# Sleep Disturbance Predicts Posttraumatic Stress Disorder and Depressive Symptoms:
## A Cohort Study of Chinese Adolescents

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### ABSTRACT

***Objective:*** To examine the cross-sectional and longitudinal associations between sleep disturbance and posttraumatic stress disorder (PTSD) and depressive symptoms in a large cohort of adolescents exposed to the 2008 Wenchuan earthquake in China.

***Methods:*** Participants were 1,573 adolescents (mean age at initial survey = 15.0 years, SD = 1.3 years; 46% male) in the Wenchuan Earthquake Adolescent Health Cohort (WEAHC) in Dujiangyan, China, 20 km away from the east epicenter. The Pittsburgh Sleep Quality Index, Post-Traumatic Stress Disorder Self-Rating Scale, and Depression Self-Rating Scale for Children were used to assess participants' sleep, PTSD symptoms, and depressive symptoms, respectively, at 12 months (T12m) and 24 months (T24m) after the Wenchuan earthquake that occurred on May 12, 2008.

***Results:*** At T12m and T24m, 38.3% and 37.5% of participants reported sleep disturbance, 22.5% and 14.0% reported PTSD symptoms, and 41.0% and 38.3% reported depressive symptoms, respectively. The prevalence rates of PTSD and depressive symptoms at T12m and T24m significantly increased with sleep disturbance and short sleep duration. After adjusting for demographics, earthquake exposure, and PTSD/depressive symptoms at T12m, sleep disturbance at T12m was significantly associated with increased risk for PTSD (odds ratio [OR] = 1.80; 95% CI, 1.17–2.75) and depressive symptoms (OR = 1.51; 95% CI, 1.14–2.02) at T24m. Furthermore, sleep disturbance predicted the persistence of PTSD (OR = 2.35; 95% CI, 1.43–3.85) and depressive symptoms (OR = 2.41; 95% CI, 1.80–3.24).

***Conclusions:*** Sleep disturbance, PTSD, and depressive symptoms were prevalent and persistent in adolescents at 12 and 24 months after exposure to the Wenchuan earthquake. Sleep disturbance predicts the development and persistence of PTSD and depressive symptoms. Early assessment and treatment of sleep disturbance may be an important strategy for prevention and intervention of PTSD and depression in adolescent trauma survivors.


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Traumatic events increase risk of mental disorders such as posttraumatic stress disorder (PTSD) and depression.[1–3] Sleep disturbances such as difficulty falling asleep, frequent awakenings, shorter sleep duration, restless sleep, and daytime sleepiness are common following a traumatic event and increase concurrently with the severity of PTSD and depression.[4–6]

Sleep disturbances are closely linked to mental disorders, but limited prospective research has examined the extent to which disturbed sleep predicts the onset of PTSD and depression. Within such few studies, the temporary relationship between sleep disturbance and subsequent PTSD and depression appears inconclusive. For example, in a study of 453 Dutch military service members,[7] the authors found that self-reported predeployment nightmares predicted PTSD symptoms at 6 months postdeployment, while predeployment complaints of insomnia did not. In a study[8] of 102 victims of motor vehicle accidents at 1 week and 1, 3, 6, and 12 months after the trauma, results showed that self-reported insomnia and daytime sleepiness at 1 month significantly predicted clinically diagnosed PTSD at 12 months. Besides, a 1-year longitudinal study[9] of high school students reported that insomnia could predict new onset of depression after adjustment for age, sex, and baseline depressive symptoms. Previous studies[7–9] have also been limited by small sample size, short follow-up, and/or inadequate sleep assessment. Moreover, the aforementioned findings are based almost exclusively on studies conducted in Western countries. It is unknown whether or the extent to which the association observed in Western populations could be generalizable to Chinese populations.[10]

The Wenchuan Earthquake Adolescent Health Cohort (WEAHC)[11,12] provides a unique opportunity to enhance understanding of short sleep duration and sleep disturbance as risk factors for the onset and persistence of PTSD and depressive symptoms in a large cohort of Chinese adolescents. The present study aimed to examine (1) the prevalence rates of sleep disturbance, PTSD, and depressive symptoms in Chinese adolescents exposed to the Wenchuan earthquake; (2) whether sleep disturbance and short sleep duration could be concurrently associated with the presence of PTSD and depressive symptoms; and (3) whether previous sleep disturbance and short sleep duration could predict the development and persistence of PTSD and depressive symptoms.

## METHODS

### Participants

Participants were 1,573 adolescents from 1 junior high school and 1 senior high school in Dujiangyan, China, 20 km away from the east epicenter. Detailed information about the Wenchuan earthquake

**Table 1. Participants' Demographics and Earthquake Exposure (N = 1,573)[a]**

| Variable | N | % |
|---|---|---|
| Sex | 1,573 | |
| Male | 720 | 45.8 |
| Female | 853 | 54.2 |
| Grade | 1,573 | |
| Middle school | 216 | 13.7 |
| High school | 1,357 | 86.3 |
| Only child | 1,573 | |
| Yes | 1,303 | 82.8 |
| No | 270 | 17.2 |
| Residence[b] | 1,528 | |
| Urban | 1,033 | 67.6 |
| Rural | 495 | 32.4 |
| Father's education[b] | 1,566 | |
| Primary school | 214 | 13.7 |
| Middle school | 679 | 43.4 |
| High school | 513 | 32.8 |
| College or above | 160 | 10.2 |
| Earthquake exposure | | |
| Family member killed/injured[b] | 1,543 | |
| No | 1,144 | 74.1 |
| Injured | 197 | 12.8 |
| Killed/missing | 202 | 13.1 |
| House damage[b] | 1,538 | |
| No | 476 | 30.9 |
| Moderate | 399 | 25.9 |
| Severe | 663 | 43.1 |
| Property loss[b] | 1,547 | |
| No/mild | 667 | 43.1 |
| Moderate | 543 | 35.1 |
| Severe | 337 | 21.8 |
| Directly witnessed[b] | 1,487 | |
| No | 597 | 40.1 |
| Yes | 890 | 59.9 |

[a]The mean (SD) age at baseline for the 1,573 participants was 15.0 (1.3) years.
[b]Number of participants differed from total N = 1,573 due to missing data.

and the cohort can be found in Fan et al[11] and Geng et al.[12] Only 7th (first year in junior high school) and 10th (first year in senior high school) graders were included for at least 2 years of follow-up before their graduation. Participants were first assessed at 6 months after the earthquake, which occurred on May 12, 2008, and every 6 months thereafter. Participants could not be assessed immediately after the earthquake because we had to wait for ethical approval from our university Ethics Committee and target school boards. Sleep was assessed at 12 and 24 months after the earthquake to examine the associations between sleep problems and PTSD and depression. Table 1 presents demographic characteristics and earthquake exposure of the cohort at 6 months.

## Procedure

This study was approved by the Human Research Ethics Committee of South China Normal University, Guangzhou, China. Permission and support were obtained from the boards of the participating schools, the Chengdu Women's Federation, and the participants' parents. A questionnaire was administered to participants in classroom settings. The questionnaire asked for information concerning demographics, earthquake exposure, sleep problems, depressive symptoms, and PTSD symptoms. It took about 30 minutes for a participant to complete the questionnaire.

**Clinical Points**

- Sleep disturbance not only predicts the development of PTSD and depressive symptoms, but also predicts the persistence of both symptoms.
- Assessment and treatment of sleep disturbance as early as possible after a natural disaster may be an important strategy for prevention and intervention of PTSD and depression in adolescent survivors.

Participants were told the objectives and procedure of the study before completing informed consent forms. Parents were sent a letter describing the study 2 weeks prior to the initial survey to obtain consent for their children's participation.

## Measures

***Sleep.*** At 12 months (T12m) and 24 months (T24m), 4 items from the Pittsburgh Sleep Quality Index (PSQI)[13] were used to evaluate self-reported sleep duration and sleep disturbance during the past month: (1) How many hours of actual sleep did you get at night? (2) How often have you had trouble sleeping because you cannot get to sleep within 30 minutes at night? (3) How often have you had trouble sleeping because you wake up in the middle of the night or early morning? and (4) How would you rate your sleep quality overall? For items 2 and 3, a frequency of at least 3 times per week indicated difficulty initiating sleep and difficulty maintaining sleep, respectively; for item 4, a response of "bad" or "very bad" was considered as having poor sleep quality. Overall *sleep disturbance* was defined as having any 1 of the following 3 symptoms: difficulty initiating sleep (≥ 3 nights a week), difficulty maintaining sleep (≥ 3 nights a week), or poor sleep quality. The Chinese version of the PSQI has satisfactory psychometric properties.[13]

***Depressive symptoms.*** Adolescents' depressive symptoms were evaluated using the Chinese version of the Depression Self-Rating Scale for Children (DSRSC).[14] The DSRSC includes 18 items with responses on a 3-point scale, ranging from 0 to 2. A total score of 15 has been used as the cutoff for screening depressive disorders in Chinese children and adolescents with acceptable sensitivity and specificity.[14] In the current study, Cronbach α was 0.81 at T12m and 0.82 at T24m.

***PTSD symptoms.*** The Post-Traumatic Stress Disorder Self-rating Scale (PTSD-SS)[15] was used to measure adolescents' PTSD symptoms. It entails 24 items based on the diagnostic criteria of PTSD as described in the *DSM-IV* and the *Chinese Classification of Mental Disorders*, Second Edition, Revised.[16] The respondent rated each item on a 5-point scale, ranging from 1 ("not at all") to 5 ("extremely severe"). The PTSD-SS had a satisfactory internal consistency and construct validity among Chinese adolescents, and a total score of 50 has been used as the cutoff to screen clinically probable PTSD.[15] In the current study, Cronbach α was 0.95 at T12m and 0.96 at T24m.

***Earthquake exposure.*** Participants' exposure to the earthquake was assessed at 6 months. Four questions were

**Table 2. Sleep, PTSD, and Depressive Symptoms at 12 and 24 Months After Earthquake**

| Variable | 12 Months (%) | 24 Months (%) | $\chi^2$ |
|---|---|---|---|
| Sleep duration, N | 1,428 | 1,313 | 82.24* |
| ≥ 9 hours | 4.1 | 2.0 | |
| 7–9 hours | 47.3 | 64.2 | |
| 5–7 hours | 47.5 | 32.7 | |
| < 5 hours | 1.1 | 1.1 | |
| Difficulty initiating sleep, N | 1,402 | 1,311 | 61.41* |
| No | 22.3 | 30.5 | |
| < 1 night/wk | 19.3 | 25.9 | |
| 1–2 nights/wk | 31.0 | 24.9 | |
| ≥ 3 nights/wk | 27.4 | 18.7 | |
| Difficulty maintaining sleep, N | 1,433 | 1,313 | 23.86* |
| No | 47.0 | 43.7 | |
| < 1 night/wk | 22.4 | 29.6 | |
| 1–2 nights/wk | 22.6 | 17.8 | |
| ≥ 3 nights/wk | 8.0 | 8.9 | |
| Subjective sleep quality, N | 1,434 | 1,310 | 39.59* |
| Very good | 19.2 | 21.7 | |
| Good | 59.2 | 48.3 | |
| Poor | 19.4 | 25.4 | |
| Very poor | 2.2 | 4.6 | |
| Sleep disturbance, % (N)[a] | 38.3 (1,408) | 37.5 (1,312) | 0.18 |
| PTSD, % (N) | 22.5 (1,392) | 14.0 (1,315) | 32.21* |
| Depression, % (N) | 41.0 (1,429) | 38.3 (1,312) | 2.08 |

[a]Sleep disturbance = difficulty initiating sleep (≥ 3 nights/wk), difficulty maintaining sleep (≥ 3 nights/wk), or poor/very poor sleep quality.
*$P < .001$.
Abbreviation: PTSD = posttraumatic stress disorder.

asked to indicate their experiences of (1) death, missing, and/or injury of a family member; (2) house damage; (3) property loss other than house damage; and (4) direct witness of tragic disaster. The first item was scored as follows: 1 = death of a family member, 2 = missing a family member, 3 = serious injury of a family member, 4 = moderate injury of a family member, and 5 = none of the above. The other 3 items were rated on a 5-point scale with 1 representing the highest level of exposure and 5 representing the lowest. Cronbach α was 0.50 for the current sample of participants.

### Statistical Analysis

Data were presented as mean (SD) for continuous variables and frequencies and percentages for categorical variables. $\chi^2$ tests were used to examine the differences in the prevalence rates of sleep problems, PTSD, and depressive symptoms between T12m and T24m. A series of logistic regression analyses were performed to examine the bivariate and multivariate associations between each sleep variable and PTSD and depressive symptoms, separately. To control for 2 sleep-related items (ie, "I don't sleep well" and "I have nightmares"), we excluded the 2 items from DSRSC and PTSD-SS and adjusted the cutoff in proportion to the change in the number of items to define the presence of PTSD or depressive symptoms. In the multivariate regression models, demographics (ie, sex, age, residence location, being an only child, and father's education level), earthquake exposure, and PTSD/depressive symptoms at T12m were entered to adjust for their potential confounding effects. These variables were selected to control for on the basis of our previous studies.[11,12] Odds ratio (OR) and 95% confidence interval (CI) were used to quantify the strength of the association. All analyses were performed using IBM SPSS Statistics for Windows, Version 21.0 (IBM Corp, Armonk, New York).

## RESULTS

### Sleep, PTSD, and Depressive Symptoms at 12 Months and 24 Months

Table 2 shows sleep duration and prevalence rates of sleep disturbance and PTSD and depressive symptoms at 12 and 24 months after the earthquake. Figure 1 illustrates the trajectory changes of sleep disturbance, PTSD, and depressive symptoms over 1 year from 12 to 24 months after the earthquake. As shown in Figure 1A, approximately 60% of participants who had sleep disturbance at T12m still had sleep disturbance at T24m, while about 26% who did not report sleep disturbance at T12m developed sleep disturbance at T24m. As shown in Figure 1B, about 45% of participants who had PTSD symptoms at T12m continued to have PTSD symptoms at T24m, while 5.7% of those who did not have PTSD symptoms developed PTSD symptoms at T24m. As shown in Figure 1C, about 64% of participants who had depressive symptoms at T12m continued to have depressive symptoms at T24m, while about 20% of those who did not have depressive symptoms at T12m developed depressive symptoms at T24m.

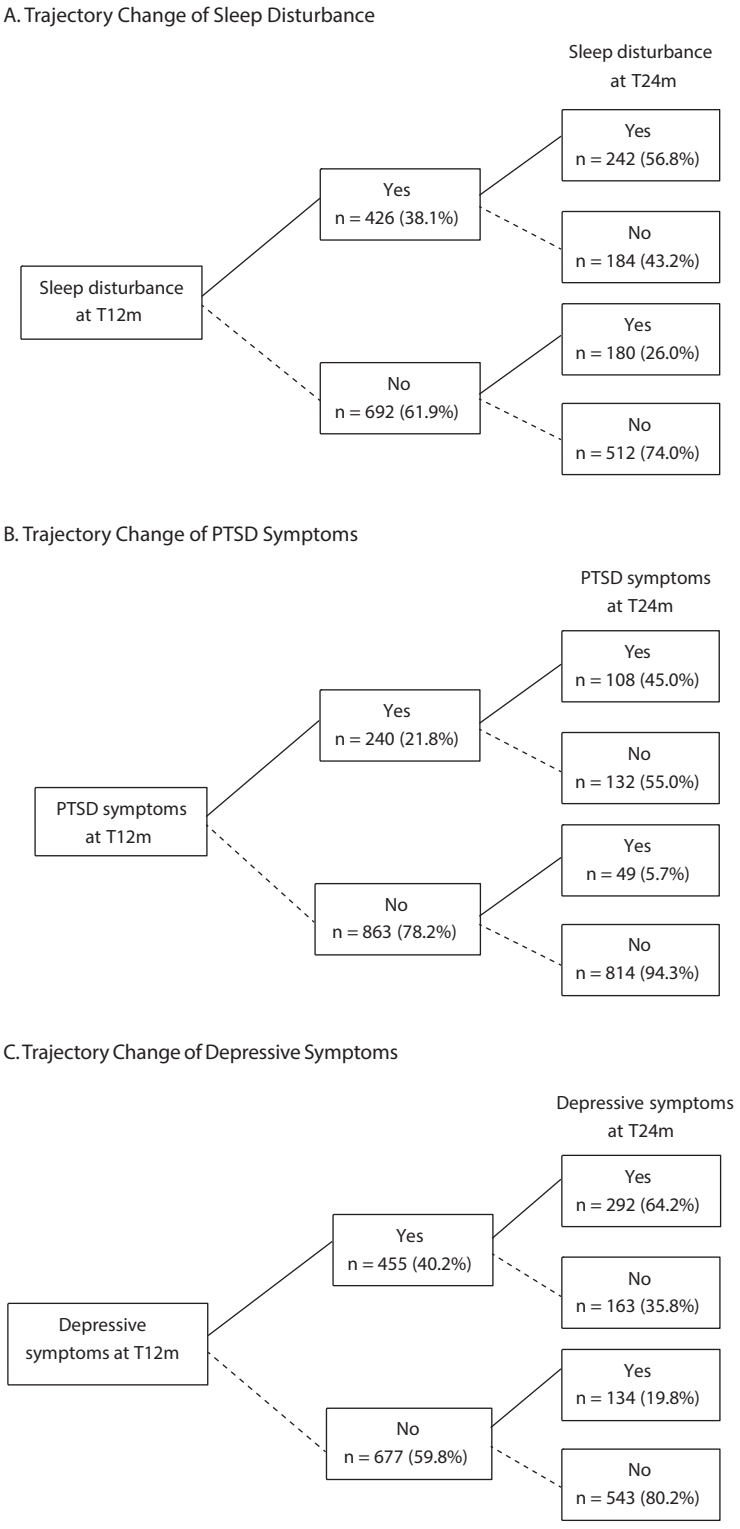
### Cross-Sectional Associations of Sleep With PTSD and Depressive Symptoms

As shown in Table 3, the prevalence rates of both PTSD and depressive symptoms at T12m significantly increased with reduced sleep duration, increased sleep disturbance including difficulty initiating sleep and difficulty maintaining sleep, or poor sleep quality at T12m. Participants who reported having overall sleep disturbance were more likely to have PTSD symptoms (36.7% vs 14.6%; OR = 3.40; 95% CI, 2.62–4.41) and depressive symptoms (54.2% vs 29.8%; OR = 2.78; 95% CI, 2.23–3.48). After adjusting for demographics and earthquake exposure, difficulty initiating sleep, difficulty maintaining sleep, poor sleep quality, and overall sleep disturbance were still significantly associated with increased odds of PTSD and depressive symptoms and short sleep duration remained significantly associated with depressive symptoms.

### Longitudinal Associations of Sleep With PTSD and Depressive Symptoms

Table 4 presents the predictive effects of sleep problems at T12m on PTSD and depressive symptoms at T24m. The unadjusted odds of PTSD and depressive symptoms were significantly increased with difficulty initiating sleep, difficulty maintaining sleep, and poor sleep quality. The unadjusted odds of PTSD symptoms were also significantly increased with reduced sleep duration. After adjusting for demographics, earthquake exposure, and PTSD symptoms at T12m, difficulty initiating sleep (OR = 2.45; 95% CI, 1.14–5.26) and difficulty maintaining sleep (OR = 2.04; 95% CI, 1.05–3.96) ≥ 3 nights per week, poor sleep quality

**Figure 1. Trajectory Changes of Sleep Disturbance, PTSD, and Depressive Symptoms From 12 Months (T12m) to 24 Months (T24m) After the Wenchuan Earthquake**




Abbreviation: PTSD = posttraumatic stress disorder.

(OR = 5.45; 95% CI, 2.12–14.00), and overall sleep disturbance (OR = 1.80; 95% CI, 1.17–2.75) at T12m were still significantly associated with increased risk for PTSD symptoms at T24m. After adjusting for demographics, earthquake exposure, and depressive symptoms at T12m, difficulty initiating sleep ≥ 3 nights per week (OR = 1.83; 95% CI, 1.19–2.79), poor sleep quality (OR = 2.08; 95% CI, 1.30–3.33), and overall sleep disturbance (OR = 1.51; 95% CI, 1.14–2.02) at T12m remained significantly associated with increased risk for depressive symptoms at T24m. However, short sleep duration was no longer a significant predictor for both PTSD and depressive symptoms.

### Sleep Disturbance Predicting Persistence of PTSD and Depressive Symptoms

Because the number of participants with persistent PTSD or depressive symptoms in most categories of individual sleep problems was small, overall sleep disturbance (yes or no) was used to predict persistence of PTSD or depressive symptoms. Demographics, earthquake exposure, and PTSD and depressive symptoms at 6 months (the earliest measure after the disaster) were adjusted for potential confounding effects. Adjusted ORs were 2.35 (95% CI, 1.43–3.85; $P < .001$) for PTSD symptoms and 2.41 (95% CI, 1.80–3.24; $P < .001$) for depressive symptoms, respectively. That is, the risk for persistent PTSD and depressive symptoms from 12 to 24 months was more than doubled among adolescents who had sleep disturbance at 12 months after the earthquake relative to those who did not.

## DISCUSSION

PTSD and depressive symptoms after a life-threatening event may be caused by the complex interaction between genetic and environmental factors. Sleep disturbance may be one of multiple factors, and its role in the development and trajectory changes of PTSD and depressive symptoms may be complicated, possibly being a comorbid condition, causal factor, or consequence of these mental disorders.[17,18] The associations between sleep and PTSD and depressive symptoms may be much more complicated in adolescents than in adults due to tremendous physiological, psychosocial, and behavioral changes, including irregular sleep patterns (bedtime delay), sleep loss, and daytime sleepiness during adolescence.[19,20]

To our knowledge, this is one of the few studies to examine the extent to which sleep disturbance is associated with development and

**Table 3. Prevalence of PTSD and Depressive Symptoms at 12 Months and Their Associations With Sleep Disturbance at 12 Months After Earthquake**

| | PTSD at T12m[a] | | | Depression at T12m[a] | | |
|---|---|---|---|---|---|---|
| Sleep at T12m | % | Crude OR (95% CI) | Adjusted OR (95% CI)[b] | % | Crude OR (95% CI) | Adjusted OR (95% CI)[b] |
| Sleep duration | | n = 1,384 | n = 1,255 | | n = 1,421 | n = 1,290 |
| ≥ 9 hours | 8.8 | 1.00 | 1.00 | 25.9 | 1.00 | 1.00 |
| 7–8 hours | 17.1 | 2.15 (0.84–5.49) | 1.35 (0.49–3.66) | 31.0 | 1.29 (0.70–2.37) | 0.98 (0.50–1.91) |
| 5–6 hours | 29.8 | 4.41 (1.74–11.21)** | 2.61 (0.96–7.13) | 46.6 | 2.50 (1.36–4.59)** | 1.71 (0.87–3.38) |
| < 5 hours | 35.7 | 5.78 (1.39–24.08)* | 3.16 (0.71–14.08) | 73.3 | 7.88 (2.18–28.54)** | 5.61 (1.45–21.74)* |
| Difficulty initiating sleep | | n = 1,361 | n = 1,233 | | n = 1,397 | n = 1,268 |
| No | 5.6 | 1.00 | 1.00 | 20.6 | 1.00 | 1.00 |
| < 1 night/wk | 16.5 | 3.35 (1.86–6.04)*** | 3.36 (1.74–6.51)*** | 38.9 | 2.45 (1.69–3.54)*** | 2.00 (1.35–2.97)*** |
| 1–2 nights/wk | 26.2 | 6.05 (3.54–10.33)*** | 5.31 (2.89–9.75)*** | 39.9 | 2.55 (1.82–3.56)*** | 1.98 (1.38–2.85)*** |
| ≥ 3 nights/wk | 38.0 | 10.42 (6.12–17.74)*** | 10.49 (5.73–19.20)*** | 53.3 | 4.38 (3.12–6.16)*** | 3.50 (2.42–5.08)*** |
| Difficulty maintaining sleep | | n = 1,389 | n = 1,259 | | n = 1,426 | n = 1,294 |
| No | 13.8 | 1.00 | 1.00 | 28.9 | 1.00 | 1.00 |
| < 1 night/wk | 22.8 | 1.85 (1.31–2.61)*** | 1.71 (1.16–2.52)** | 43.3 | 1.88 (1.42–2.47)*** | 1.85 (1.37–2.51)*** |
| 1–2 nights/wk | 36.0 | 3.52 (2.56–4.85)*** | 2.96 (2.06–4.26)*** | 49.2 | 2.38 (1.81–3.14)*** | 2.13 (1.57–2.87)*** |
| ≥ 3 nights/wk | 39.8 | 4.15 (2.68–6.43)*** | 4.03 (2.48–6.56)*** | 54.9 | 2.99 (1.99–4.49)*** | 2.72 (1.76–4.22)*** |
| Sleep quality | | n = 1,390 | n = 1,260 | | n = 1,427 | n = 1,295 |
| Very good | 9.1 | 1.00 | 1.00 | 19.7 | 1.00 | 1.00 |
| Good | 19.3 | 2.40 (1.52–3.77)*** | 2.36 (1.40–3.99)*** | 36.5 | 2.34 (1.69–3.26)*** | 2.19 (1.53–3.15)*** |
| Poor | 43.1 | 7.61 (4.69–12.35)*** | 7.86 (4.50–13.74)*** | 62.3 | 6.74 (4.59–9.90)*** | 5.71 (3.76–8.68)*** |
| Very poor | 64.5 | 18.26 (7.83–42.59)*** | 28.89 (10.30–81.07)*** | 54.8 | 4.95 (2.30–10.66)*** | 5.14 (2.17–12.14)*** |
| Sleep disturbance[c] | | n = 1,366 | n = 1,238 | | n = 1,403 | n = 1,274 |
| No | 14.6 | 1.00 | 1.00 | 29.8 | 1.00 | 1.00 |
| Yes | 36.7 | 3.40 (2.62–4.41)*** | 3.37 (2.50–4.53)*** | 54.2 | 2.78 (2.23–3.48)*** | 2.55 (1.99–3.25)*** |

[a]Excluding 2 sleep-related items (poor sleep and nightmares).
[b]Adjusting for age, sex, residence location, only child, father's education, and earthquake exposure.
[c]Sleep disturbance = difficulty initiating sleep (≥ 3 nights/wk), difficulty maintaining sleep (≥ 3 nights/wk), or poor/very poor sleep quality.
*$P < .05$.
**$P < .01$.
***$P < .001$.
Abbreviations: PTSD = posttraumatic stress disorder, T12m = 12 months after earthquake.

**Table 4. Prevalence of PTSD and Depressive Symptoms at 24 Months and Their Associations With Sleep Disturbance at 12 Months After Earthquake**

| | PTSD at T24m[a] | | | Depression at T24m[a] | | |
|---|---|---|---|---|---|---|
| Sleep at T12m | % | Crude OR (95% CI) | Adjusted OR (95% CI)[b] | % | Crude OR (95% CI) | Adjusted OR (95% CI)[c] |
| Sleep duration | | n = 1,257 | n = 1,112 | | n = 1,254 | n = 1,142 |
| ≥ 9 hours | 3.8 | 1.00 | 1.00 | 26.9 | 1.00 | 1.00 |
| 7–8 hours | 11.7 | 3.37 (0.80–14.14) | 1.96 (0.41–9.32) | 30.7 | 1.20 (0.64–2.28) | 1.03 (0.49–2.19) |
| 5–6 hours | 17.4 | 5.38 (1.29–22.46)* | 2.10 (0.43–10.24) | 43.4 | 2.08 (1.10–3.92)* | 1.41 (0.65–3.06) |
| < 5 hours | 30.8 | 11.33 (1.80–71.32)** | 4.84 (0.54–43.77) | 53.8 | 3.17 (0.91–11.06) | 1.39 (0.31–6.25) |
| Difficulty initiating sleep | | n = 1,235 | n = 1,094 | | n = 1,232 | n = 1,123 |
| No | 4.6 | 1.00 | 1.00 | 22.7 | 1.00 | 1.00 |
| < 1 night/wk | 11.5 | 2.71 (1.36–5.37)** | 1.58 (0.69–3.60) | 34.9 | 1.83 (1.24–2.69)** | 1.29 (0.82–2.02) |
| 1–2 nights/wk | 16.4 | 4.08 (2.19–7.58)*** | 2.12 (0.99–4.53)† | 37.7 | 2.06 (1.46–2.92)*** | 1.50 (0.99–2.28)†† |
| ≥ 3 nights/wk | 22.0 | 5.87 (3.18–10.83)*** | 2.45 (1.14–5.26)* | 49.4 | 3.33 (2.34–4.73)*** | 1.83 (1.19–2.79)** |
| Difficulty maintaining sleep | | n = 1,260 | n = 1,114 | | n = 1,257 | n = 1,144 |
| No | 8.8 | 1.00 | 1.00 | 29.7 | 1.00 | 1.00 |
| < 1 night/wk | 14.6 | 1.77 (1.14–2.74)* | 1.26 (0.73–2.16) | 41.2 | 1.66 (1.23–2.24)*** | 1.19 (0.83–1.69) |
| 1–2 nights/wk | 21.1 | 2.77 (1.85–4.15)*** | 1.29 (0.76–2.19) | 44.4 | 1.89 (1.41–2.54)*** | 1.24 (0.87–1.77) |
| ≥ 3 nights/wk | 26.4 | 3.71 (2.22–6.22)*** | 2.04 (1.05–3.96)* | 45.7 | 1.99 (1.31–3.04)*** | 1.20 (0.72–2.00) |
| Sleep quality | | n = 1,261 | n = 1,115 | | n = 1,258 | n = 1,145 |
| Very good | 3.7 | 1.00 | 1.00 | 21.7 | 1.00 | 1.00 |
| Good | 12.9 | 3.89 (1.93–7.83)*** | 3.26 (1.33–8.00)** | 36.0 | 2.03 (1.44–2.84)*** | 1.35 (0.91–2.02) |
| Poor | 27.4 | 9.91 (4.81–20.39)*** | 5.45 (2.12–14.00)*** | 53.0 | 4.07 (2.75–6.03)*** | 2.08 (1.30–3.33)** |
| Very poor | 28.0 | 10.20 (3.40–30.57)*** | 2.40 (0.58–9.89) | 44.0 | 2.83 (1.22–6.60)* | 1.26 (0.43–3.66) |
| Sleep disturbance[d] | | n = 1,240 | n = 1,098 | | n = 1,237 | n = 1,128 |
| No | 9.4 | 1.00 | 1.00 | 29.9 | 1.00 | 1.00 |
| Yes | 22.2 | 2.77 (2.00–3.83)*** | 1.80 (1.17–2.75)** | 48.4 | 2.20 (1.73–2.79)*** | 1.51 (1.14–2.02)** |

[a]Excluding 2 sleep-related items (poor sleep and nightmares).
[b]Adjusting for age, sex, residence location, only child, father's education, earthquake exposure, and PTSD symptoms at 12 months.
[c]Adjusting for age, sex, residence location, only child, father's education, earthquake exposure, and depressive symptoms at 12 months.
[d]Sleep disturbance = difficulty initiating sleep (≥ 3 nights/wk), difficulty maintaining sleep (≥ 3 nights/wk), or poor/very poor sleep quality.
†$P = .053$.
††$P = .054$.
*$P < .05$.
**$P < .01$.
***$P < .001$.
Abbreviations: PTSD = posttraumatic stress disorder, T12m = 12 months after earthquake, T24m = 24 months after earthquake.

persistence of PTSD and depressive symptoms in a large cohort of adolescents exposed to a natural disaster. Our major findings were 3-fold. First, sleep disturbance, PTSD, and depressive symptoms were prevalent and persistent after exposure to the earthquake. The prevalence rates of sleep disturbance and depressive symptoms were more than doubled compared with those reported in previous studies in the general populations of Chinese adolescents.[21,22] Second, sleep disturbance was concurrently and longitudinally associated with increased risk of PTSD and depressive symptoms, while short sleep duration was only associated with concurrent PTSD and depressive symptoms. Third, sleep disturbance significantly predicted the persistence of PTSD and depressive symptoms.

Our study demonstrated significant concurrent and longitudinal associations between sleep disturbance and PTSD and depressive symptoms. Given that sleep disturbances are core symptoms and risk factors of multiple mental disorders,[23] our results were expected and consistent with several studies[8,9] that prospectively demonstrated the association of previous sleep disturbances with later onset of PTSD and depression. Our study also found that over the follow-up from 12 to 24 months after the earthquake, sleep disturbance significantly predicted the persistence of PTSD and depressive symptoms. These results suggest that the roles of sleep disturbance in the development and persistence of PTSD and depression may be similar or that PTSD and depressive symptoms are highly comorbid. Further studies are needed to examine if there are differences in the psychopathological and biological mechanisms underlying the relationship of sleep disturbance with PTSD and depressive symptoms.

Previous studies[24–26] have found that short sleep duration was associated with increased risk for mental or behavioral problems like anxiety, depression, suicidality, or addictive behaviors. However, most of these studies have been limited by cross-sectional design. For example, Liu and colleagues[24,25] reported a significant dose-response relationship between self-reported sleep duration and multiple domains of behavioral and emotional problems and suicidal behavior. Furthermore, in a recent cross-sectional study of 1,640 American veterans,[26] the authors found that short sleep duration was significantly associated with increased odds of concurrent PTSD, depression, and smoking behavior. Consistent with previous studies, we also found that self-reported short sleep duration was cross-sectionally associated with PTSD and depressive symptoms. However, our longitudinal analysis did not demonstrate that short sleep duration could independently predict the onset of PTSD and depressive symptoms after adjusting for demographics, earthquake exposure, and baseline PTSD/depressive symptoms. There are several possible explanations for this finding. First, short sleep duration may be a consequence of sleep disturbance and PTSD and depressive symptoms. Second, short sleep duration is associated with advancing age during adolescence,[19,20] and, thus, the prospective association disappeared after adjusting for demographics including age. Third, our measure of sleep duration is not an objective instrument or prospective sleep-wake diary, which may provide a more accurate estimate of participants' actual sleep patterns and the variability over the 12 months of follow-up. Further studies are warranted to address such issues and investigate how time-varying changes in sleep duration would influence the incidence and development of PTSD and depressive symptoms in adolescent survivors.

Several limitations should be considered in the interpretation of our results. First, we did not collect data on participants' sleep and mental health before or immediately after the earthquake because the earthquake occurred unpredictably and because we could not conduct the initial survey until we obtained approval from our Ethics Committee and target school boards. Second, all measures relied on self-reported questionnaires rather than diagnostic interview or objective assessments, which may be susceptible to participants' own psychiatric states and thus cause reporting bias. Although almost all measures used in our study are well established and standardized and have been widely used in Chinese population studies, a single-item measure of sleep quality may cause discriminant concern of the study. Third, there might be changes in participants' sleep duration and sleep problems over the 12-month period of follow-up. Prospective sleep-wake diaries or actigraphic recording could provide a more accurate estimate of participants' actual sleep duration and variability.[27] Fourth, some participants with severe mental health problems might have been receiving psychosocial intervention and/or medical treatments during the follow-up, which could affect their PTSD and depressive symptoms. Future work could improve the study design by collecting such data to determine the extent to which psychosocial and medical interventions could affect the prospective association of sleep disturbance with the development and persistence of PTSD and depressive symptoms. Furthermore, some recent epidemiologic studies[27,28] demonstrated a bidirectional relationship between sleep disturbances and mental disorders, which suggested that previous mental disorders could also predict later disturbed sleep. Further analyses will be conducted to examine whether PTSD and depressive symptoms at an earlier stage of postdisaster are associated with the development and persistence of sleep disturbance in Chinese adolescents.

Despite the limitations, our study made a unique contribution to the literature, as it is the first known study that investigated both cross-sectional and longitudinal associations of sleep disturbance with PTSD and depressive symptoms in a large cohort of Chinese adolescents exposed to a natural disaster. The most important finding is that sleep disturbance not only was concurrently and prospectively associated with increased risk of PTSD and depressive symptoms, but also predicted the persistence of both symptoms. This finding supports the causal role of sleep disturbance in the development and chronicity of PTSD and depressive symptoms. Our study also suggested that several simple items assessing sleep problems may be

quick and effective ways to screen individuals at increased risk of PTSD and depressive symptoms after a traumatic event. Moreover, because sleep disturbance may develop earlier and can predict PTSD[5] and because PTSD symptoms can develop weeks or months following a catastrophic event and may wax and wane over time,[29,30] assessment and treatment of sleep disturbance as early as possible may be an important strategy for prevention and intervention of these mental disorders in adolescent survivors. Future studies are warranted to identify individual characteristics for whom interventions with sleep will improve latent PTSD symptoms and for whom intervention is not needed.

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