MADRID
inter.noise 2019
June 16 - 19
NOISE CONTROL FOR A BETTER ENVIRONMENT

Effects of traffic noise on the sleep of older adults

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ABSTRACT

Nighttime exposure to noise has been found to affect residents' sleep quality and increase the incidence of some diseases. The present study's objective is to investigate the association between self-reported sleep and outdoor traffic noise exposure. The survey was conducted in a residential community near traffic roads. Eighty-three residents aged 50 to 80 years took part in the study. Sleep quality over the past 30 days was assessed using the Pittsburgh Sleep Quality Index (PSQI). Additional questions were used to assess the effects of outdoor traffic noise and the magnitude of sleep disturbance over three months. Environmental sound level was measured with sound-level metres simultaneously. This study thus showed an association between exposure to outdoor traffic noise and disturbed sleep. Older people are significantly more affected by traffic and other noises. Some correlative improve measurements are given according to the results, which help residents improve their sleep quality.

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Keywords： older adults, Pittsburgh Sleep Quality Index (PSQI), sleep quality, traffic noise

I-INCE Classification of Subject Number: 63

1. INTRODUCTION

In addition to air, water, and food, the only other biological necessity our bodies require is sleep.[1] Little doubt exists among health professionals about the fundamental importance of sufficient, restorative sleep in maintaining one's physical and mental health. Sleep loss has been implicated in a variety of negative health outcomes[2] including cardiovascular abnormalities,[3] immunological problems,[4] psychological health concerns,[5] and neurobehavioural impairment that can lead to accidents.[6]

It is well established that noise can disturb sleep, and if this disturbance is severe and frequent enough it can lead to significant fragmentation and sleep deprivation which seriously affects our physical and mental health.[7] Previous studies have shown that residents exposed to environmental noise such as aircraft, road, and train noises at night exceeding a certain decibel level suffer from sleep disorders, more or less.[8-13] Among those noises, road traffic noise is the most common and influential factor affecting nighttime sleep for residents. Recently, the World Health Organization's (WHO's) Night Noise Guidelines for Europe[14] suggested a nighttime annual average outdoor level of 40 dBA to reduce negative health outcomes from sleep disturbance even among the most vulnerable groups.

Older adults are often troubled by various diseases including insomnia which has important health risk implications. Sleep in older adults has been extensively studied. Epidemiological studies also indicate a positive correlation between age and the prevalence of insomnia complaints.[15-17] The majority of older people have reported sleep disturbances[18-20] in many related studies. Therefore, creating a good sleeping environment is very important for older adults' health. It is important to analyse the various environmental factors that are more likely to affect the sleep of older people.

However, fewer studies have examined whether older adults' sleep is more susceptible to traffic noise. Moreover, most of the above studies select European or American cities as research sites; comparatively, there is not enough attention paid to researching pollution hazards of traffic noise in China, which differs in levels of social development and culture. Residents' assessment of the impact of traffic noise is also different from the results in the European and American studies.

Different from urban fringe living areas in Europe and America, Chinese city houses tend toward a high floor area ratio, high-density, and high-rise planning model. As a result, most residential areas are close to the main roads, which may increase the impact of traffic noise on residential areas. Currently, nearly 70% of urban residents in China live in an environment with excessive noise.

Therefore, taking a typical old-age community in Harbin, China as the research site and using a questionnaire consisting of the Pittsburgh Sleep Quality Index (PSQI) and other questions, we aimed to reveal the effects of traffic noise on older adults' sleep.

2. METHODOLOGY

2.1 Case Site

Study locations were drawn from areas in Hongxing Mingyuan Community, Nangang District, Harbin, China. Harbin is the capital city of Heilongjiang Province, the northernmost province of China. As the economic, political, and cultural centre of Heilongjiang Province, Harbin attracts large numbers of people and traffic every day, which causes traffic congestion in the city. There are 21 main roads and 57 secondary roads in the urban area of Harbin. The urban trunk road network density is relatively low, and the road network planning is not reasonable as shown in Figure 1. At the same time, the number of motor vehicles in Harbin is growing annually. The road and bridge facilities—invested in heavily during the year—cannot keep up with the fast-growing traffic demands of the city. The resulting traffic congestion has led to increasingly serious traffic noise pollution in excess of the national standards in Harbin.

Nangang District, where the Hongxing Mingyuan Community is located, is the central city of Harbin. The residential building is adjacent to the main road (Wenchang Road and Wenchang Viaduct), which has a large amount of traffic every day and is shown in Figure 1 and Figure 2.

Figure 1: Survey site

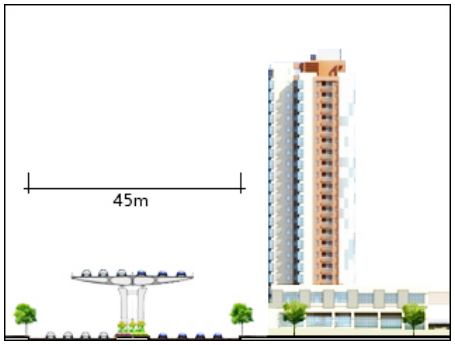

Figure 2: The large road next to the site

2.2 Participants

There were 83 older adults aged 50 to 80 years in the neighbourhood participating in the survey. Of the participants, 52% were women. At the beginning, we randomly selected 110 residents (one person per household) from the neighbourhood. Of them, 93 were willing to participate in the survey, including 10 participants younger than 50 years of age. In the end, we got 83 valid responses.

2.3 Subject Measures

Participants were required to complete a questionnaire including the PSQI and other personal characteristics and residence information.

The PSQI is a measure of the subjective experience of sleep that has had detailed psychometric assessment[21] and is one of the most common subjective methodologies used in sleep research. It can provide an assessment of sleep quality over the previous

30 days. The PSQI differentiates between ‘poor-‘and ‘good-‘quality sleepers by measuring seven areas: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medication, and daytime dysfunction over the past month.[22] The components of the PSQI are scored on a scale from 0 (better) to 3 (worse); therefore, the global PSQI is a score ranging from 0–21. A global score greater than 5 is indicative of a poor-quality sleeper, whereas a score of 5 or less is indicative of a good-quality sleeper.[23] The PSQI global score has good internal constancy (Cronbach’s $\alpha = .71$).

Participants also needed to provide some personal characteristics including gender, age, occupation, family population, and residence information such as floor, bedroom location to the traffic road, etc. Additionally, participants also needed to self-report the impact of traffic noise on sleep using an 11-point scale, which was scored on a scale from 0 (no effect) to 10 (serious impact).

2.4 Object Measures

The traffic noise measurements of the sound pressure level were performed simultaneously. In order to ensure the accuracy and representativeness of the data, the measurement should be carried out under weather conditions without rain or snow, and the wind speed should not exceed 5.5 m/s. The measuring point was selected on the sidewalk 2 m away from Wenchang Road. The measurement was carried out in November 2018 for seven consecutive days, from 22:00-8:00 daily. An 801 sound-level metre was set 1 m from the wall and main reflectors and 1.2-1.5 m from the ground outside the buildings to record Leq at the measuring point with fast-style and A-weight. We finally got that the equivalent outdoor sound level of the building on the street side is 74.6 dBA.

3. RESULTS

3.1 The PSQI

According to the calculation method in the appendix, we get the global PSQI score for each participant. For the 83 participants who completed the PSQI in its entirety, the average score across the entire sample was 5.96 with a 95% confidence interval (5.72, 6.17). Of the participants who have poor sleep quality, 45% scored greater than 5 and 30% scored greater than 8.

The results of the questionnaire also showed that elderly residents go to bed late at night and get up early in the morning, which leads to a low total sleep duration. As indicated in Figure 3, participants go to sleep at 22:12 PM and get up at 5:36 AM on average. The average sleep duration is approximately seven hours and twenty-four minutes, which is the optimal sleep duration of 7~8 hours.

According to the statistical analysis of the responses to the question ‘During the past month, how often have you had trouble sleeping because you ___’ in the questionnaire, we got the degree of influence of different factors on residents' sleep. As can be seen from Figure 4, the most influential factor was c., ‘go to the toilet at night’, affecting more than 60% of participants’ sleep. About 50% of participants had trouble

sleeping because of noise.

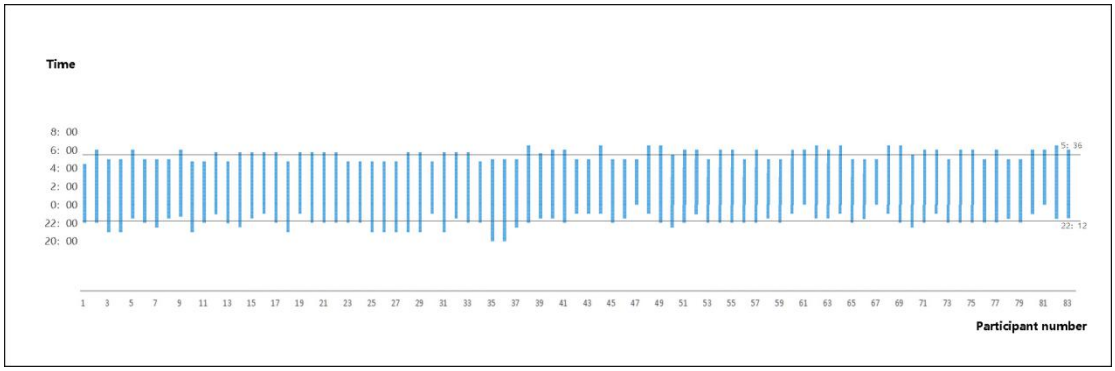

Figure 3: Habitual sleep time and duration

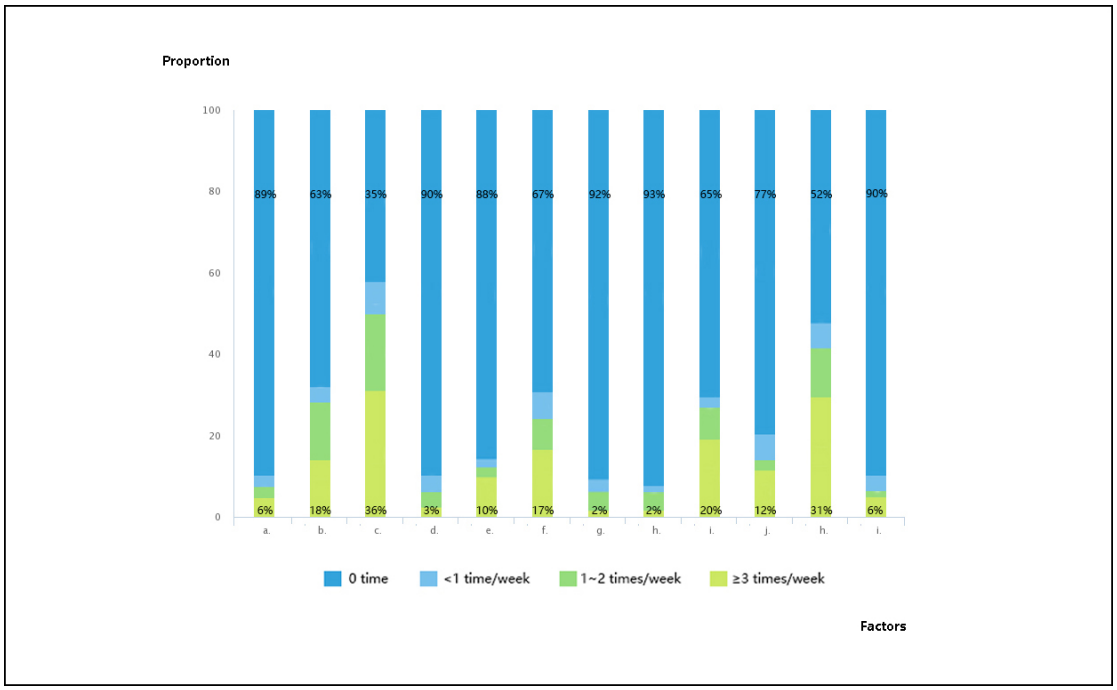

Figure 4: Result of the question 'During the past month, how often have you had trouble sleeping because you ___'

a. Difficulty falling asleep (cannot fall asleep within 30 minutes). b. Easy to wake up or wake up early at night. c. Go to the toilet at night. d. Poor breathing. e. Cough or snoring. f. Feeling cold. g. Feeling hot. h. Nightmare. i. Pain/discomfort. j. Stress/anxiety. k. noise. l. Other things that affect sleep.

3.2 Effect of traffic noise

From Figure 5, we conclude that noise is the second most important influence on participants' sleep quality, but the specific relationship needs to be further revealed. As can be seen from the scatter plot in Figure 6, the PSQI score seems to have a slowly increasing trend with the influence of noise. Upon further data analysis, only a moderate correlation was found to exist between noise effect and self-reported sleep quality (Pearson coefficient = 0.341, p value $<$ 0.01).

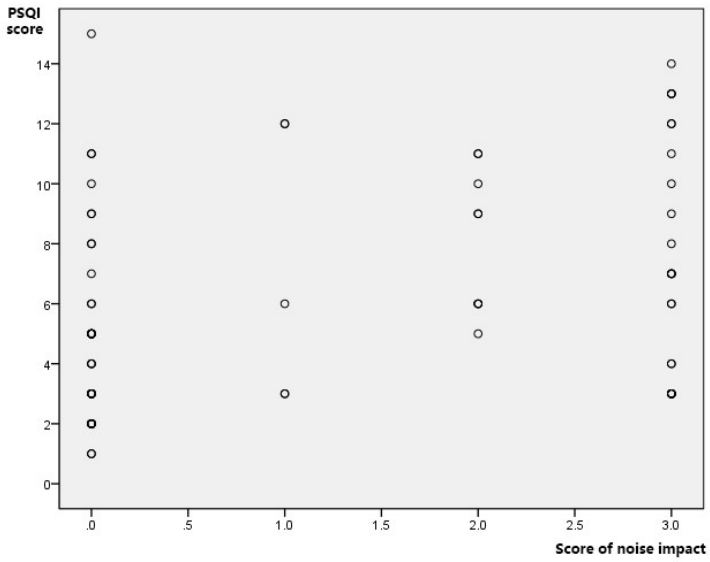

Figure 5: Correlation between score of noise impact and PSQI score

At the same time, another discovery indirectly confirmed the impact of noise on sleep. Participants whose bedroom location is on the side close to the road have higher PSQI scores (6.05, SD = 3.45) than those who sleep on the other side (5.93, SD = 3.82), which means participants whose bedrooms are located away from the road have better sleep quality.

Participants were also required to evaluate the effects of 11 common sources of noise on sleep including road traffic, neighbours, people living with coughing or snoring, family activities, home appliances, elevator equipment, construction/decoration, wind/rain/thunderstorm, community outdoor activities, resident activity beside the road, and others on a 11-point scale scored from 0 (no effect) to 10 (serious impact).

The results showed that the average score of participants' evaluations of the impact of traffic noise is 6.2 points, which is the highest among all the noises. Almost everyone's evaluation score for traffic noise was greater than 0, meaning that it affects almost every participants' sleep.

4. CONCLUSIONS

The survey shows that the nighttime sleep of elderly residents in the neighbourhoods close to roads with a large traffic volume is susceptible to being affected by traffic noise, and the noise impact of self-evaluation is weakly related to sleep quality.

More than 60% of participants' sleep has been affected by having to 'go to the toilet at night', making it the most influential factor. The effect of noise is secondary, which is the only environmental factor. Other common factors included 'easy to wake up or wake up early at night', 'feeling cold', and 'pain/discomfort'. Therefore, taking measures to reduce environmental noise is the most effective, largely beneficial, and simplest method for solving this health problem for most older adults.

The current research still has certain flaws. More samples are needed for further confirmation on the following:

1. We found that gender and family population have a very weak relationship with the PSQI. More samples may help us to discover it.

2. We have found that traffic noise has a certain impact on the sleep of elderly residents; however, further quantitative research controlling for noise levels, which will have greater practical implications, may be needed.

3. The PSQI is only self-reported sleep quality, which may not be the same as the actual sleep condition. If we can combine some objective measurement methods, it may make the results more convincing and interesting.

5. ACKNOWLEDGEMENTS

This study was supported by the National Natural Science Foundation of China (Project Number: 51878210, 51678180, 51308145).

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7. APPENDIX

PSQI Scoring
Component 1 #9 Score
Component 2 #2 Score (<15 min (0), 16-30 min (1), 31-60 min (2), >60 min (3))
+ #5a Score (if sum is equal 0 = 0; 1-2 = 1; 3-4 = 2; 5-6 = 3)
Component 3 #4 Score (>7 (0), 6-7 (1), 5-6 (2), <5 (3)
Component 4 (total # of hours asleep)/(total # of hours in bed) x 100
>85% = 0, 75%-84% = 1, 65%-74% = 2, <65% = 3
Component 5 # sum of scores 5b to 5j (0 = 0; 1-9 = 1; 10-18 = 2; 19-27 = 3)

Component 6 #6 Score
Component 7 #7 Score + #8 score (0 = 0; 1-2 = 1; 3-4 = 2; 5-6 = 3)
Global PSQI Add the seven component scores together