of mental health in this population, mainly on loneliness and depressive symptoms. Loneliness is a negative affective state, which is experienced when a person perceives them as socially isolated, or has insufficient quality and/or quantity of social connection.[8-10] A

cross-sectional study in Anhui province showed that 78.1% of the aged population had moderate to severe levels of loneliness (n=5652) [11]. In a population-based survey in Hubei province, the authors reported 54.5% empty-nest group had moderate or high loneliness, which was higher than 44.4% in the not-empty-nest group (n=590). [12] A comparative study in rural Hubei province reported that the feeling of loneliness and depressive symptoms were higher in empty-nest elderly than in not-empty-nest elderly ($35.93 \pm 9.37$ vs. $34.08 \pm 9.30$, p=0.017; $8.81 \pm 6.50$ vs. $7.66 \pm 6.09$, p=0.028, respectively).[13] Depressive symptoms are also common in empty-nest elderly. A meta-analysis showed that depression affects 40.4% of empty-nest rural elderly in China (95% confidence interval [CI]: 28.6% to 52.2%). [12] In a study in Yongzhou city, the authors reported that the prevalence of depression (mild depression or above) of empty-nest elderly was higher than that of not-empty-nest (79.7% vs. 67.9%, p=0.003). [14] These studies consistently reported that empty-nest was correlated with worse mental health outcomes.

However, there are methodological limitations in these researches. The definitions of empty-nest elderly differed in different studies. For example, empty-nest elderly was defined as those who had children, but did not live with any of their children together;[4] as those who did not live with their children or did not have any children;[15] as those without children or those with children who had already left their care, and thus, these older adults live alone or with a spouse.[16] These operational definitions of empty-nest elderly only considered the living situation of elderly parents and adult children at the time of investigation. But in the real world, adult children may come back and forth between urban and rural areas. For example, most migrant workers will travel back to their home in the countryside and live for several

weeks during the Chinese New Year or other festivals. When they do not live with their

parents in the same household, they may live nearby (for example, in the same village) that

allows them to visit and take care of the parents conveniently. Therefore, empty-nest status of

elderly should not be determined simply by asking if the elderly live with their children or nor

at the time of investigation. In this study, empty-nest elderly were the participants that who

had at least one adult child and all their child/children had lived out of the original township

for at least 10 months in the past 12 months prior to the interview.

The purpose of this study was to compare the feeling of loneliness, depressive symptoms,

and major depressive episode between empty-nest and not-empty-nest older adults in a

community-based survey in Liuyang city, Hunan province, China. We hypothesize that the

empty-nest rural elderly aged 60 and above are more susceptible to major depressive episode,

feeling of loneliness, and depressive symptoms compared with the not-empty-nest individuals.

Furthermore, given that loneliness had been shown to be a predictor of depressive

symptoms,[17][18] we hypothesize that loneliness is the mediating factor in the relations between

empty-nest and depressive symptoms and major depressive episode.

**Methods**

**Samples and sampling**

Multi-staged randomized cluster sampling method was used (Fig.1). Two out of thirty-three

townships in Liuyang, Hunan, China, were randomly selected, then two villages were

randomly selected from each township, and later, two village teams (the smallest rural

community in China) were randomly selected from each village. Finally, a total of eight

village teams were included.

The sample only involved adults aged 60 and above who were inhabitants in rural Liuyang.

The inclusion criteria were: (1) age $\geq$ 60, (2) living in the survey site for at least half year, (3)

being at home during the investigation period, and (4) being able to participate in the study.

Of the 1,058 elderly in the survey site, 860 elderly met the inclusion criteria and 839

questionnaires were drawn back, with a response rate of 97.6%. Living with others besides

one's children, cognitive impairment, or duration of separation from one's children were not

exclusion criteria. Twenty-five participants who had no child were then excluded, and the rest

814 elderly with at least one child were included for analysis.

**Instruments and measures**

General information questionnaire

We used a self-designed questionnaire consisting of demographic data, including age,

gender, marital status, educational level, annual income per household, physical disease,

number of children, and residence status. Information about where each child of the

participant lived and how long they lived there in the last 12 months prior to the interview

were also collected.

Based on the living status of the adult children, the 814 elderly were divided into two

groups, empty-nest and non-empty-nest group. Empty-nest elderly were those all their child

had lived out of the original township for at least 10 months in the past 12 months prior to the

interview. In the non-empty-nest group, at least one adult child of the participant had lived

nearby for more than 2 months in the past 12 months.

University of California at Los Angeles (UCLA)-Loneliness Scale Short-form (ULS)

This scale was developed to determine the perception of loneliness degree. It consists of 8

questions which are scored from 1 to 4 points.[9] During the translation and validation of the

Chinese version of ULS-8, two items were deleted. Therefore the scores of ULS-6 ranged

from 4 to 24, while a higher score indicates more intense feeling of loneliness. This

instrument showed satisfactory reliability and validity in previous study in China.[19]

The Geriatric Depression Scale (GDS)

GDS was created by Brink (1982). Here its Chinese revision was used to assess the

depression level. GDS has a retest reliability of 0.85 and a convergent validity of 0.82.[20] GDS

is frequently used as special table to screen the elderly depression symptoms. Depression was

measured by 30-item. Specifically, a subject was asked to express his/her feelings in the

previous 2 weeks. Each item had two answers: ''yes'' or ''no''. Ten entries in 30-item were

scored with inverse sequential (the negative answer means depression), and other 20 entries

with positive sequence (the affirmative answer shows the existence of depression), One

answer that represents depression will be given one point. The scores ranged from 0 to 30 and

showed the depression degree as reported by the elderly. A higher score indicates higher level

of depression experienced by an older adult. Generally, the GDS scores 0–10, 11–20, and

21–30 are considered to be normal, minimal to mild depression, and moderate to severe

depression, respectively.[21]

Structured Clinical Interview for DSM-IV Axis I Disorders-Non-Patient Edition

(SCID-I/NP)

The Chinese revision of SCID was used to screen and diagnose major depressive episode.

A major depressive episode is defined by the presence of 5 or more out of nine symptoms for

at least two weeks in the month prior to interview, and at least one of the two core symptoms

must present (i.e., a person suffering from a major depressive episode must have either a

depressed mood or loss of interest or pleasure in daily activities consistently).

Physical disease

Participants were asked to report their physical diseases. Diagnoses of chronic illnesses

made by physicians were recorded. When necessary and consented, medical records were

reviewed. Those with at least one diagnosis of chronic illness were classified as 'having a

physical disease'.

**Procedures and quality control**

Face-to-face interviews were conducted to collect information from 23 Nov. 2011 to 20 Apr.

2012. Totally 12 interviewer including10 medical postgraduates and 2 medical undergraduates

were involved. They were divided into two groups and received a standardized training for

one week. After training, pilot studies were conducted in 2 sites. To improve the response rate

of household investigation, we selected some locals as guides who had a high reputation,

understood and supported our research, and communicated with the participants masterly.

Most of the interviews were conducted in private spaces of the households. Prior to an

interview, the participant was informed about the background and purpose of our research.

Both parties read and signed the informed consent forms detailing the right of interviews.

This study was approved by Central South University, Changsha, Hunan, China. Two

experienced investigators, one from each group of interviewers, were responsible for quality

control. Measures of quality control during the interviews included: observing and monitoring

the quality of interview, collecting all finished questionnaires every day, checking the logical

errors and missing items, and determining whether the investigator should re-interview the

respondent so as to obtain the missing items and correct the logical errors. During the survey,

we randomly selected 45 cases for re-tests one to two weeks after the initial interview, which

were conducted by one investigator who was blind to the results of the primary interviews.

The test-retest correlation coefficients of ULS-6 and GDS were 0.722 and 0.702, respectively.

**Statistical method**

Statistical analyses were performed on SPSS 17.0 (SPSS/IBM, Chicago, IL). Demographic

characteristics of the 814 rural elderly were compared by Chi-square test or Wilcoxon rank

sum test. Scores of ULS-6 or GDS between empty-nest and not-empty-nest rural elderly were

compared by t-test. The relationships between living situation, loneliness and depressive

symptom among rural elderly were studied via multiple linear regressions by controlling age,

gender, marital status, income, educational level, and physical disease. The risk factor of

major depressive episode was explored via binary logistic regression. The significance level

was set at P<0.05. The inclusion criterion and exclusion criterion were 0.05 and 0.10,

respectively.

To examine the hypothesis that loneliness mediates the relations between empty-nest and

depression, path analysis was conducted using AMOS 17.0. Living situation (empty-nest or

not), loneliness, depression symptom, and major depressive episode were included in the

models. The minimum fit function chi-square (CMIN), CMIN/DF, comparative fit index

(CFI), the incremental fit index (IFI), and the root mean square error of approximation

(RMSEA) with 90% confidence intervals were used to estimate the model fit.

**Results**

**Demographic characteristics**

Among the included 814 rural elderly (426 men and 388 women), 436 (53.6%) were

couples, 335 (41.2%) were empty-nest elderly and 479 (58.8%) were not-empty-nest elderly.

The participants aged from 60 to 90 years (mean 69.1 ± 7.1) and the years of school

educational ranged from 0 to 15 years (mean 3.5 ± 2.8). The comparison of demographic

characteristics between empty-nest and not-empty-nest groups was shown in Table 1. No

significant differences between groups were found in age, gender, marital status, educational

level, annual income per household, and physical disease (all *P*>0.05).

**Between-group comparison of loneliness, depressive symptom, and major depressive**

**episode**

Between-group comparisons of ULS-6 score, GDS score, and major depressive episode

were shown in Table 2. The mean scores of loneliness and depressive symptom, or prevalence

of major depressive episode are significantly higher in the empty-nest group (all *p values*

<0.05). The effect size of empty-nest on loneliness was high significant, while that on

depressive symptoms was low significant (Cohen D=0.97, 0.28, respectively).

**Multivariate analysis**

The results of multiple linear regression of ULS-6 scores and GDS scores were shown in

Table 3. The independent variables involved in the linear regression models were gender, age,

marital status, annual income per household, educational level, physical disease, living

situation (empty-nest or not-empty-nest). Those who were empty-nest elderly and who had

unstable marital status and physical diseases had significantly higher scores of ULS-6. Those

who were empty-nest elderly and who had lower education level and income, unstable marital

status, and physical diseases showed significantly higher scores of GDS.

Using the same set of independent variables, logistic regression model was used to

compare the prevalence of major depressive episode between empty-nest and not-empty-nest

elderly (table 4). Empty-nest situation was correlated to higher prevalence of major

depressive episode (OR = 2.41, 95% CI = 1.34 - 4.34). Lower income and physical diseases

were also risk factors of major depressive episode.

**Path analysis**

Based on the results of regressive model, we established two path analysis models to

explore the relationship between living situation, loneliness, depressive symptom and major

depressive episode (figure 2). In model 1, there are six hypotheses. The fit indexes were not

satisfying for this model (CMIN=0, IFI=1, CFI=1, RMSEA=0.343).

We then removed the path between living situation and depressive symptom and the path

between living situation and major depressive episode, and created model 2. In model 2, there

are four hypotheses. The first one was that living situation had a direct effect on loneliness

(0.43). The second one was that loneliness had direct effect on depressive symptom (0.42).

The third one was that loneliness had direct effect on major depressive episode (0.32).

Loneliness played a mediating role between living situation, depressive symptom and major

depressive episode. The fit indexes were satisfying for this model (*CMIN=2.896,*

*CMIN/DF*=1.448, p=0.235, IFI=0.998, CFI=0.998, RMSEA=0.023).

**Discussion**

We found that after controlling for demographic characteristics and physical diseases,

empty-nest older adults had significantly higher level of feeling of loneliness and depressive

symptoms, and higher prevalence of major depressive episode. Moreover, the relationships

between empty-nest and depression were mediated by loneliness. These results supported our hypothesis that the separation of rural elderly and their adult children may have negative impact on the mental health among rural elderly.

Empty-nest living situation is associated with elevated level of loneliness in rural elderly (*Cohen D=0.97*). After controlling for demographic variables and physical disease, the difference remained statistically significant. This is consistent with a previous study reporting a higher loneliness rate in empty-nest elderly. [4] Other risk factors for loneliness include unstable marital status and physical condition. Loneliness is a subjective feeling related to low quantity and/or quality interpersonal relationship. Our results indicate that adult children and spouses are important resources of social support for rural elderly. Physical diseases may cause loneliness through limiting the ability of rural elderly to participate in social activities.

The GDS scores of empty-nest was higher than that of not-empty-nest in rural elderly (Cohen D=0.28). This result is consistent with a previous study reporting the mean score of GDS among rural elderly is 8.73.[22] The prevalence of major depressive episode is also significantly higher in empty-nest older adults (10.1% vs. 4.6%, *p<0.05*), both are higher than the prevalence of major depressive disorder reported among adults aged 15 and over in four provinces in China (3.2%).[23] Therefore, empty-nest rural elderly are more likely to suffer from both depressive symptoms and major depressive episode. Other risk factors of depressive symptoms include unstable marital status, lower education level, lower income, and physical diseases, while only lower income and physical diseases are correlated to major depressive episode. These results are consistent with previous studies that lower socio-economic status and physical diseases are risk factors for depression.[24]

The path analysis shows that there are no significant direct effects of empty-nest on depression among rural elderly, and loneliness is the mediating factor between empty-nest and depression. Our findings may have important implications. Depression in rural elderly, particularly among those whose adult children have left them, might be prevented or intervened if we can alleviate the feeling of loneliness. Potential measures include facilitating video and/or audio communications between empty-nest rural elderly and their adult children who are living and working in urban areas;[25] encouraging or organizing local group activities to promote social integration and to increase social support among rural older adults;[26] providing peer support by identifying younger and capable older adults who are willing to help other elderly people voluntarily.[27] Loneliness is not only related to adverse mental health outcomes, but also to a variety of medical conditions, such as cardiovascular disease, diabetes, dementia, and all-cause mortality. [28-32]Therefore, it is important to develop and validate intervention approaches targeting social connections for elderly in rural China, as well as in other countries.

The strength of this study is that we focused on the rapidly growing vulnerable population—rural elderly. However, there are several limitations need to be considered when interpreting our results. First, the sample of this study is older adults (60 or above) in one county in Hunan, China. It is not a nationally representative sample of rural elderly in China and does not provide information in urban older adults. Empty-nest situation may differ in different parts of China. Rural residents in better developed rural communities, such as in the East and/or Coast areas, are probably less likely to be migrant workers. Therefore, older adults in these areas are less likely to be empty-nest. Second, we did not examine some

variables that may be relevant to the observed relationship between empty-nest and loneliness

and depression, such as the quality of parent-children relationship, the frequency and quality

of contacts during their separation. Social support resources other than spouses and children

(for instance, other family members, friends) were not included. These should be investigated

in future researches. Third, this is a cross-sectional study. Our results only indicate the

correlations between empty-nest and loneliness, depressive symptoms, and major depressive

episode. Further intervention studies aiming at preventing/intervening depression in this

population through providing social connections and promoting social integration are

warranted.

**Ethical and consent to participate statement**

This study was approved by the Ethical Review Committee of the School of Public Health of Central South University. Each participant has provided written informed consent prior to participating in the study.

**Acknowledgments**

The authors would like to thank village cadres for guiding us to visit each household in the rural regions of Liuyang county, Hunan province, China.

**Footnotes**

**Contributors**    LZ and SYX conceived and designed the study. GJW, MH, SYX collected the data. GJW and LZ analyzed and interpreted the data. GJW drafted the article, while LZ, MH and SYX critically revised it for intellectual consent. All the authors gave final approval to the version submitted for publication.

**Role of funding**    This work was supported by the National Science and Technology Support Program (MZ, No.2009BAI77B03 and SYX, 2009BAI77B01) and the Fundamental Research Funds for the Central Universities of Central South University, China (GJW, 2015zzts104).

**Source Conflict of interest**    All authors declare that they have no conflicts of interest.

**Patient consent**    Obtained.

**Ethics approval**    Ethical Review Committee of the XiangYa School of Public Health of Central South University.

**Provenance and peer review**    Not commissioned, externally peer review.

**Data sharing statement**      we have no unpublished data to share.

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Table 1 The comparison of demographic characteristics between not-empty-nest and

empty-nest older adults

| Variables | not-empty-nest (n=479) | | Empty-nest (n=335) | | Total (n=814) | | $\chi^2$ /Z | $p$ |
|---|---|---|---|---|---|---|---|---|
| | N | % | N | % | N | % | | |
| Age(years) | | | | | | | | |
| 60~65 | 171 | 35.7 | 134 | 40.0 | 305 | 37.5 | 3.469 | 0.483 |
| 66-70 | 113 | 23.6 | 80 | 23.9 | 193 | 23.6 | | |
| 71~75 | 103 | 21.5 | 61 | 18.1 | 164 | 20.1 | | |
| 76~80 | 59 | 12.3 | 33 | 9.9 | 92 | 11.4 | | |
| 81~ | 33 | 6.9 | 27 | 8.1 | 60 | 7.4 | | |
| Gender | | | | | | | | |
| Male | 251 | 52.4 | 175 | 52.2 | 426 | 52.3 | 0.002 | 1.000 |
| Female | 228 | 47.6 | 160 | 47.8 | 388 | 47.7 | | |
| Marital status | | | | | | | | |
| Married | 370 | 77.2 | 239 | 71.3 | 609 | 74.8 | 3.643 | 0.059 |
| Divorced/separated/widowed /never married | 109 | 22.8 | 96 | 28.7 | 205 | 25.2 | | |
| Educational level | | | | | | | | |
| Below Primary school | 127 | 26.5 | 88 | 26.3 | 215 | 26.4 | 0.254 | 0.881 |
| Primary school | 291 | 60.8 | 208 | 62.1 | 499 | 61.3 | | |
| Middle school or above | 61 | 12.7 | 39 | 11.6 | 100 | 12.3 | | |
| Annual income per household (RMB) | | | | | | | | |
| 0~1800 | 183 | 38.2 | 132 | 39.4 | 315 | 38.7 | 0.145 | 0.930 |
| 1801~5000 | 186 | 38.8 | 129 | 38.5 | 315 | 38.7 | | |
| 5001~ | 110 | 23.0 | 74 | 22.1 | 184 | 22.6 | | |
| Physical disease | | | | | | | | |
| Yes | 280 | 58.5 | 197 | 58.8 | 477 | 58.6 | 0.010 | 0.942 |

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|---|---|---|---|---|---|---|---|---|
| No | 199 | 41.5 | 138 | 41.2 | 337 | 41.4 | | |

Table 2 The comparison of scores of ULS-6, scores of GDS and prevalence of major

depressive episode between not-empty-nest and empty-nest older adults

| Variables | not-empty-nest (n=479) | Empty-nest (n=335) | $\chi^2 / t$ | Cohen's d | p |
|---|---|---|---|---|---|
| Scores of ULS-6 (Mean±SD) | 12.87±3.02 | 16.19±3.90 | 13.08 | 0.97 | 0.000 |
| Scores of GDS (Mean±SD) | 6.92±5.19 | 8.50±6.26 | 3.80 | 0.28 | 0.000 |
| Major Depressive Episode (n, %) | 22 (4.6) | 34 (10.1) | 9.500 | --- | 0.003 |

ULS-6: UCLA- Loneliness Scale, GDS: Geriatric Depression Scale

Cohen's d effect size: Low significance (0.2-0.5), Moderate significance (0.5-0.8), High

significance (>0.8).

Table 3 Correlates of loneliness and depressive symptom among 814 rural older adults in

Liuyang, China

| Independent variables | loneliness | | | | Depressive symptom | | | |
|---|---|---|---|---|---|---|---|---|
| | Coef | Std. coef | t | p | Coef | Std. coef | t | p |
| Gender | -0.377 | -0.050 | -1.506 | 0.133 | -0.368 | -0.032 | -0.914 | 0.361 |
| Age | 0.029 | 0.055 | 1.613 | 0.107 | 0.039 | 0.049 | 1.352 | 0.177 |
| Marital status | 1.275 | 0.147 | 4.382 | 0.000 | 1.200 | 0.091 | 2.566 | 0.010 |
| Annual income per household | 1.433E-5 | 0.026 | 0.828 | 0.408 | -9.623E-5 | -0.117 | -3.460 | 0.001 |
| Educational level | -0.404 | -0.065 | -1.869 | 0.062 | -0.959 | -0.102 | -2.761 | 0.006 |
| Physical disease | -0.749 | -0.098 | -3.142 | 0.002 | -2.946 | -0.254 | -7.682 | 0.000 |
| Living situation (empty-nest or not-empty-nest) | 3.245 | 0.423 | 13.673 | 0.000 | 1.465 | 0.126 | 3.839 | 0.000 |

Table 4 Correlates of major depression episode among 814 rural older adults in Liuyang,

China

| Variables | | N | MDE |
|---|---|---|---|
| | | | OR(95%CI) |
| Gender | Male | 426 | ref |
| | Female | 388 | 0.56(0.30, 1.04) |
| Age | 60-65 | 305 | Ref |
| | 66-70 | 193 | 1.16(0.50, 2.69) |
| | 71-75 | 164 | 1.48(0.65, 3.37) |
| | 75-80 | 92 | 1.84(0.70, 4.86) |
| | 80- | 60 | 1.61(0.54, 4.85) |
| Marital status | Married | 610 | Ref |
| | Divorced/separated/ widowed/Never married | 204 | 1.26(0.67, 2.39) |
| Educational level | Middle school | 215 | Ref |
| | Primary school | 499 | 4.39(0.90,21.37) |
| | Below Primary school | 100 | 2.64(0.60, 11.74) |
| Annual income per household (RMB) | >5000 | 315 | Ref |
| | 1800~5000 | 315 | 7.54(1.74, 32.62) |
| | <1800 | 184 | 6.01(1.38, 26.26) |
| Physical disease | No | 280 | ref |
| | Yes | 199 | 8.67(3.34, 22.47) |
| Living situation | Not-empty-nest | 335 | Ref |
| | Empty-nest | 479 | 2.41(1.34, 4.34) |

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Fig 1 Flow chart of participant's enrolment

Fig 2 A path diagram showing the observed direct effects between variables using path analysis. Model 1: Hypothesized model of living situation, loneliness, depressive symptom and major depressive episode. Model 2: Final model of living situation, loneliness, depressive symptom and major depressive episode.

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   └─────────────┘  └─────────────┘      └──────────────┘  └──────────────┘
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| Sample 1 | Sample2 | Sample3 | Sample 4 | Sample 5 | Sample 6 | Sample 7 | Sample 8 |

1228 residents aged 60 years and over

→ 170 residents not living in the survey areas

1058 residents fit the included criteria

→ 198 residents were excluded
117 unable to communicate due to serious physical or mental illness
81 absent for three consecutive visits

860 residents eligible

→ 21 residents did not complete the survey
15 refused
6 dropped out

839 residents completed survey

→ 25 residents were excluded because they had no child

814 residents included for analysis

Fig 1.Flow chart of participant's enrolment

194x172mm (300 x 300 DPI)

Fig 2 A path diagram showing the observed direct effects between variables using path analysis. Model 1: Hypothesized model of living situation, loneliness, depressive symptom and major depressive episode. Model 2: Final model of living situation, loneliness, depressive symptom and major depressive episode.
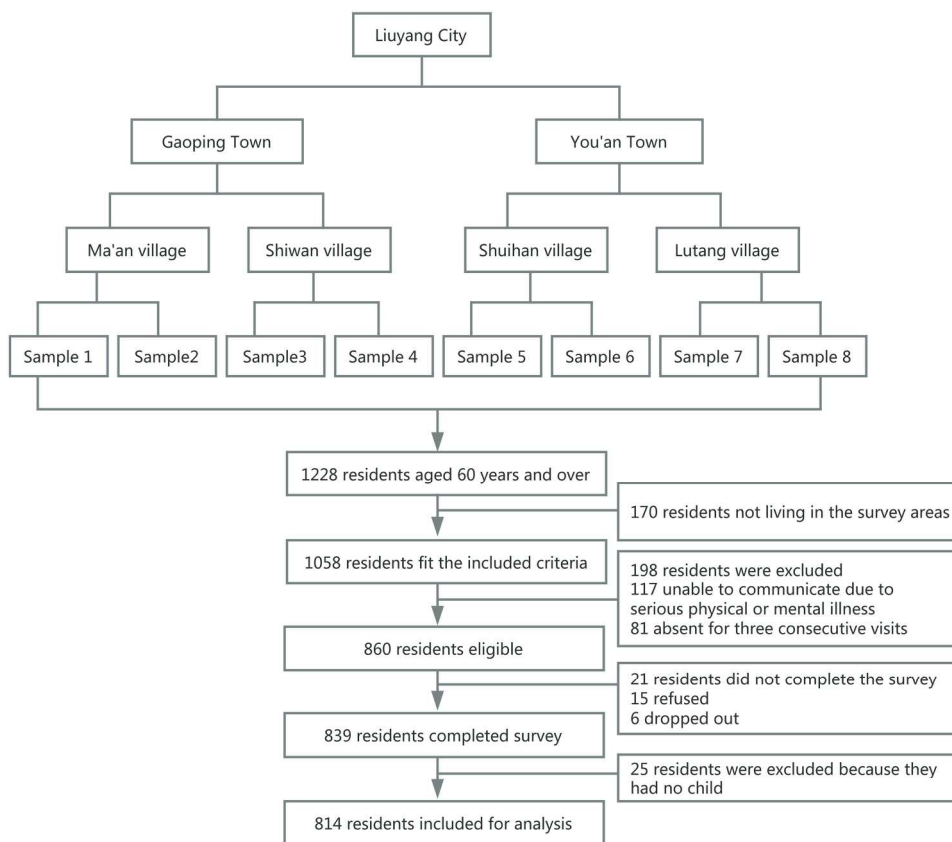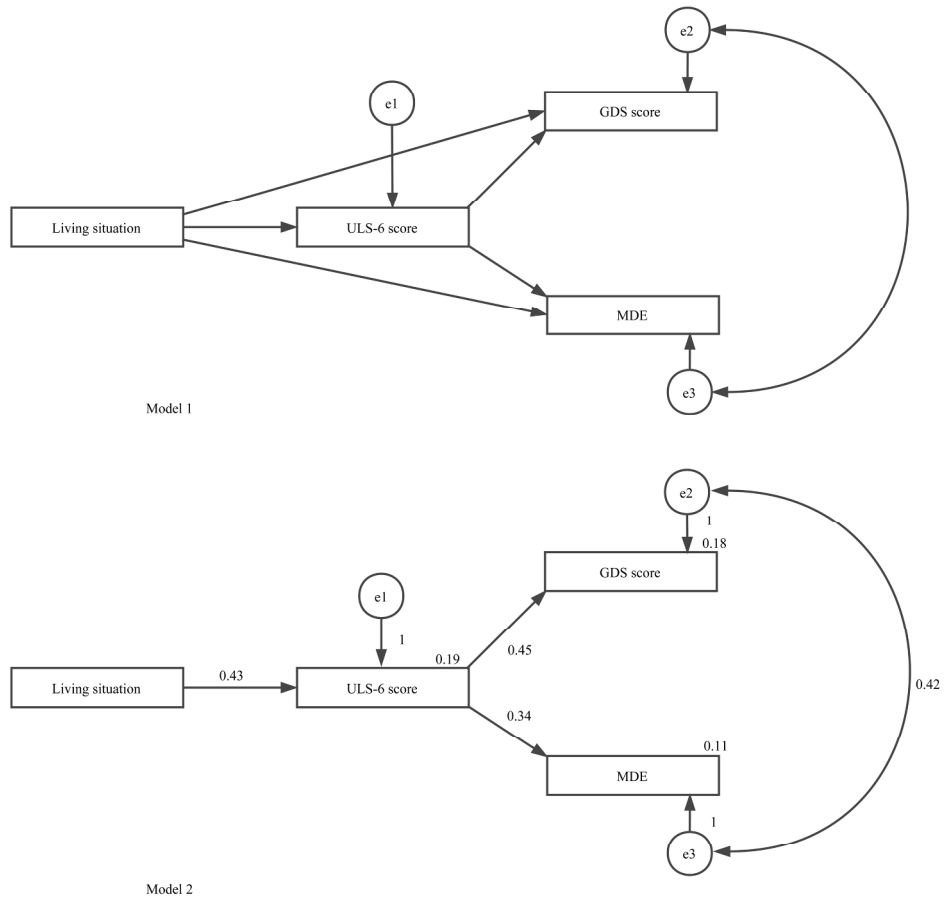
237x228mm (300 x 300 DPI)

**STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies***

| Section/Topic | Item # | Recommendation | Reported on page # |
|---|---|---|---|
| **Title and abstract** | 1 | (*a*) Indicate the study's design with a commonly used term in the title or the abstract | 1 |
| | | (*b*) Provide in the abstract an informative and balanced summary of what was done and what was found | 2 |
| **Introduction** | | | |
| Background/rationale | 2 | Explain the scientific background and rationale for the investigation being reported | 5 |
| Objectives | 3 | State specific objectives, including any prespecified hypotheses | 7 |
| **Methods** | | | |
| Study design | 4 | Present key elements of study design early in the paper | 7 |
| Setting | 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection | 7 |
| Participants | 6 | (*a*) Give the eligibility criteria, and the sources and methods of selection of participants | 8 |
| Variables | 7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable | 8,9,10 |
| Data sources/ measurement | 8* | For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group | 8,9,10,23 |
| Bias | 9 | Describe any efforts to address potential sources of bias | 10,11 |
| Study size | 10 | Explain how the study size was arrived at | 7,8,23 |
| Quantitative variables | 11 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why | 8,9,10,23 |
| Statistical methods | 12 | (*a*) Describe all statistical methods, including those used to control for confounding | 11 |
| | | (*b*) Describe any methods used to examine subgroups and interactions | No. |
| | | (*c*) Explain how missing data were addressed | 10,11 |
| | | (*d*) If applicable, describe analytical methods taking account of sampling strategy | 7,8,23 |
| | | (*e*) Describe any sensitivity analyses | No. |
| **Results** | | | |

| Participants | 13* | (a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed | 23 |
|---|---|---|---|
| | | (b) Give reasons for non-participation at each stage | 23 |
| | | (c) Consider use of a flow diagram | 23 |
| Descriptive data | 14* | (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders | 11,12,13,21,22 |
| | | (b) Indicate number of participants with missing data for each variable of interest | 21,22,23 |
| Outcome data | 15* | Report numbers of outcome events or summary measures | 22 |
| Main results | 16 | (*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included | 12,23 |
| | | (*b*) Report category boundaries when continuous variables were categorized | 21,22,23 |
| | | (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period | 23 |
| Other analyses | 17 | Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses | No. |
| **Discussion** | | | |
| Key results | 18 | Summarise key results with reference to study objectives | 13,14,15 |
| Limitations | 19 | Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias | 15,16 |
| Interpretation | 20 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence | 15,16 |
| Generalisability | 21 | Discuss the generalisability (external validity) of the study results | 15,16 |
| **Other information** | | | |
| Funding | 22 | Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based | 17 |

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.