Dose-response association of sleep quality with anxiety symptoms in Chinese rural population: the Henan Rural Cohort

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Abstract

Objectives
The epidemiological evidence on the effect of sleep quality on anxiety symptoms has been inconclusive. This study aimed at exploring the relationship between sleep quality and anxiety symptoms in rural China and further validating the association utilizing a meta-analysis.

Methods
A total of 27,911 participants aged 18–79 years from the Henan Rural Cohort Study completed assessments of sleep quality. Logistic regression and restricted cubic spline analysis was conducted to evaluate the sleep quality with anxiety symptoms. A meta-analysis was used to validate the result of the cross-sectional study.

Results
Altogether, 6087(21.80%) were poor sleepers and 1557(5.58%) had anxiety symptoms. The odds of anxiety were increased with increment of Pittsburgh Sleep Quality Index (PSQI) score after fitting restricted cubic splines. And the poor sleep quality was associated with a higher possibility of anxiety symptoms OR(95%CI) (4.61, 3.71-5.73) in men, and (3.56, 3.10-4.10) in women on multivariable analysis. Further stratified analyses showed that the effect of sleep quality and anxiety symptoms could be modified by age, marital status, lifestyle and chronic disease. The meta-analysis showed that pooled OR of anxiety symptoms was significantly higher for poor sleepers (1.49, 1.41-1.56, I² =98.9%, P <0.001).

Conclusions
These findings indicate that poor sleep quality was associated with increased odds of anxiety symptoms. In addition, relationship between poor sleep quality and anxiety symptoms was observed in this rural population, especially in participants aged ≥60 years and those with unhealthy habits or had a chronic disease.

Introduction
Anxiety is an emotion characterized by tension and restlessness, associated with mental and physical discomfort [1]. In 2010, mental and substance use disorders accounted for 7.4% of all disability-
adjusted life years (DALYs) worldwide, among which depression, anxiety, and alcohol abuse accounted for 40.5%, 14.6%, and 9.6%, respectively [2]. A recent meta-analysis estimated that mental disorders account for 14.3% of all deaths worldwide, or about 8 million deaths per year [3]. According to reports, generalized anxiety disorder (GAD) were present in 8.4% of adults from the Manaus Metropolitan Region [4].

Sleep which occupies a large part of our life and affects human health. In western countries, the prevalence of insomnia in the general population ranges from 10-30% [5, 6]. In the general population, the pooled prevalence of insomnia in China was 15.0% [7]. Previous studies showed that sleep duration was associated with a higher risk of all-cause mortality and cardiovascular events [8], and hypertension [9-12].

Mental disorders and sleep can interplay, recent population-based cross-sectional studies have found major relationships between insomnia and anxiety symptoms [13-15]. However, studies on the relationship of sleep quality and anxiety symptoms are scarce, especially among under-developed rural populations in China [16]. In this context, to fill in the gap and add to the evidence for effect of poor sleep quality on anxiety symptoms, this study analyzed the sleep quality measured by Pittsburgh Sleep Quality Index (PSQI) with anxiety symptoms in a Chinese rural population aged 18-79 years, and used meta-analysis to verify this association.

Methods

Study population

The participants of the current study were included from the Henan Rural Cohort, which has been previously described in detail [17, 18]. Briefly, a multistage cluster sampling method was utilized to select samples from permanent residents. Target population aged 18-79 years was recruited in Suiping, Yuzhou, Yima, Tongxu and Xinxiang counties of Henan province from July 2015 to September 2017 and registered in Chinese Clinical Trial Register (Registration number: ChiCTR-OOC-15006699). Consequently, a total of 39259 adults (15490 men and 23769 women) were obtained in the baseline of Henan rural cohort.

For the current analysis, a total of 29 995 completed the evaluation of anxiety symptoms. Furthermore, participants were excluded if they had missing data on PSQI score (n = 269), self-
reported experience of night shift work (n = 1530), or had a history of cancer (n = 285). The final samples included 27 911 subjects aged 18–79 years in the current study.

Ethics approval was provided by the Zhengzhou University Life Science Ethics Committee. Signed informed consent was obtained for each participant.

Covariates
Data collection was performed by well-trained investigators in a face-to-face interview using a structured questionnaire. Demographic variables of participants included gender, age (continuous variable), marital status (married/cohabitation, other), educational levels (primary school or below, junior high school and senior high school or above), smoking status (non-smoker, or current smoker), alcohol consumption (non-drinker, or current drinker), high vegetables and fruits intake (defined as more than 500 g per day), and personal and family history of diseases.

High fat diet was determined according to reported intake of meat of live stocks and poultry of 75 g or above per day. Physical activity levels were classified into three categories; light, moderate and vigorous referenced to the criterion in the International Physical Activity Questionnaire [19]. Additionally, the physical measurement was conducted on the basis of a standard protocol [20].

Height and weight were measured with individuals wearing light clothes and barefoot to the nearest 0.1 kg and 0.1 cm. Body mass index (BMI) was computed by body weight in kilograms divided by square of height in meters.

Evaluation Of Sleep Quality
Information on sleep was collected by PSQI [21], which consisted of 19 items. The scale which scores 0 to 21 has been widely used to evaluate sleep quality and well validated and readily completed by most participants. A previous study reported that at least acutoff score of 5 PSQI yields a sensitivity of 89.6% and a specificity of 86.5%[21]. Thus, a participant with a more than 5 PSQI score is considered as having a poor sleep quality in this study. Self-reported night sleep duration was obtained by asking the following question of the PSQI, “What time did you usually go to bed and wake up during the past month?” And the sleep onset latency was collected by the following question: “How long (in minutes) has it taken you to fall asleep each night during the past month?” The fall
asleep time was calculated as bed time plus sleep latency. The night sleep duration was computed on the basis of wake-up time and fall asleep time[22].

**Definition Of Anxiety Symptoms**

The anxiety symptoms of participants were collected using the two-item generalized anxiety disorder scale (GAD-2)[23] which included two items (feeling nervous, anxious, or on edge and not being able to stop or control worrying) yielding a sensitivity of 85% [24]. The scores of this scale ranged from 0 to 6. At least a score of three was viewed as the occurrence of anxiety symptoms, which was also utilized in the current study [25].

**Meta-analysis**

Based on the results of previous studies and current studies, a meta-analysis was conducted on the relationship between poor sleep quality and anxiety symptoms. A systematic electronic literature search was conducted in PubMed, Web of Science, CNKI (China National Knowledge Infrastructure) and Wanfang databases: (sleep quality OR PSQI score) AND anxiety symptoms. The included studies had at least two groups (good sleep quality, poor sleep quality) or three groups (good sleep quality, intermediate sleep quality, poor sleep quality), and anxiety symptoms. The exclusion criteria were :(1) studies in aged 17 or younger, (2) editorials, (3) reviews, (4) studies no OR or HR effect.

Information extracted from all relevant articles included title, first author name, year of publication, study design, sample size, the age range of participants, adjustment factors, sleep quality criteria, definition of anxiety symptoms, and OR (95% CI) for poor sleep quality. Data were extracted from the original literature, and ambiguity was resolved through discussion if there was any inconsistency.

**Statistical analysis**

Mean ± standard deviation (SD) and frequencies (percentages) was presented for continuous and categorical variables, respectively. Multivariable restricted cubic regression spline curves [28] with 3 knots (5th, 50th, and 95th) were fitted to observe the shape of the association between continuous PSQI score and anxiety symptoms. Furthermore, the PSQI score was dichotomized to examine the association between poor sleep quality (≥ 6) and anxiety symptoms with good sleep quality (< 6) as reference group by performing logistic regression models. In the fully adjusted model, age, gender (only in total population), high vegetables and fruits intake, high fat diet, physical activity, marital
status, smoking status, drinking status, educational levels, average monthly income and BMI, night sleep duration and napping duration were included in the model as the underlying confounder.

Additionally stratified analyses were conducted by each potential modifier to examine whether poor sleep quality and anxiety symptoms were potentially changed by age, sex, marital status, smoking, drinking, income, physical activity, BMI, snoring, hypertension, (T2MD) type 2 diabetes mellitus. Finally, a meta-analysis was conducted to validate the current result. The difference in effect size caused by heterogeneity in studies can be quantified by the $I^2$ statistics [26]. The random effects model was used for substantial heterogeneity, and a fixed effects model was used for homogeneity (or low heterogeneity) ($I^2 > 50$%). Egger's test was used to evaluate publication bias in the process of meta-analysis. A two-tailed $P$ value of less than 0.05 was determined the statistical significance in the current study. All analyses were run on SAS version 9.1 (SAS Institute) and R version 3.5.1.

**Results**

**Demographic characteristics**

Table 1 displays the Demographic characteristics of participants by the presence or absence of anxiety symptoms. In total, among the 27911 participants included in this study, the mean (SD) age was 55.96 (12.22) years, 16743 (59.99%) were women, the mean (SD) PSQI score was 3.79 (2.73), 6087 (21.81%) were poor sleepers, and 1557 (5.58%) have anxiety symptom. Those with anxiety symptoms were more likely to have lower education and income, lower physical activity levels, and have poorer sleep quality.

| Variables                  | Total | Men | Women |
|----------------------------|-------|-----|-------|
| Age(year), mean ± SD       |       |     |       |
| No-anxiety                 |       |     |       |
| 26354                      | 1557  | 10719| 449   |
| Anxiety                    |       | 56.94±12.27 | 56.34±11.37 | 0.180 |
|                           |       | 56.21±12.16 | 56.62±12.05 | 0.316 |
| Married/cohabitation, n (%)|   23697| 2381(88.92) | 1381(88.70) | 0.121 |
|                           |       | 9645(89.98) | 397(88.42) | 0.282 |
|                 |       | 14052(89.88) | 984(88.810.257 | < 0.001 |
| Educational levels, n (%)  |       | < 0.001 | 0.061 | < 0.001 |
| Primary school or below    |       |       |       |
| No-anxiety                 |       | 11921| 3693 |
|                           |       | (45.23| (34.45)| |
| Anxiety                    |       | 848  | 179  |
|                           |       | (54.46) | (39.87) | |
|                           |       | 3693 (34.45) | 179(39.87) | |
| Junior high school         |       | 10131| 4828 |
| No-anxiety                 |       | (38.44) | (45.04) | |
|                           |       | 547  | 187  |
| Anxiety                    |       | (35.13) | (41.65) | |
|                           |       | 4828 (45.04) | 187(41.65) | |
|                           |       | 5303 (33.92) | 360(32.49) | |
Association between sleep quality and anxiety symptoms

Figure 1 presents the association between PSQI score and the likelihood of anxiety symptoms.

Modeling PSQI score as a continuous variable, this study observed the increased likelihood of anxiety symptoms increased with the elevated PSQI score after adjustment of potential covariates. (See Figure 1 in the supplemental material).
Table 2 reports results of sleep quality and anxiety symptoms, with less than 6 score of PSQI as reference category. Compared to the reference group, poor sleep quality (PSQI ≥ 6) was associated with a higher possibility of anxiety symptoms (3.85, 3.43-4.34) in total populations, (4.61, 3.71-5.73) in men, and (3.56, 3.10-4.10) in women on multivariable analysis.

### Table 2

| Models | Total | Men | Women |
|--------|-------|-----|-------|
|        | Good sleep quality | Poor quality | Good sleep quality | Poor quality | Good sleep quality | Poor sleep quality |
| Cases/N | 785/21824 | 772/6087 | 264/9427 | 185/1741 | 521/12397 | 587/4346 |
| Model 1 | 1 | 3.89 (3.51-4.32) | 1 | 4.13 (3.39-5.02) | 1 | 3.56 (3.15-4.03) |
| Model 2 | 1 | 3.85 (3.43-4.34) | 1 | 4.61 (3.71-5.73) | 1 | 3.56 (3.10-4.10) |

Model 1: unadjusted; Model 2: adjusted for age, gender, high vegetables and fruits intake, high fat diet, physical activity, marital status, smoking status, drinking status, educational levels, average monthly income, BMI, night sleep duration and napping duration.

### Stratified analysis for poor sleep quality and anxiety symptoms

The ORs of anxiety symptoms associated with poor sleep quality were significantly higher among aged 60 or older (4.42, 3.70-5.28), married (4.00, 3.53-4.53), smokers (4.74, 3.46-6.49), participants with light level of physical activity (5.57, 4.48-6.92), those who had obesity (4.67, 3.43-6.35) and those with snoring (4.63, 3.77-5.68), T2DM (4.86, 3.32-7.10) (See Fig. 2 in the supplemental material).

### Meta-analysis of poor sleep quality and anxiety symptoms

To verify the current results, a meta-analysis included previously published literature and the current study was conducted. After screening, four unique studies were finally included, corresponding to 7489 participants. Compared with good sleepers, poor sleep participants were more likely to suffer from anxiety symptoms (OR 1.49, 95%CI 1.41-1.56, I^2 = 98.9%, P < 0.001) (See Fig. 3 in the supplemental material). No publication bias was detected (Egger's test: 0.356).

### Discussion

This study demonstrated that in a large population in Chinese rural area, a positive association between poor sleep quality and the odds of prevalent anxiety symptoms was found in both men and women. According to the stratified analysis, this study observed stronger positive associations in aged 60 or older, smokers, participants with a light level of physical activity, obesity and chronic...
disease (e.g., T2DM). The meta-analysis in the current study showed that the result of this study was consistent with previous studies. The present study is the first to focus on the association between poor sleep quality and the odds of anxiety symptoms in a large Chinese rural population. This study used baseline data from a large cohort study that rigorously controlled for quality and standardized assessments of outcomes and confounders.

In China, an estimated 170 million adults suffer from mental illness, accounting for 20% of the total disease burden [27]. The current study explored the associations between the sleep quality and anxiety symptoms in rural China; this had not been explored for in previously published studies. Therefore, this study is meaningful among rural residents. The study found several results: Firstly, those with anxiety symptoms were more likely to have a lower income and are exposed to unhealthy lifestyles, such as lower physical activity levels. Secondly, the meta-analysis showed that poor sleep participants were more likely to suffer from anxiety symptoms.

This study presents the association between poor sleep quality and the likelihood of anxiety symptoms, which is consistent with a previous study among adult women that poor sleep quality were most strongly associated with anxiety symptoms [28]. Another study conducted in Hong Kong, China [29] and Spain [30] reported that poor sleep quality was negatively associated with health-related quality of life (HRQOL). Furthermore, results are consistent with insomnia being a risk factor for the development of anxiety symptoms [13]. A study in patients with cardiovascular diseases demonstrated that the presence of poor sleep quality was independently associated with anxiety symptoms [31]. However, there was another study found that poor sleep quality was associated with both depression and anxiety, whereas only daytime sleepiness was associated with anxiety symptoms in older adults [32].

The mechanisms behind the association between sleep quality and anxiety are not clear completely. Lack of sleep can lead to a range of adverse neurobehavioral consequences and physiological changes, such as inattention, depression, impaired glucose tolerance, and sympathetic nervous system activation [33]. These changes in sleep quality may manifest as the onset of mental illness, including anxiety. Nevertheless, we should keep in mind that our findings, based on cross-sectional
data, are limited to confirming a causal relationship between sleep quality and anxiety, and the exact mechanisms remain to be studied.

It should be noted that sleep quality of our sample was assessed with the validated instrument PSQI questionnaire [34]. Internal consistency of the PSQI was adequate to good among rural population in large observational studies [28]. Considering trade-off between validity and academic authority, and the testability of PSQI, this study decided to use it. And a study assessed the prevalence and associated factors in rural population using the two-item GAD scale (GAD-2), which included two items (feeling nervous, anxious, or on edge and not being able to stop or control worrying) yielding a sensitivity of 85% [35]. Furthermore, the GAD-2 had preeminent overall accuracy for identifying anxiety symptoms (AUC = 0.97; 95% CI, 0.94-1.00), which is a clinically effective and psychometrically valid tool for screening anxiety symptoms [23, 36].

This study successfully demonstrated the following strengths. First, this study thoroughly clarified the association between poor sleep quality and anxiety symptoms in a large-scale rural population from the Henan rural cohort. Second, this study confirmed the association through meta-analysis, which is the first quantitative comprehensive analysis of this association so far. It gave us a chance to understand the relationship between sleep quality and anxiety symptoms in the Chinese rural population.

The current study also has some limitations. First, this was a cross-sectional study, and there is the possibility of reverse causality. Second, although the PSQI is a well-validated scale of sleep quality, the recall bias on the results cannot be excluded thoroughly. Third, some non-anxious subjects may inevitably be misclassified as anxiety disorders, which would lead to information bias.

Conclusions
In conclusion, a positive association between PSQI score and increased odds of anxiety symptoms was observed. Moreover, this study also found that poor sleep quality contributes to the increased prevalence of anxiety symptoms in a Chinese rural population, especially in those who were 60 years old or above, smokers, with light level of physical activity, obesity. In addition, these findings suggest that people should develop good sleeping habit to prevent anxiety symptoms.
Abbreviations
PSQI Pittsburgh Sleep Quality Index
DALYs Disability-adjusted life years
GAD Generalized anxiety disorder
BMI Body mass index
GAD-2 The two-item generalized anxiety disorder scale
SD Standard deviation
T2MD Type 2 diabetes mellitus
HRQOL Health-related quality of life

Declarations

Ethics approval and consent to participate
Ethical approval for this study was obtained from the “Zhengzhou University Life Science Ethics Committee”, and written informed consent was obtained from all participants. Ethics approval code: [2015] MEC (S128)

Consent for publication
All authors made significant contributions to the manuscript and all authors have read and approved the final version as well as agreed with the publishment on *BMC Public Health*.

Availability of data and materials
Available with the research team. Data will be made available upon reasonable request to Dr. Chongjian Wang

Competing interests
The authors have declared that no competing interests exist.

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Authors' contributions

During the research, Chongjian Wang and Zhenxing Mao designed the study. Jiali Shen, Haiqing Zhang, Yan Wang, Tanko Abdulai, Miaomiao Niu, Zhicheng Luo, Yikang Wang, Ruiying Li, Fang Wang directed the collection of the data. Jiali Shen and Haiqing Zhang analyzed the data. Jiali Shen and Haiqing Zhang wrote the manuscript. Yan Wang and Tanko Abdulai provided writing assistance. All authors read and approve this version of the article.

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References

1. Major M, Rompre PH, Guitard F, Tenbokum L, O’Connor K, Nielsen T, Lavigne GJ: A controlled daytime challenge of motor performance and vigilance in sleep bruxers. J Dent Res 1999, 78(11):1754-1762.

2. Whiteford HA, Degenhardt L, Rehm J, Baxter AJ, Ferrari AJ, Erskine HE, Charlson FJ, Norman RE, Flaxman AD, Johns N et al: Global burden of disease attributable to mental and substance use disorders: findings from the Global Burden of Disease Study 2010. Lancet 2013, 382(9904):1575-1586.

3. Walker ER, McGee RE, Druss BG: Mortality in Mental Disorders and Global Disease Burden Implications: A Systematic Review and Meta-analysis (vol 72, pg 334, 2015). Jama Psychiat 2015, 72(12):1259-1259.

4. Silva MT, Caicedo Roa M, Martins SS, da Silva ATC, Galvao TF: Generalized anxiety disorder and associated factors in adults in the Amazon, Brazil: A population-based study. Journal of affective disorders 2018, 236:180-186.

5. Morin CM, LeBlanc M, Daley M, Gregoire JP, Mérette C: Epidemiology of insomnia: prevalence, self-help treatments, consultations, and determinants of help-seeking behaviors. Sleep medicine 2006, 7(2):123-130.

6. Klink ME, Quan SF, Kaltenborn WT, Lebowitz MD: Risk factors associated with complaints of insomnia in a general adult population. Influence of previous complaints of insomnia. Archives of internal medicine 1992, 152(8):1634-1637.

7. Cao XL, Wang SB, Zhong BL, Zhang L, Ungvari GS, Ng CH, Li L, Chiu HF, Lok GK, Lu JP
et al: The prevalence of insomnia in the general population in China: A meta-analysis. *PLoS ONE* 2017, **12**(2):e0170772.

8. Yin J, Jin X, Shan Z, Li S, Huang H, Li P, Peng X, Peng Z, Yu K, Bao W et al: Relationship of Sleep Duration With All-Cause Mortality and Cardiovascular Events: A Systematic Review and Dose-Response Meta-Analysis of Prospective Cohort Studies. *Journal of the American Heart Association* 2017, **6**(9).

9. Zhang H, Li Y, Mao Z, Liu M, Huo W, Liu R, Liu X, Tu R, Yang K, Qian X et al: A dose-response association of night sleep duration with hypertension in a Chinese rural population: the Henan Rural Cohort Study. *Journal of the American Society of Hypertension: JASH* 2018, **12**(12):867-879 e863.

10. Gangwisch JE, Feskanich D, Malaspina D, Shen S, Forman JP: Sleep duration and risk for hypertension in women: results from the nurses' health study. *American journal of hypertension* 2013, **26**(7):903-911.

11. Wu L, He Y, Jiang B, Liu M, Wang JH, Zhang D, Wang YY, Zeng J, Yao Y: Association between sleep duration and the prevalence of hypertension in an elderly rural population of China. *Sleep medicine* 2016, **27-28**:92-98.

12. Wu X, Sun Y, Niu K, Yao W, Bian B, Yu X, Zhao H, Huang J: Association of self-reported sleep duration and hypertension: Results of a Chinese prospective cohort study. *Clin Exp Hypertens* 2016, **38**(6):514-519.

13. Neckelmann D, Mykletun A, Dahl AA: Chronic insomnia as a risk factor for developing anxiety and depression. *Sleep* 2007, **30**(7):873-880.

14. Spira AP, Stone K, Beaudreau SA, Ancoli-Israel S, Yaffe K: Anxiety symptoms and objectively measured sleep quality in older women. *Am J Geriatr Psychiatry* 2009, **17**(2):136-143.

15. Gould CE, Spira AP, Liou-Johnson V, Cassidy-Eagle E, Kawai M, Mashal N, O'Hara R,
Beaudreau SA: **Association of Anxiety Symptom Clusters with Sleep Quality and Daytime Sleepiness.** *The journals of gerontology Series B, Psychological sciences and social sciences* 2018, **73**(3):413-420.

16. Yu Y, Hu M, Liu ZW, Liu HM, Yang JP, Zhou L, Xiao SY: **Recognition of depression, anxiety, and alcohol abuse in a Chinese rural sample: a cross-sectional study.** *Bmc Psychiatry* 2016, **16**.

17. Liu X, Mao Z, Li Y, Wu W, Zhang X, Huo W, Yu S, Shen L, Li L, Tu R et al: **The Henan Rural Cohort: a prospective study of chronic non-communicable diseases.** *International journal of epidemiology* 2019.

18. Tian ZY, Li YQ, Mao ZX, Yu SC, Wang YH, Liu XT, Tu RQ, Zhang HQ, Qian XL, Zhang X et al: **Sex-specific relationship between visceral fat index and dyslipidemia in Chinese rural adults: The Henan Rural Cohort Study.** *Prev Med* 2018, **116**:104-111.

19. Craig CL, Marshall AL, Sjostrom M, Bauman AE, Booth ML, Ainsworth BE, Pratt M, Ekelund U, Yngve A, Sallis JF et al: **International physical activity questionnaire: 12-country reliability and validity.** *Med Sci Sport Exer* 2003, **35**(8):1381-1395.

20. **Geographical variation in the major risk factors of coronary heart disease in men and women aged 35-64 years. The WHO MONICA Project.** *World health statistics quarterly Rapport trimestriel de statistiques sanitaires mondiales* 1988, **41**(3-4):115-140.

21. Buysse DJ, Reynolds CF, 3rd, Monk TH, Berman SR, Kupfer DJ: **The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research.** *Psychiatry research* 1989, **28**(2):193-213.

22. Zhang H, Zhao X, Li Y, Mao Z, Huo W, Jiang J, Wang Y, Liu X, Abdulai T, Tian Z et al: **Night sleep duration and sleep initiation time with hypertension in Chinese**
rural population: the Henan Rural Cohort. European journal of public health 2019.

23. Luo Z, Li Y, Hou Y, Zhang H, Liu X, Qian X, Jiang J, Wang Y, Liu X, Dong X et al: Adaptation of the two-item generalized anxiety disorder scale (GAD-2) to Chinese rural population: A validation study and meta-analysis. General hospital psychiatry 2019, 60:50-56.

24. Kroenke K, Spitzer RL, Williams JB, Monahan PO, Lowe B: Anxiety disorders in primary care: prevalence, impairment, comorbidity, and detection. Annals of internal medicine 2007, 146(5):317-325.

25. Christensen H, Batterham PJ, Grant JB, Griffiths KM, Mackinnon AJ: A population study comparing screening performance of prototypes for depression and anxiety with standard scales. BMC medical research methodology 2011, 11:154.

26. Melsen WG, Bootsma MC, Rovers MM, Bonten MJ: The effects of clinical and statistical heterogeneity on the predictive values of results from meta-analyses. Clinical microbiology and infection : the official publication of the European Society of Clinical Microbiology and Infectious Diseases 2014, 20(2):123-129.

27. Qian JW: Mental Health Care in China: Providing Services for Under-treated Patients. J Ment Health Policy 2012, 15(4):179-186.

28. Gould CE, Spira AP, Liou-Johnson V, Cassidy-Eagle E, Kawai M, Mashal N, O'Hara R, Beaudreau SA: Association of Anxiety Symptom Clusters with Sleep Quality and Daytime Sleepiness. J Gerontol B-Psychol 2018, 73(3):413-420.

29. Lo CMH, Lee PH: Prevalence and impacts of poor sleep on quality of life and associated factors of good sleepers in a sample of older Chinese adults. Health Qual Life Out 2012, 10.
30. Faubel R, Lopez-Garcia E, Guallar-Castillón P, Balboa-Castillo T, Gutiérrez-Fisac JL, Banegas JR, Rodríguez-Artalejo F: **Sleep duration and health-related quality of life among older adults: a population-based cohort in Spain.** *Sleep* 2009, **32**(8):1059-1068.

31. Matsuda R, Kohno T, Kohsaka S, Fukuoka R, Maekawa Y, Sano M, Takatsuki S, Fukuda K: **The prevalence of poor sleep quality and its association with depression and anxiety scores in patients admitted for cardiovascular disease: A cross-sectional designed study.** *Int J Cardiol* 2017, **228**:977-982.

32. Gould CE, Karna R, Jordan J, Kawai M, Hirst R, Hantke N, Pirog S, Cotto I, Schussler-Fiorenza Rose SM, Beaudreau SA et al: **Subjective but Not Objective Sleep is Associated with Subsyndromal Anxiety and Depression in Community-Dwelling Older Adults.** *Am J Geriatr Psychiatry* 2018, **26**(7):806-811.

33. Banks S, Dinges DF: **Behavioral and physiological consequences of sleep restriction.** *J Clin Sleep Med* 2007, **3**(5):519-528.

34. Zhang H, Li Y, Zhao X, Mao Z, Abdulai T, Liu X, Tu R, Wang Y, Qian X, Jiang J et al: **The association between PSQI score and hypertension in a Chinese rural population: the Henan Rural Cohort Study.** *Sleep medicine* 2019, **58**:27-34.

35. Kroenke K, Spitzer RL, Williams JBW, Monahan PO, Lowe B: **Anxiety disorders in primary care: Prevalence, impairment, comorbidity, and detection.** *Annals of internal medicine* 2007, **146**(5):317-325.

36. Hughes AJ, Dunn KM, Chaffee T, Bhattarai J, Beier M: **Diagnostic and Clinical Utility of the GAD-2 for Screening Anxiety Symptoms in Individuals With Multiple Sclerosis.** *Arch Phys Med Rehab* 2018, **99**(10):2045-2049.

Figures
The association between sleep quality and anxiety from restricted cubic splines by gender

Model 1: unadjusted; Model 2: adjusted for age, gender (only in total population), high vegetables and fruits intake, high fat diet, physical activity, marital status, smoking status, drinking status, educational levels, average monthly income, BMI, night sleep duration and napping duration;
OR (95% CI) of poor sleep quality (PSQI ≥6) between anxiety symptoms stratified by potential modifiers. Adjusted for age, gender, high vegetables and fruits intake, high fat diet, physical activity, marital status, smoking status, drinking status, educational levels, average monthly income, BMI, night sleep duration and napping duration Abbreviation: BMI, body mass index; T2DM, type 2 diabetes mellitus

| Variables                  | Anxiety/ν | OR (95%CI)     |
|----------------------------|-----------|----------------|
| Age (years)                |           |                |
| <60                        | 384/2964  | 3.39(2.89-3.97)|
| ≥60                        | 388/3123  | 4.42(3.70-5.28)|
| Marital status             |           |                |
| No                         | 88/768    | 2.96(2.08-4.20)|
| Yes                        | 684/5319  | 4.00(3.53-4.53)|
| Smoking                    |           |                |
| No                         | 677/5208  | 3.71(3.27-4.21)|
| Yes                        | 95/879    | 4.74(3.46-6.49)|
| Drinking                   |           |                |
| No                         | 698/5351  | 3.85(3.40-4.36)|
| Yes                        | 74/736    | 3.63(3.24-5.19)|
| Income                     |           |                |
| <500 RMB                   | 374/2546  | 4.01(3.37-4.78)|
| 500- RMB                   | 204/1848  | 3.87(3.09-4.85)|
| ≥1000 RMB                  | 194/1693  | 3.63(2.90-4.55)|
| Physical activity          |           |                |
| Light                      | 242/1876  | 5.57(4.48-6.92)|
| Moderate                   | 289/2383  | 3.38(2.63-4.35)|
| Vigorous                   | 241/1828  | 3.39(2.75-4.17)|
| BMI                        |           |                |
| Underweight                | 20/185    | 2.64(1.24-5.60)|
| Normal                     | 343/2591  | 3.75(3.15-4.36)|
| Overweight                 | 285/2350  | 3.82(3.15-4.64)|
| Obesity                    | 119/1032  | 4.67(3.43-6.35)|
| Snoring                    |           |                |
| No                         | 478/4182  | 3.35(2.89-3.87)|
| Yes                        | 294/1905  | 4.63(3.77-5.68)|
| Hypertension               |           |                |
| No                         | 524/3901  | 3.95(3.43-4.55)|
| Yes                        | 248/2181  | 3.66(2.96-4.52)|
| T2DM                       |           |                |
| No                         | 683/5457  | 3.74(3.30-4.23)|
| Yes                        | 80/621    | 4.80(3.32-7.10)|

Figure 2
Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

Supplementary file.docx