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Study on the relationship between indoor ventilation frequency and anxiety and depression symptoms in older persons: based on the data of 2018 CLHLS

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Abstract

Background To investigate the association between indoor ventilation frequency and symptoms of depression and anxiety in older persons.

Methods A binary logistic regression model was used to analyze the effects of indoor ventilation frequency on depression and anxiety by using data from the 2018 Chinese longitudinal healthy longevity survey (CLHLS).

Results A total of 9,690 older persons with an average age of (83.20 ± 11.27) years were included, including 4,458 males (46.0%) and 5,232 females (54.0%). The average score of indoor ventilation frequency was (6.06 ± 1.98) points, including 770 people (7.9%) with low frequency, 3,066 people (31.6%) with medium frequency, and 5,854 people (60.4%) with high frequency. 842 (8.7%) had symptoms of depression and 204 (2.1%) had symptoms of anxiety. Compared with the older persons with low indoor ventilation frequency, the older persons with higher ventilation frequency had a lower incidence of depression (OR(95%CI) = 1.92 (1.50 ~ 2.46), 1.51 (1.27 ~ 1.79); $P < 0.001$). However indoor ventilation frequency was not associated with anxiety symptoms.

Conclusion Indoor ventilation frequency is related to depressive symptoms in older persons. Communities and families should pay more attention to indoor ventilation and intervene in time to promote and improve the mental health of older persons.

Keywords Indoor ventilation frequency, Older persons, Anxiety, Depression

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Introduction

China's recent 7th population census showed that the proportion of older persons aged 60 and above in the total population was as high as 18.7%, indicating that the degree of aging in China has become very serious [1]. The National Health Commission subsequently released the "14th Five-Year Plan for Healthy Aging", which aims to address the current severe aging situation and enable older persons to live a healthy and active life in their old age. As China's population continues to age, more and more Chinese older persons face health risks (e.g., loneliness, anxiety, and depression) [2]. Depression, as one of the most common mental health disorders in older persons, seriously affects their health status and quality of life [3], and its global prevalence has reached 7.0% [4]. The Global Burden of Disease Study 2019 showed that depression is one of the most disabling mental illnesses [5]. The disease burden of depression not only affects the quality of life of millions of people but also imposes a heavy social burden through long-term health care services [4]. Anxiety is also one of the common psychological problems among older persons, which is not only closely associated with the occurrence of heart disease and cognitive decline, but also raises the risk of chronic non-communicable respiratory diseases [6, 7]. As China has the largest elderly population in the world, anxiety and depression symptoms in older persons should be given sufficient attention [8].

Several research studies have been conducted to show that air pollution is associated with increased symptoms of depression and anxiety [9, 10]. A UK Biobank-based study showed that estimates of long-term exposure to multiple air pollutants were associated with an increased risk of depression and anxiety [11]. A meta-analysis has also shown that $PM_{2.5}$ exposure is associated with depression and anxiety [12]. Around the world, most people spend most of their time indoors (80.0–90.0%) [13]. Whereas the concentration of pollutants indoors may be several times higher than outdoors, opening windows and ventilating the air is considered an important means of reducing indoor air pollution [14]. However, the evidence of the relationship between the frequency of indoor ventilation and anxiety and depressive symptoms is still insufficient. Therefore, this study aimed to investigate the relationship between indoor ventilation frequency and anxiety and depression symptoms in Chinese older persons.

Methods

Data sources and sample

The data for this study were obtained from the 8th round of the China Elderly Health Survey Program. All respondents signed an informed consent form, and the survey was approved by the Biomedical Ethics Committee of Peking University (IRB00001052-13074). In this study, 15,779 older persons aged 65 years and above were selected as target subjects, and data from 9,690 older persons were finally included after filtering out outliers and missing values.

Introduction and definition of variables

(1) Depressive symptoms and anxiety symptoms: depressive symptoms were assessed using the 10-item Center for Epidemiologic Studies Depression Scale (CESD-10), of which 7 are negative and 3 are positive, with a total score ranging from 10 to 50, with higher scores indicating higher levels of depression [6]. Checking the related literature, in this study, 10 ~ 30 have no depressive symptoms and 31 ~ 50 are with depressive symptoms [15]. Anxiety symptoms were assessed using the Generalized Anxiety Disorder Scale (GAD-7), which has 7 entries, with each entry scored from 0 to 3. A GAD-7 score of ≥ 10 suggests the presence of anxiety symptoms, and the higher the score, the more severe the anxiety symptoms.

(2) Indoor ventilation frequency: 0 points for not opening windows, 1 point for opening windows 1–5 times/week, 2 points for > 5 times/week, and the sum of the ventilation frequency scores for the four seasons was the total ventilation frequency score, 0–3 points for low frequency, 4–5 points for medium frequency, and 6–8 points for high frequency.

(3) General information: including age, gender, marital status, education level, place of residence, economic status, impaired ability to perform daily living, smoking and drinking status, self-assessed health and life satisfaction. Self-assessed health and life satisfaction were determined by the questionnaire question, "How do you feel about your health now?" Self-assessed health was determined by answering "very good", "good", "fair", and "bad Answers of "very good" and "good" were judged as good, answers of "fair" were judged as fair, and answers of "bad" and "very bad" were judged as bad; satisfaction with life was determined by the questionnaire question, "How do you feel about your life now?" Determine the degree of life satisfaction, answer "very good", "good" is judged as satisfied, answer "general" is judged as general, answer "bad", "very bad" is judged as bad. Answers of "very good" and "good" were judged as satisfactory, answers of "fair" were judged as average, and answers of "bad" and "very bad" were judged as unsatisfactory. Disability was determined by the questionnaire question "Are you limited in your daily life activities due to health problems?" Patients with incapacitation were identified by answering "yes" to

the question, and "no" to the question that there was no incapacitation.

Data analysis

SPSS 27.0 was used for data cleaning organization and analysis. Discontinuous variables were reported as mean (X ± S) standard deviation, categorical variables were reported as frequency and percentage, intergroup comparisons of the occurrence of anxiety and depressive symptoms among older persons with different characteristics were tested by X^2 and a binary logistic regression model was used to analyze the relationship between frequency of indoor ventilation and anxiety and depressive symptoms. The test level α = 0.05.

Results

Baseline characteristics of the total sample

A total of 9,690 older persons were included in this study, with an age range of 65 to 117 years and a mean age of (83.20 ± 11.27) years, of whom 4,458 (46.0%) were male and 5,232 (54.0%) were female.

Indoor ventilation frequency

Indoor ventilation frequency scores ranged from 0 to 8, with a mean score of (6.06 ± 1.98), of which 770 (7.9%) were low frequency, 3,066 (31.6%) were medium frequency, and 5,854 (60.4%) were high frequency.

Depressive symptoms and anxiety symptoms

842 (8.7%) had depressive symptoms and 204 (2.1%) had anxiety symptoms. Differences in the detection rates of depressive symptoms among older persons by gender, age, years of education, smoking, alcohol consumption, hours of sleep, life satisfaction, self-rated health, economic status, socialization, exercise, disability, and frequency of indoor ventilation were statistically significant. Differences in the detection rates of anxiety symptoms among older persons by gender, years of education, smoking, alcohol consumption, hours of sleep, place of residence, life satisfaction, self-rated health, economic status, socialization, exercise, incapacitation, and frequency of indoor ventilation were statistically significant (Table 1).

Factors influencing depression and anxiety symptoms in older persons

A logistic model was fitted with indoor ventilation frequency as the independent variable (0 = low; 1 = moderate; 2high), gender, age, years of education, smoking, alcohol consumption, hours of sleep, life satisfaction, self-rated health, economic status, socialization, exercise, and disablement as the control variables, and depressive symptoms as the dependent variable (0 = none; 1 = have), which, controlling for the general information, reduced the risk of depressive symptoms in older adults (OR (95% CI) = 1.92 (1.50 to 2.46), 1.51 (1.27 to 1.79); $P < 0.001$). A logistic model was fitted with indoor ventilation frequency as the independent variable (0 = low; 1 = moderate; 2high), gender, years of education, smoking, alcohol consumption, hours of sleep, place of residence, life satisfaction, self-assessed health, economic status, socialization, exercise, and incapacitation as the control variables, and anxiety symptom as the dependent variable (0 = none; 1 = yes), and the control variables were such that the frequency of indoor ventilation was not significantly associated with the anxiety Symptoms association was not significant, the assignments are shown in Table 2, and the results of the analysis are shown in Table 3.

Discussion

This nationally representative population study examined the association between indoor ventilation frequency and symptoms of anxiety and depression. In this study, it was found that the detection rate of depressive symptoms in the older persons with low ventilation frequency was 16.1% and that in the older persons with medium ventilation frequency was 10.4%, both of which were higher than those in the group with high ventilation frequency (6.8%) and higher than the prevalence rate of depressive symptoms in general older persons in China (10.0-20.0%) [16]. The detection rate of anxiety symptoms in the older persons with low ventilation frequency was 4.2%, and the detection rate of depression symptoms in the older persons with medium ventilation frequency was 2.1%, both higher than that in the high ventilation frequency group (1.9%), and higher than the prevalence rate of anxiety symptoms in China's general older persons (1.2% ~ 15.0%) [17].

As far as we know, no studies have explored the relationship between indoor ventilation frequency and anxiety and depression in older persons. This study found that low indoor ventilation frequency was associated with increased depressive symptoms in older persons. It may be related to the fact that ventilation can effectively improve indoor air quality, increase indoor oxygen content, and remove indoor harmful gases and transmission [18], while air quality is negatively correlated with depressive symptoms [19]. The study by Zhang [20]found that the increase in $PM_{2.5}$ pollution concentration of 1 μg/m^3 would significantly increase the depressive mood index of residents by 3.88%. Yao [21] conducted a cohort study using CHARLS data, and the results showed that air pollution increased the risk of depressive symptoms in older persons, and the risk of depressive symptoms in the male group was higher, which was consistent with the results of this study [21]. In addition, we have previously verified the mediating effect of self-rated health and life satisfaction on impaired ability of daily living and depressive

Table 1 Detection of depressive symptoms and anxiety symptoms in older persons with different sociodemographic characteristics [*n*(%)]

Characteristics	Depressive Symptoms				Anxiety Symptoms			
	NO	YES	X^2	*P*	NO	YES	X^2	*P*
Age (years)			16.021	**<0.001**			1.007	0.316
<80	3,697(92.7)	292(7.3)			3,912(98.1)	77(1.9)		
≥80	5,151(90.4)	550(9.6)			5,574(97.8)	127(2.2)		
Years of education (years)			54.567	**<0.001**			22.620	**<0.001**
0	3,796(89.0)	470(11.0)			4,145(97.2)	121(2.8)		
1～6	3,108(92.7)	246(7.3)			3,294(98.2)	60(1.8)		
>6	1,944(93.9)	126(6.1)			2,047(98.9)	23(1.1)		
SEX			43.715	**<0.001**			27.377	**<0.001**
Male	4,686(89.6)	546(10.4)			5,085(97.2)	147(2.8)		
female	4,162(93.4)	296(6.6)			4,401(98.7)	57(1.3)		
marital status			38.896	**<0.001**			5.714	**0.017**
not be married	4,736(89.7)	545(10.3)			5,153(97.6)	128(2.4)		
nuptial	4,112(93.3)	297(6.7)			4,333(98.3)	76(1.7)		
current address			3.630	0.057			14.227	**<0.001**
countryside	6,609(91.0)	654(9.0)			7,087(97.6)	176(2.4)		
municipalities	2,239(92.3)	188(7.7)			2,399(98.8)	28(1.2)		
cigarette smoking			10.403	**0.001**			16.201	**<0.001**
NO	7,387(90.9)	739(9.1)			7,934(97.6)	192(2.4)		
YES	1,461(93.4)	103(6.6)			1,552(99.2)	12(0.8)		
drink			14.794	**<0.001**			4.137	**0.042**
NO	7,449(90.8)	751(9.2)			8,017(97.8)	183(2.2)		
YES	1,399(93.9)	91(6.1)			1,469(98.6)	21(1.4)		
exercise			105.099	**<0.001**			20.303	**<0.001**
NO	5,617(89.2)	683(10.8)			6,137(97.4)	163(2.6)		
YES	3,231(95.3)	159(4.7)			3,349(98.8)	41(1.2)		
socialize			9.038	**0.003**			6.450	**0.011**
NO	7,427(90.9)	740(9.1)			7,982(97.7)	185(2.3)		
YES	1,421(93.3)	102(6.7)			1,504(98.8)	19(1.2)		
economic situation			372.161	**<0.001**			167.331	**<0.001**
hunger	708(75.4)	231(24.6)			867(92.3)	72(7.7)		
general	6,231(92.0)	543(8.0)			6,653(98.2)	121(1.8)		
rich	1,909(96.6)	68(3.4)			1,966(99.4)	11(0.6)		
incapacity			254.963	**<0.001**			47.798	**<0.001**
NO	6,325(94.4)	378(5.6)			6,607(98.6)	96(1.4)		
YES	2,523(84.5)	464(15.1)			2,879(96.4)	108(3.6)		
Self-assessment of health			957.803	**<0.001**			294.970	**<0.001**
good	4,551(97.8)	102(2.2)			4,616(99.2)	39(0.8)		
general	3,388(90.4)	359(9.6)			3,691(98.5)	56(1.5)		
no good	909(70.5)	381(29.5)			1,181(91.6)	109(8.4)		
Life satisfaction			887.710	**<0.001**			304.024	**<0.001**
dissatisfied	6,560(95.3)	326(4.7)			6,806(98.8)	80(1.2)		
general	2,149(85.2)	372(14.8)			2,442(96.9)	79(3.1)		
unsatisfactory	139(49.1)	144(50.9)			238(84.1)	45(15.9)		
Ventilation frequency			91.526	**<0.001**			17.429	**<0.001**
lower	646(83.9)	124(16.1)			738(95.8)	32(4.2)		
medium	2,746(89.6)	320(10.4)			3,003(97.9)	63(2.1)		
high	5,456(93.2)	398(6.8)			5,745(98.1)	109(1.9)		

Table 2 Variable assignment of influencing factors of depression and anxiety symptoms in older persons

variable	Assignment
Sex	0 = female; 1 = male
Age	0 = < 80 years; 1 = ≥ 80 years
Years of education	0 = 0 years; 1 = 1 ~ 6 years; 2 = > 6 years
Marital status	0 = not in marriage; 1 = in marriage
Place of residence	0 = rural; 1 = urban
Smoking	0 = No; 1 = Yes
Alcohol consumption	0 = No; 1 = Yes
Exercise	0 = No; 1 = Yes
Socializing	0 = No; 1 = Yes
Economic status	0 = poor; 1 = average; 2 = rich
Disability	0 = No; 1 = Yes
Self-assessed health	0 = good; 1 = fair; 2 = bad
Life satisfaction	0 = satisfactory; 1 = fair; 2 = unsatisfactory
Ventilation Frequency	0 = low; 1 = medium; 2 = high

symptoms in older persons [22]. The limitation of the older persons 's daily activity ability may affect their frequency of opening Windows for ventilation, which will affect their health and eventually cause the occurrence of depressive symptoms.

This study found that the relationship between indoor ventilation frequency and anxiety in older persons was not statistically significant. Although many studies have shown a positive correlation between air pollution and depressive symptoms [23, 24], the relationship between the two remains controversial. For example, VERT [25] 's investigation of 958 adult residents showed that the correlation between long-term exposure to air pollution and anxiety symptoms did not reach statistical significance. In this study, there are more older persons in the sample, so they may pay more attention to their physical health, while air quality has little influence on them. In addition, insufficient ventilation may increase the concentration of indoor harmful gases, long-term exposure will cause chronic effects on the nervous system, and this cumulative effect is more likely to trigger depressive symptoms, while anxiety is more directly related to stressors, such as noise, sudden events, etc., ventilation frequency may have a weak impact on anxiety symptoms.

This is the first study to examine indoor ventilation frequency and symptoms of anxiety and depression in older persons. The strengths of this study also include a large sample of Chinese seniors living in a nationally representative community and the inclusion of many older persons. However, there are some limitations to this study. First, this is a cross-sectional survey that does not reflect longitudinal changes, and longitudinal studies are needed to further investigate the relationship between indoor ventilation frequency and depressive symptoms. Second, our study assessed depression and anxiety symptoms using the 10-item Center for Epidemiologic Studies Depression Scale (CESD-10) and the Anxiety Screening Tool (GAD-7 scale) rather than clinical diagnostic criteria. In addition, the inclusion of persistent anxiety and depression scores as dichotomous variables may have reduced the statistical effect. However, the 10-item Center for Epidemiologic Studies Depression Scale (CESD-10) and the GAD-7 scale are well-validated tools and have been widely used in epidemiological studies. Third, the CLHLS study over-sampled older persons. Therefore, the results of this study may be difficult to generalize to the entire population. Fourth, the indoor ventilation frequency does not accurately record the ventilation

Table 3 Logistic regression analysis results of depressive symptoms and anxiety symptoms in older persons

Variable	Depressive symptoms (yes)		Anxiety symptoms (yes)	
	OR(95%CI)	*P*	OR(95%CI)	*P*
Intercept	-3.28	<0.001	-4.04	<0.001
Indoor ventilation frequency				
Low	1.92(1.50 ~ 2.46)	**<0.001**	1.37(0.89 ~ 2.10)	0.150
Medium	1.51(1.27 ~ 1.79)	**<0.001**	0.97(0.70 ~ 1.35)	0.872
Socialization	1.06(0.83 ~ 1.36)	0.647	0.84(0.50 ~ 1.39)	0.486
Years of education	1.00(0.88 ~ 1.13)	0.949	1.04(0.81 ~ 1.33)	0.784
Marital status	0.76(0.63 ~ 0.91)	0.003	0.95(0.70 ~ 1.31)	0.769
Economic status	0.58(0.50 ~ 0.68)	<0.001	0.47(0.35 ~ 0.62)	<0.001
Disability	1.75(1.48 ~ 2.07)	<0.001	1.45(1.07 ~ 1.97)	0.016
Exercise	0.66(0.54 ~ 0.81)	<0.001	0.80(0.56 ~ 1.16)	0.241
Drinking	1.05(0.81 ~ 1.37)	0.712	1.24(0.76 ~ 2.02)	0.395
Smoking	0.97(0.75 ~ 1.25)	0.812	0.39(0.21 ~ 0.75)	0.004
Self-rated Health	2.76(2.44 ~ 3.13)	<0.001	2.36(1.87 ~ 2.99)	<0.001
Life Satisfaction	2.05(1.79 ~ 2.34)	<0.001	1.76(1.39 ~ 2.23)	<0.001
Place of residence			0.60(0.38 ~ 0.95)	0.028
Sex	0.73(0.61 ~ 0.89)	0.001	0.59(0.41 ~ 0.85)	0.004
Age	1.05(0.86 ~ 1.27)	0.652		

duration, only a rough estimate of the number of times. Therefore, the depth of the study may be affected, and more accurate investigation studies can be conducted in the future to explore the relationship between ventilation frequency and depressive symptoms.

Conclusions

In summary, low indoor ventilation frequency is associated with a higher risk of depressive symptoms among Chinese older persons. Therefore, attention should be paid to the indoor ventilation of older adults, health education and inspection should be conducted to urge older persons to open the windows more often for ventilation and screening for depressive symptoms, to achieve the prevention of depression and early intervention, and to promote the healthy aging of older persons in China.

Abbreviations

CLHLS Chinese Longitudinal Healthy Longevity Survey.

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Author contributions

LL and XHQ: design of the study and interpretation of data. JW: data processing. SHQ and JPC: data processing, article design, and revision. PPH: article modification. All authors contributed to the article and approved the submitted version.

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Data availability

The data are held in a public repository. The details of the CLHLS were presented online (https://opendata.pku.edu.cn/dataverse/CHADS;jsessionid=121de1752184d9c4953cc0f28935).

Declarations

Ethical approval and consent to participate

The CLHLS study was approved by the research ethics committees of Duke University and Peking University (IRB00001052–13074). The HUNT3 Study was approved by the Norwegian Regional Committee of Medical Research Ethics (4.206.250 dated 06.04.2006, 2015/1640/REK Nord, dated 18.08.2015). The procedures used in this study adhere to the tenets of the Declaration of Helsinki. All participants provided written informed consent. No experimental interventions were performed.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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