Sleep Problems Among Adolescent Survivors Following the 2008 Wenchuan Earthquake in China: A Cohort Study

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ABSTRACT

Objective: To examine sleep problems and associated risk factors among adolescent survivors following the 2008 Wenchuan earthquake, the deadliest earthquake to strike China in 30 years.

Method: A cohort of students (N = 1,573) in the 7th and 10th grades from Dujiangyan City, 21 kilometers from the epicenter, was followed up periodically for 2 years. Participants were assessed at 12 months (n = 1,398; May 18-22, 2009), 18 months (n = 1,288; November 23-27, 2009), 24 months (n = 1,313; May 17-21, 2010), and 30 months (n = 1,038; November 22-26, 2010) after the earthquake. Adolescents were asked to complete the Pittsburgh Sleep Quality Index (PSQI; cutoff for sleep problems: total score of ≥ 8), Post-Traumatic Stress Disorder Self-Rating Scale (cutoff for probable posttraumatic stress disorder: \geq 50), Depression Self-Rating Scale for Children (cutoff for depressive disorder: ≥ 15), Screen for Child Anxiety Related Emotional Disorders (cutoff for clinical anxiety: \geq 25), Social Support Rate Scale, and Adolescent Self-Rating Life Events Checklist and provide demographic information. Trajectory analysis was used to examine sleep disturbance changes and associated risk factors.

Results: Twelve months after the earthquake, 48.90% of participants reported sleeping less than 7 hours per night, 27.68% disclosed difficulties initiating sleep, 8.82% experienced problems staying sleep, 22.60% felt their sleep quality was poor, and 40.01% had difficulties functioning during daytime hours. Overall sleep problems, as assessed by the PSQI global scale, were stable from 18 months to 30 months following the earthquake, and the prevalence rates were between 28.79% and 30.18%. The risk of sleep issues was significantly increased in senior high school students (OR = 2.29) and in those who witnessed the tragic events directly (OR = 1.21). Depression (OR = 1.69), anxiety (OR = 1.57), poor social support (OR = 1.83), and negative life events (OR = 2.62) were also associated with increased risk and persistence of sleep problems.

Conclusions: Sleep disturbances are common and persistent in adolescent earthquake survivors. Multiple demographic, psychosocial, and earthquake-related factors are associated with the increased risk of sleep difficulties.

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Corresponding author: Fang Fan, PhD, Center for Studies of Psychological Application South China Normal University Shipai Rd, Guangzhou, 510631, China (fangfan@scnu.edu.cn). **S** leep undergoes significant changes during adolescence. Adolescent sleep is characterized by sleep insufficiency, irregular sleep-wake patterns, and daytime sleepiness. For example, although young adults need to sleep 9.2 hours per night under ad lib sleep conditions,¹ they typically sleep an average of 7.5 hours per night.^{2,3} Epidemiologic studies have shown that short sleeping periods (less than 8 hours per night) are associated with poor daytime functioning, internalizing/externalizing problems, and suicidal behavior in adolescents.^{3–5} Multiple psychosocial, school, family, and biological factors are associated with sleep changes and problems in adolescence.^{1,2,6,7} Negative life events, including natural disasters, may have a negative impact on adolescents' sleep quantity and quality.

Sleep disturbances are common in individuals in the immediate and long-term aftermath of exposure to disasters.^{8,9} High prevalence rates of sleep disturbances have been reported among survivors of earthquakes,^{10–12} hurricanes,^{13–15} terrorist attacks,^{16–18} and wars and other traumatic events.^{19–21} For example, North et al¹⁶ reported that 6 months after the Oklahoma City bombing, 70% of survivors had insomnia and more than 50% had nightmares. Most of these studies were conducted in developed countries and focused on adults. Little is known about the sleep problems of adolescent natural disaster survivors, especially those in developing countries.

Only a few longitudinal studies have investigated sleep problems and sleep changes following disasters. Findings have been varied. Kato et al¹² found that sleep disturbances did not decrease in survivors of the Hanshin-Awaji earthquake from 3 weeks to 8 weeks after the disaster. Dirkzwager et al²² found that, compared to controls, postdisaster increases in sleep problems were significantly larger in young people who had been exposed to a fireworks disaster. The prevalence rates of sleep problems in these youth declined during the 2-year study period. As yet, no longitudinal studies have been specifically concerned with adolescent sleep pattern changes and disturbances following a natural disaster.

A number of cross-sectional studies have examined risk factors associated with sleep problems among adolescents. These factors have included high levels of trauma exposure,^{10,11,13–15,20,22} low levels of social support,²³ recent stressful life events, and psychiatric disorders.^{24–28} However, no causal relationships can be determined from cross-sectional research. Longitudinal studies are needed to examine trajectory changes of sleep problems as well as factors predicting sleep changes among adolescent natural disaster survivors.

For the purposes of the current study, a total of 1,573 adolescent survivors from the Wenchuan earthquake were followed up for 30 months to investigate sleep problems and their predictors. The aims were to (1) examine the prevalence of sleep problems in adolescent earthquake survivors, (2) describe trajectory changes of sleep problems, and (3) examine risk factors concerning the development and persistence of sleep problems.

- Sleep problems were common and persistent for up to 30 months among adolescent survivors of the 2008 Wenchuan earthquake.
- Sleep problems and psychiatric symptoms are not only coexisting but also bidirectional, and multiple demographic, psychosocial, and earthquake-related factors are associated with increased risk and persistence of sleep problems.
- Early detection of and intervention for sleep problems is important to reduce the impact of natural disasters on health and well-being in adolescent survivors.

METHOD

Event

The Wenchuan earthquake of 2008 had a magnitude of 8.0 M_s and 7.9 M_w. The epicenter was in Wenchuan County, Ngawa Tibetan and Qiang Autonomous Prefecture, China, 80 km west/northwest of the provincial capital city of Chengdu. The main tremor occurred at 14:28:01.42 China Standard Time (CST) (06:28:01.42 UTC) on Monday, May 12, 2008, and lasted for approximately 2 minutes. Almost 80% of buildings in the area were destroyed. At 14:28 CST on May 12, 2008, tremors also struck China's northwestern province of Sichuan with a magnitude of 8.0. The event as a whole resulted in 69,227 deaths, 374,176 injuries, and 18,222 missing persons, and 4.8 million people were left homeless. Approximately 15 million people were affected by the earthquake, with a direct economic loss of nearly US \$120.7 billion. Dujiangyan City, near Wenchuan, suffered 3,069 deaths, 4,388 injuries, and 429 missing persons.²⁹

Participants

A total of 2,463 students in the 7th–10th grades from 1 middle school and 1 high school in Dujiangyan City were assessed 6 months after the earthquake. Detailed sampling and assessments can be found in Fan et al.³⁰ Only students in 7th grade (first year in middle school) and 10th grade (first year in high school) were included in this cohort study. A total of 1,573 students were followed up for 2 years prior to their graduation. Participants were from a variety of social backgrounds and considered representative of all students in the district. Participants were followed up at 12, 18, 24, and 30 months after the disaster.

Procedure

This study was approved by the Human Research Ethics Committee of South China Normal University. Permission and support were also obtained from the respective school boards, the Chengdu Women's Federation, and participants' parents.

A self-administered questionnaire was used to assess adolescents' sleep problems and related factors during May 18–22, 2009, about 12 months after the earthquake. The questionnaire asked for information concerning demographics, earthquake experiences, sleep problems, life events, social support, anxiety, depression, and posttraumatic stress disorder (PTSD). The same tool was used to reevaluate participants at 18 months (November 23–27, 2009), 24 months (May 17–21, 2010), and 30 months (November 22–26, 2010) after the earthquake. The assessment was administered in the form of group testing.

Before the assessment started, test examiners briefly introduced the assessment tool to ensure informed consent. Students were asked to participate but were also informed that they were not obligated to do so and could withdraw from the study at any time. Students who agreed to participate were given a copy of the questionnaire. They were asked to read questionnaire guidelines carefully and sign consent forms if they wished to participate. Parents were also provided with information packs 2 weeks prior to assessment and asked to provide consent for their children's participation. Parents were provided with the research team's contact details to use in the event of any queries related to the study.

Of the 1,573 target participants, a total of 1,398 students completed the assessment at 12 months, while 1,288 completed it at 18 months, 1,313 completed it at 24 months, and 1,038 completed it at 30 months.

Measures

Participants' experience of and degree of exposure to the earthquake were assessed using 4 items: (1) death, disappearance, and/or injury of family members; (2) house damage; (3) property loss; and (4) direct observation of the disaster. The first item included 5 choices: 1 = death of a family member, 2 = disappearance of 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 Likert scale with 1 representing the highest level of exposure and 5 representing the lowest.

At 12 months, 5 items selected from the Pittsburgh Sleep Quality Index (PSQI)^{31,32} were used to evaluate reported sleep duration and sleep problems during the past month. These were (1) How many hours of sleep do you get at night? $(\geq 9 \text{ hours}/7-9 \text{ hours}/5-7 \text{ hours});$ (2) Do you have difficulty getting to sleep within 30 minutes at night? (no/less than once a week/once or twice a week/3 or more times a week) (difficulty initiating sleep); (3) Do you wake up in the middle of the night or early morning? (no/less than once a week/once or twice a week/3 or more times a week) (difficulty maintaining sleep); (4) How would you rate your sleep quality overall? (very good/fairly good/fairly bad/very bad); and (5) How much of a problem has it been for you to keep up enough enthusiasm to get things done? (no problem at all/only a very slight problem/somewhat of a problem/a very big problem). For item 1, 7 hours or less of sleep per night indicated a sleep shortage; for item 2 (difficulty initiating sleep) and item 3 (difficulty maintaining sleep), a sleep problem was defined as a sleeping difficulty with a frequency of at least 3 times per week; for item 4, a rating of "fairly bad" or "very bad" was interpreted as poor sleep quality; and for item 5, "somewhat of a problem" or "a very big problem" was considered to be representative of daytime dysfunction.

At 18, 24, and 30 months following the earthquake, adolescents' sleep problems were assessed using the full PSQI (Chinese-language version).³¹ The scale consists of 19 selfrated questions. A global PSQI score of 8 or greater indicates sleep problems. In the current study, Cronbach a values were 0.70 at 18 months, 0.73 at 24 months, and 0.70 at 30 months.

Adolescents' depressive symptoms were evaluated using the Depression Self-Rating Scale for Children (Chineselanguage version).³³ It includes 18 items with responses on a 3-point Likert scale ranging from 0 to 2. A total score of \geq 15 is understood to be a cutoff point to screen depressive disorders in Chinese people with acceptable sensitivity and specificity. In the current study, the Cronbach α values were 0.81 at 12 months, 0.82 at 18 months, and 0.84 at 24 months.

The Adolescent Self-Rating Life Events Checklist (Chineselanguage version)³⁴ was used to measure the severity of recent negative life events during the past 6 months. It incorporates 26 items, including 6 dimensions: interpersonal conflicts, academic pressure, being punished, personal loss, physical health problems, and others. The impact of each negative life event was rated on a 5-point Likert scale (1 = not at all and 5 = extremely severe). In the current study, the Cronbach a values were all 0.90 at 12, 18, and 24 months.

The Social Support Rate Scale (SSRS)³⁵ was used to assess individual social support. It includes 10 items incorporating the 3 dimensions of (1) objective support, (2) subjective support, and (3) utilization of social support. The validity and reliability of the Chinese version of the SSRS have been demonstrated. In the current study, the Cronbach α was 0.78 at 18 months.

The Post-Traumatic Stress Disorder Self-Rating Scale (PTSD-SS)³⁶ was applied to measure adolescents' PTSD symptoms. It is composed of 24 items based on the diagnostic criteria of PTSD as described in *DSM-IV* and the *Chinese Classification of Mental Disorders*, Second Edition, Revised.³⁷ The respondent rated each item on a 5-point Likert scale ranging from 1 ("not at all") to 5 ("extremely severe"). The PTSD-SS has been reported to have a satisfactory 2-week testretest reliability (r=0.87), internal consistency (coefficient α =0.92), and construct validity among Chinese adolescents. A cutoff score of ≥ 50 can screen clinically probable PTSD. In the current study, Cronbach α values were 0.95 at 12 and 18 months and 0.96 at 24 months.

The Chinese version of the Screen for Child Anxiety Related Emotional Disorders³⁸ was used to measure child anxiety. It consists of 41 items with responses on a 3-point Likert scale ranging from 0 to 2. The Chinese version has been validated by Su and colleagues.³⁸ A total score of \geq 25 has been suggested to be the cutoff point to screen clinical levels of anxiety in Chinese children and adolescents. In the current study, the Cronbach α values were 0.93 at 12 months, 0.94 at 18 months, and 0.95 at 24 months.

Statistical Analysis

Of the 1,573 target participants, 135 adolescents did not report sleep problems at any of the 4 waves. These participants

were excluded from the current analysis. Among the remaining participants (N = 1,438), 37% had missing sleep-related data during at least 1 wave. To investigate possible bias and to avoid loss of statistical power introduced by missing data, multiple imputation was applied.^{39,40} First, 10 complete data sets were acquired using the PROC Mi MCMC algorithm in SAS.⁴⁰ These data sets were subsequently analyzed using standard statistical analyses. Estimates were obtained by averaging across the results from each data set using Rubin's rules.⁴¹

Because some categories had very few participants, the 4 earthquake exposure variables were recoded. Social support scores and negative life events scores were also recoded into 3 categories, with low and high categories defined as 1 standard deviation below or above the mean.

Latent variable growth models were used to capture the changes in adolescents' sleep problems.⁴² Generalized estimating equations (GEEs) were applied to examine the bivariate and multivariable associations between participant characteristics and sleep problems at 18, 24, and 30 months.⁴³ The GEE models included invariant variables and time-varying variables. The invariant variables included participants' gender, school grade, parents' educational levels, residence type, siblings, family members killed/ injured, house damage, property loss, direct observation of the disaster, and social support. Anxiety, PTSD, depression, and negative life events were modeled as time-varying covariates. All analyses were performed using SAS statistical software, version 9.0 (SAS Institute, Inc; Cary, North Carolina).

RESULTS

Sample Characteristics

Of the 1,438 participants who provided at least 1 wave of sleep data, 644 were boys and 794 were girls; 210 were junior high school students and 1,228 were senior high school students; and the mean age was 15.6 (SD = 1.3) years at 12 months after the earthquake. A majority of the participants had no siblings (82.9%) and were living in urban environments (67.4%). As shown in Table 1, 13.0% of participants reported dead or missing family members, and 12.9% reported injured family members. House damage was common, with 26.6% of participants reporting their house as destroyed or seriously damaged and 42.2% reporting their house as moderately damaged. Nonresidential property damages and losses were also commonly reported, with 21.5% of the sample having complete or major property loss and 35.5% having moderate property loss. Furthermore, 59.5% of participants witnessed the tragic events directly.

Prevalence of Psychiatric Symptoms

The prevalence of psychiatric symptoms in this sample was high. At 12 months after the earthquake, 51.67%, 40.89%, and 22.39% of the participants were screened as having symptomatology consistent with anxiety, depression, and PTSD, respectively. Although there was a decline in participants' PTSD and anxiety symptoms after the

Table 1. Demographics and Earthquake Exposures of Study Participants (N = 1,438)^a

Variable	
Male	44.8
Age at baseline, mean (SD), y	15.6 (1.3)
Grade	
Junior high students (7th grade)	14.6
Senior high students (10th grade)	85.4
No. of children in the family	
1	82.9
≥2	17.1
Residence location	
Urban	67.4
Rural	32.6
Family member injured or killed/missing	
No	74.1
Injured	12.9
Killed/missing	13.0
House damage	
No	31.2
Moderate	42.2
Severe	26.6
Property loss	
No	43.0
Moderate	35.5
Severe	21.5
Directly witnessed the disaster	
No	40.5
Yes	59.5
^a Values expressed as percentages unless otherwi	se noted.

Table 2. Prevalence of Sleep Problems and Other Psychiatric Symptoms Among Adolescent Survivors of the Wenchuan Earthquake $(N = 1,438)^a$

	12 mo	18 mo	24 mo	30 mo
Sleep duration < 7 h	48.90	30.87	34.87	40.34
Difficulty initiating sleep	27.68	21.87	20.42	17.42
Difficulty maintaining sleep	8.82	10.49	10.42	10.73
Poor sleep quality	22.60	28.46	31.39	28.31
Daytime dysfunction	40.01	35.48	42.82	40.75
Overall PSQI sleep problems	NA	29.22	30.18	28.79
Anxiety	51.67	39.99	40.61	NA
Depression	40.89	31.92	38.80	NA
PTSD	22.39	12.17	13.91	NA

^aValues expressed as percentages of subjects.

Abbreviations: NA = not applied, PSQI = Pittsburgh Sleep Quality Index, PTSD = posttraumatic stress disorder.

earthquake, the rates of PTSD-, depression-, and anxietylike features continued to be high 24 months after the disaster (Table 2).

Prevalence and Longitudinal Course of Sleep Problems

Twelve months after the earthquake, about 48.90% of the students reported sleeping periods of less than 7 hours, with 27.68% experiencing difficulty initiating sleep and 8.82% encountering difficulty maintaining sleep. Poor sleep quality was reported by 22.60% of the students, and 40.01% did not have enough enthusiasm to engage in daytime activities.

Latent variable growth model results showed that difficulty initiating sleep declined from 12 months after the earthquake onward (slope = -0.39, P < .01; quadratic = 0.10,

Figure 1. Longitudinal Trajectories of Specific Sleep Problems Among Adolescent Survivors of the Wenchuan Earthquake



Abbreviation: PSQI = Pittsburgh Sleep Quality Index.

Table 3. Latent Growth Models for Sleep Problems Among	
Adolescent Survivors of the Wenchuan Earthquake	

	Slope	Р	Quadratic	Р
Sleep duration < 7 h	-1.27	<.01	0.49	<.01
Difficulty initiating sleep	-0.39	<.01	0.10	.14
Difficulty maintaining sleep	0.32	.12	-0.12	.22
Poor sleep quality	0.39	<.01	-0.07	.23
Daytime dysfunction	-0.51	<.01	0.29	<.01
Overall PSQI sleep problems	0.11	.31	NA	NA
Abbreviations: $NA = not applied$	$d_{\rm PSOI} = P$	ittsburgh (Sleep Quality I	ndex

P=.14). Difficulty maintaining sleep was stable over time (slope = 0.32, *P* = .12; quadratic = -0.12, *P* = .22). The percentage of participants reporting less than 7 hours of sleep per night (slope = -1.27, *P* < .01; quadratic = 0.49, *P* < .01) and daytime dysfunction (slope = -0.51, *P* < .01; quadratic = 0.29, *P* < .01) first declined and then increased. However, poor sleep quality increased over time (slope = 0.39, *P* < .01; quadratic = -0.07, *P* = .23). The course of these sleep problems over time (12 to 30 months after the earthquake) is illustrated in Figure 1. The mean (SD) PSQI scores were 5.78 (2.76), 6.01 (2.95), and 5.65 (2.79) at 18, 24, and 30 months, respectively. The prevalence rates of overall sleep problems as assessed by the PSQI total score were stable from 18 months to 30 months after the earthquake (28.79%–30.18%, Tables 2 and 3).

Individual trajectories of sleep problems are presented in Figure 2. No sleep problems appeared to be present in 48.75% (n = 701) of the participants from 18 months to 30 months after the earthquake. Sleep problems were present during all of the last 3 waves in 9.94% (n = 143) of the participants, while the remaining participants' sleep problems fluctuated within these time periods.

Risk Factors for Sleep Problems

Bivariate and multivariate GEE logistic regressions for sleep problems at 18, 24, and 30 months after the earthquake





are presented in Table 4. Bivariate logistic regressions indicated that a number of variables were associated with sleep problems. Multivariate logistic regression showed that the risk of sleep problems significantly increased for senior high school student participants (OR = 2.29; 95% CI, 1.67–3.15) and those who witnessed the tragic events directly (OR = 1.21; 95% CI, 1.01–1.45), felt anxiety (OR = 1.57; 95% CI, 1.32–1.86), experienced depression (OR = 1.69; 95% CI, 1.43–1.99), received low levels of social support (OR for medium vs high = 1.47; 95% CI, 1.18–1.85; OR for low vs high = 1.83; 95% CI, 1.32– 2.53), and encountered high levels of negative life events (OR for medium vs low = 1.36; 95% CI, 1.11–1.67; OR for high vs low = 2.62; 95% CI, 1.85–3.71).

To assess potential reverse causation in the cases of negative life events, PTSD, depression, and anxiety among adolescent survivors, all models were rerun using data from 18 months and 24 months. The results showed that previous sleep problems significantly increased with subsequent negative life events (OR = 1.13; 95% CI, 1.08–1.18), PTSD (OR = 1.67; 95% CI, 1.26–2.21), anxiety (OR = 1.83; 95% CI, 1.49–2.24), and depression (OR = 2.72; 95% CI, 2.22–3.34).

DISCUSSION

This is the first longitudinal study to report sleep problems among Chinese adolescents following a natural disaster. Our results indicated that sleep problems were very common at 12 months after the earthquake and stable from 18 months to 30 months after the earthquake. The results also demonstrated that a number of factors were associated with sleep problems, including school grade/age, earthquake exposure, social support, recent negative life events, depression, and anxiety.

Prevalence of Sleep Problems

This study showed that, 12 months following the Wenchuan earthquake, 48.90% of students were sleeping less than 7 hours per day, 27.68% had difficulties falling asleep, 8.82% experienced difficulties staying asleep, 22.60% reported bad sleep quality, and 40.01% were unenthusiastic about doing things in the daytime. Compared to the general population of adolescents in China, the rates of sleep problems among adolescent survivors were higher. In a study of 1,359 Chinese adolescents, Liu and colleagues²⁴ found that 10.8% of the participants had trouble falling asleep, 6.3% experienced difficulties staying asleep, and 2.1% frequently awoke in the very early hours of the morning. In another study,² 18.8% of adolescents reported poor sleep quality, and 26.2% expressed sleep dissatisfaction.

The findings from the present study were consistent with other research that has illustrated sleep disturbances as a common phenomenon following disasters. Eight weeks after the 1995 Hanshin-Awaji earthquake, Kato et al¹² reported that 46% of young evacuees had difficulty sleeping. Swenson and colleagues'¹⁵ study of preschool hurricane survivors showed that 17% of children refused to sleep alone, 15% had trouble falling asleep, and 7% had bad dreams. Results of epidemiologic surveys of sleep problems vary following disasters, largely due to different types of disasters, nonstandardized questionnaires, and different time intervals of inquiry.

Table 4. Unadjusted and Adjusted GEE Logistic Regression Models Predicting Sleep Problems Among Adolescent Survivors of the Wenchuan Earthquake^a

	Unadjusted		Adjusted	
Variable	OR	95% CI	OR	95% CI
Gender				
Male	1.00		1.00	
Female	1.27	1.06 - 1.53	1.06	0.89-1.27
Grade				
Junior high students (7th grade)	1.00		1.00	
Senior high students (10th grade)	2.88	2.08 - 4.00	2.29	1.67-3.15
No. of children in the family				
1	1.00		1.00	
≥ 2	1.25	0.99-1.58	1.14	0.91-1.43
Residence location	1 00		1 00	
Urban	1.00		1.00	
Kurai	1.31	1.08-1.58	1.14	0.95-1.58
missing				
No	1.00		1.00	
Injured	1.00	0.82-1.68	1.00	0.80-1.38
Killed/missing	1 31	1.00 - 1.73	1 11	0.79-1.58
House damage	1.51	1.00 1.75	1.11	0.79 1.50
No	1.00		1.00	
Moderate	1.17	0.93-1.46	1.19	0.94-1.52
Severe	1.50	1.21-1.86	1.05	0.83-1.33
Property loss				
Ňo	1.00		1.00	
Moderate	1.11	0.88 - 1.41	1.16	0.88-1.52
Severe	1.59	1.26 - 2.01	0.99	0.78-1.27
Directly witnessed the disaster				
No	1.00		1.00	
Yes	1.26	1.05 - 1.52	1.21	1.01-1.45
Social support ^b				
High	1.00		1.00	
Medium	1.65	1.32-2.08	1.47	1.18-1.85
Low	2.82	2.02-3.94	1.83	1.32-2.53
Anxiety ²	1.00		1.00	
NO Vec	1.00		1.00	132 186
PTSDC	2.17	1.07-2.32	1.57	1.52-1.00
No	1.00		1.00	
Yes	1.71	1.41-2.08	1.13	0.92-1.39
Depression ^c	10/1	1111 2100	1110	0.72 1.07
No	1.00		1.00	
Yes	2.17	1.87-2.52	1.69	1.43-1.99
Negative life events ^c				
Ľow	1.00		1.00	
Medium	1.74	1.43-2.12	1.36	1.11-1.67
High	4.16	3.09-5.60	2.62	1.85-3.71

^aPittsburgh Sleep Quality Index scores >7 indicate sleep problems.

^bSocial support was assessed at 18 months after the earthquake and used as an invariant variable here.

^cAnxiety, PTSD, depression, and negative life events were assessed at 12, 18, and 24 months after the earthquake and modeled as time-varying variables.

Abbreviations: GEE = generalized estimating equation,

PTSD = posttraumatic stress disorder.

Course of Sleep Problems

Longitudinal analyses showed that the various types of sleep problems had different courses of development from 12 months to 30 months after the earthquake. Difficulty initiating sleep declined over time, which indicated participants' gradual emotional recovery. Loss of sleep time and daytime dysfunction first decreased and then increased. One reason for this pattern may be mounting academic stress experienced by students entering higher school grades.⁴⁴ Data from the PSQI showed that sleep problems were stable from 18 months to 30 months following the earthquake with prevalence rates of approximately 28.8%–30.2%. In comparison to other findings from China, the rate of sleep problems at 30 months after the earthquake was noticeably higher. For example, studies using the same scale have reported that the prevalence rates of sleep problems in Chinese adolescents were 18.8% in Shandong province²⁴ and 20% in Anhui province.⁴⁵ Sleep problems in adolescent survivors are still common at 30 months after the earthquake, making the need for ongoing support and intervention evident. Admittedly, there are sampling differences between this study and others, making direct comparisons of findings difficult.

Factors Associated With Sleep Problems

Consistent with previous studies,^{10,11,13-15,20,22} our results showed that trauma exposure was significantly associated with sleep problems among adolescents. To be specific, bivariate analyses suggested that students who had family members killed or missing in the earthquake, severe house damage, or family property loss or who witnessed the tragedy directly reported more sleep problems. However, after adjustment for other factors, only witnessing the tragic event directly was associated with sleep problems. One explanation for this finding may be that individuals with high levels of earthquake exposure received more social support than those with lower exposure. For example, only houses completely destroyed by the earthquake were rebuilt, and more government funds were given to families with deceased members.

In the current study, gender was not significantly related to sleep problems among adolescent survivors. However, a number of studies have reported that females suffer more mental health problems than males following disasters.⁴⁶ One and a half years after the 1988 Armenian earthquake, Pynoos et al¹¹ found that females reported more bad dreams than males and gender was not associated with sleep disturbances in children. Dirkzwager and colleagues' study,²² conducted after a man-made disaster, demonstrated no gender differences in sleep problems in either children or adolescents.

Similar to other studies,^{24,47} the present study found that senior high school students were at greater risk of developing sleep problems than their junior high peers. This increased risk may be attributed to greater academic stress experienced by senior high school students. High academic stress levels are particularly evident for senior high school students in China due to high parental academic expectations and great pressure to enter reputable universities.

A number of studies have reported that stressful life events are associated with sleep problems in the general Chinese population.^{24,25} Our study showed that previous negative life events significantly increased the risk of subsequent sleep problems among adolescent survivors. However, the relationship between stressful events and mental health is not simple, because individuals with sleep problems may experience more stressful life events. Our longitudinal data analysis showed that sleep problems significantly predicted negative life events after adjustment for other factors (OR = 1.13; 95% CI, 1.08–1.18), supporting this study's hypothesis.

Our study also showed that adolescents' access to social support systems might be predictive of their future mental health status. Facing similar levels of negative life events, participants with low levels of baseline social support reported more sleep problems. This highlights further the importance of social support after children and adolescents are exposed to disasters.

Sleep disturbances have been found to co-occur with a number of psychiatric conditions including PTSD, anxiety, and depression.^{47–51} In the present longitudinal study, previous depression and anxiety, but not PTSD symptoms, increased the risk of later sleep problems in adolescents. Results also showed that sleep problems significantly predicted PTSD (OR=1.67; 95% CI, 1.26–2.21), anxiety (OR=1.83; 95% CI, 1.49–2.24), and depression (OR=2.72; 95% CI, 2.22–3.34). These results draw attention to the complex relationship between sleep problems and mental disorders.

Although a longitudinal design, a large sample, and standardized tools were used, this study had some methodological limitations. First, sleep problems and related factors were primarily assessed using self-reported data as opposed to clinical interview and objective measures of sleep. Second, because only students in the 7th and 10th grades from the initial assessment were followed up, it is not known whether this study's findings can be generalized to all adolescent survivors from the earthquake. Third, although the rates of sleep problems among non-disaster-affected adolescents in China were provided, we do not know the extent to which adolescents' sleep was disturbed by the earthquake, because the study did not have a sleep-impaired control group unaffected by the earthquake. Another concern was the absence of sleep data prior to the earthquake. No conclusion could be made about the sleep changes after the disaster compared with possible sleeping difficulties prior to the earthquake. It is not known if the sleep trajectory is unique to the cohort of interest or the same as that of the general adolescent population in China, because the study did not have a control group.

Ongoing sleep data collection for adolescent earthquake survivors and controls will provide additional long-term data to inform comparisons between sleep changes in adolescents from natural disasters and the general population.

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