

ORIGINAL ARTICLE

Bidirectional associations between insomnia, posttraumatic stress disorder, and depressive symptoms among adolescent earthquake survivors: a longitudinal multiwave cohort study

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Abstract

Study Objectives: To assess insomnia symptoms in adolescents with probable posttraumatic stress disorder (PTSD) and to determine whether there are longitudinal and reciprocal associations between insomnia, PTSD, and depressive symptoms.

Methods: Participants were 1,492 adolescent survivors who had been exposed to the 2008 Wenchuan earthquake in China. Insomnia, PTSD, and depressive symptoms were measured at 12 months (T1, $n = 1407$), 18 months (T2, $n = 1335$), and 24 months (T3, $n = 1361$) postearthquake by self-report questionnaires. Generalized estimating equation (GEE) models were used to examine the cross-sectional and longitudinal associations of insomnia with PTSD and depression.

Results: Insomnia, PTSD, and depressive symptoms were common among adolescent survivors. Among participants with probable PTSD, approximately 47% (48.5%, T1; 48.1%, T2; and 44.2%, T3) reported difficulty falling asleep or difficulty maintaining sleep. Cross-sectional analyses showed that insomnia co-occurred with PTSD (odds ratio [OR] = 2.04) and depressive symptoms (OR = 2.10). Longitudinal analyses revealed that probable PTSD (OR = 1.50) and depression (OR = 1.42) predicted the incidence of insomnia; in turn, insomnia predicted the incidence of depression (OR = 1.65) over time. Furthermore, PTSD predicted (OR = 3.11) and was predicted (OR = 3.25) by depressive symptoms.

Conclusions: There is a bidirectional relationship between insomnia, PTSD, and depressive symptoms. This suggests that insomnia, PTSD, and depression are intertwined over time.

Statement of Significance

This is the first study to examine cross-sectional and longitudinal relationships between insomnia and posttraumatic stress disorder (PTSD)/depression in a large sample of adolescents with three waves of data collection. The findings provide new evidence of bidirectional relationships among insomnia, PTSD, and depression in adolescents after a traumatic disaster. The reciprocal associations among insomnia, PTSD, and depression provide insights into the improvement of interventions for postdisaster mental health problems, particularly for residual insomnia symptoms in PTSD. Future research needs to validate these findings in other trauma-exposed population as well as to expand upon them to determine possible moderating and mediating variables. Clinical studies should examine whether intervening in merely one condition can relieve other symptoms.

Key words: insomnia; PTSD; depression; adolescents; longitudinal study

Submitted: 11 September, 2018; Revised: 21 May, 2019

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Introduction

Insomnia symptoms are highly prevalent in posttraumatic stress disorder (PTSD) and are among the most distressing chronic symptoms [1–3]. It is estimated that 40% to 50% patients with PTSD suffer from difficulty initiating or maintaining sleep [4, 5]. PTSD comorbid with insomnia can result in adverse outcomes, including but not limited to suicide, functional impairment, and physical health problems [6–8]. Furthermore, studies have indicated that insomnia, in comparison to other sleep disturbances (e.g. nightmares), is less likely to respond to treatment for PTSD [9, 10]. Indeed, residual insomnia is one of the most intractable problems for current treatment of PTSD [10, 11]. Therefore, understanding the causal relationship between insomnia and PTSD is of great importance for not only the exploration of the mechanisms of their comorbidity but also the improvement of clinical intervention.

There have already been a few longitudinal studies examining the associations between PTSD and insomnia [12–16]. Specifically, two studies that similarly took the military as participants both investigated the impact of insomnia before deployment on later development of PTSD after military deployment, but their results came out to be distinct. One found that predeployment insomnia symptoms were significantly associated with higher odds of developing PTSD, depression, and anxiety postdeployment [12], while the other indicated that predeployment nightmares rather than insomnia predicted PTSD symptoms at 6 months postdeployment [13]. Bryant et al. assessed 1,033 traumatically injured patients during hospital admission and at 3 months after injury and found that insomnia immediately prior to trauma predicted subsequent PTSD [14]. In addition, with a sample of injured survivors of motor vehicle accidents, one study reported that insomnia complaints as early as 1 month after the trauma was possible to detect subjects who would later develop chronic PTSD [15]. There was another study reporting that insomnia at 8 weeks postpartum was associated with the maintenance of PTSD symptoms 2 years postpartum [16]. In summary, extant studies have indicated that both pretrauma and peri-trauma insomnia would contribute to the development and maintenance of PTSD. Insomnia and PTSD may persist for a long time [17]. It is unknown whether insomnia could predict PTSD in the long term after trauma. To our best knowledge, there has been only one study examining the bidirectional relationship between insomnia and PTSD, which indicated that insomnia significantly predicted PTSD, whereas PTSD failed to predict insomnia among Iraq combat veterans [18].

PTSD is highly comorbid with depression [19]. Longitudinal studies have shown that PTSD could predict and was also predicted by depression [20, 21]. In general population, the bidirectional relationship between insomnia and depression has already been confirmed [22, 23]. Given that trauma is a common risk factor for both depression and insomnia, a bidirectional relationship between depression and insomnia in trauma-exposed population could be inferred. Thus, the longitudinal interplay of insomnia, PTSD, and depression would be expected. However, no studies to date have examined these associations in traumatized children and adolescents.

In our previous studies, we found significant cross-sectional relationships between sleep duration, sleep disturbances, and PTSD symptoms [17]. Furthermore, sleep disturbances predicted the persistence of PTSD and depressive symptoms [24].

Expanding on those findings, the primary aims of the current study were to report the prevalent rates of insomnia in adolescent PTSD and to examine the bidirectional relationships between insomnia, PTSD, and depression in a large cohort of earthquake survivors with three waves of data collection. Specifically, the present study examined (1) the prevalence of insomnia symptoms in PTSD; (2) whether insomnia was associated with PTSD or depressive symptoms cross-sectionally; and (3) whether there were bidirectional relationships between insomnia, PTSD, and depressive symptoms. We hypothesized that insomnia, PTSD, and depressive symptoms were related bidirectionally with each other. Given that PTSD is highly comorbid with depression, PTSD or depressive symptoms would be controlled when examining the associations of insomnia and the other symptoms, which might result in seemingly weakened longitudinal relationships.

Methods

Participants and procedure

Participants were adolescent survivors who participated in the Wenchuan Earthquake Adolescent Health Cohort (WEAHC) study [25]. The purpose of the WEAHC study was to document the long-term mental health outcomes among adolescent survivors, as well as to explore the underlying psychological, neurobiological, and genetic mechanisms. Details of the study aims and design had been described in our previous studies [17, 25–27]. The WEAHC study enrolled 1,573 students from one junior high school and one senior high school in Dujiangyan District, which was directly exposed to the Wenchuan earthquake. Participants were initially assessed at 6 months postearthquake and then were followed for four times at 6 month intervals. Because insomnia, PTSD, and depression symptoms were assessed at 12 (T1), 18 (T2), and 24 (T3) months postearthquake, these three waves of data were used in the current study.

There were 1,407, 1,335, and 1,361 students completing the measures of insomnia, PTSD, and depression at T1, T2, and T3, respectively. The response rates were 94.3%, 89.5%, and 91.2% at T1, T2, and T3, respectively. Males were more likely to miss out than females at T1 and T2; participants who reported witnesses of the tragic scenes were more likely to miss out than those who did not at T2. Details of demographics and earthquake exposure are shown in Table 1.

The Human Research Ethics Committee of South China Normal University approved the WEAHC study. Students completed self-administered paper-and-pencil questionnaires in the classroom setting during school days under instructions of trained interviewers who were psychological professionals from South China Normal University. Written informed consent and parental permission were obtained from all participants at each assessment.

Measures

Demographics and exposure to the earthquake

Demographic characteristics included gender (0 = male, 1 = female), grade in school at baseline (0 = 7th, 1 = 10th), number of children in the family (0 = one child, 1 = more than one children),

Table 1. Demographics and earthquake exposure variables (N = 1492)

Variable	n (%)
Sex	
Male	666 (44.6)
Female	826 (55.4)
Mean age at 12 months postearthquake, years (SD)	15.01 (1.26)
Grade	
Junior high students	212 (14.2)
Senior high students	1,280 (85.8)
No. of children in the family	
1	1,239 (83.0)
≥2	253 (17.0)
Residence location	
Urban	836 (56.0)
Rural	656 (44.0)
Death, disappearance, and/or injury of family members	
No	1,107 (74.2)
Injury	193 (12.9)
Death/disappearance	192 (12.9)
House damage	
No	461 (30.9)
Moderate	391 (26.2)
Severe	640 (42.9)
Property loss other than house damage	
No	641 (43.0)
Moderate	524 (35.1)
Severe	327 (21.9)
Direct witness of tragic scenes	
No	602 (40.3)
Yes	890 (59.7)

and residence (0 = urban, 1 = rural). The degree of exposure to the earthquake was assessed with the following items: death, disappearance, and/or injury of family members; house damage; property loss other than house damage; and witness or hearing of tragic scenes. For the first item, the choices were: “death of family members,” “disappearance of family members,” “serious injury of family members,” “moderate injury of family members,” or “none of the above”; for house damage and property loss other than house damage, the degree of exposure was measured on a five-point scale; for witness or hearing of tragic scenes, the choices were: “witness a lot,” “witness some,” “hear a lot,” “hear some,” and “none of the above.” When the earthquake occurred, participants were at school. Thus, witness or hearing of tragic scenes might be different from death of family members, house damage, or property loss.

Insomnia

Insomnia symptoms during the past month were assessed with two particular items extracted from the Pittsburgh Sleep Quality Index (PSQI) [28]: “Difficulty falling asleep: cannot get to sleep within 30 minutes” and “Difficulty maintaining sleep: wake up in the middle of the night or early morning.” Both items were rated on a four-point scale: “never,” “less than once a week,” “once or twice a week,” and “three or more times a week.” Insomnia was defined by the selection of “three or more times a week” on either item (or both). To screen high-risk adolescents quickly and effectively, the two items rather than full version PSQI were used. The method to assess insomnia here was validated in our previous studies of adolescents [29, 30].

PTSD symptoms

The severity of PTSD symptoms during the past 6 months was measured by the PTSD Self-Rating Scale (PTSD-SS), which was developed on the basis of PTSD diagnostic criteria in *Diagnostic and Statistical Manual of Mental Disorders* (4th ed.; DSM-IV) and the *Chinese Classification of Mental Disorders* (2nd ed., rev.; CCMD-2-R) [31]. The PTSD-SS consists of 24 items, which are all scored on a scale of 1 (*none*) to 5 (*very severe*). Two PTSD-SS sleep-related items (nightmares and sleep disorders) were omitted in the present analyses to avoid overlap with the symptom of insomnia, so the PTSD severity score was based on the remaining 22 items. The possible total score range was 24–110, and a cutoff score of 46 was used to screen clinically significant PTSD symptoms [31]. The full version of PTSD-SS was also analyzed to examine whether inflation effect of repeated items existed. The PTSD-SS has been demonstrated to have satisfactory test-retest reliability, internal consistency, and construct validity in Chinese adolescents [31, 32]. Cronbach's alpha of the PTSD-SS in the present study ranged from .945 to .956.

Depressive symptoms

Adolescents' depressive symptoms over the previous week were measured using the Depression Self-Rating Scale (DSRS) [33]. The Chinese version of the DSRS has been validated, showing good reliability and validity among Chinese adolescents [34]. The DSRS consists of 18 items, each of which is scored 0–2. Most of the items are similar to DSM diagnostic criteria for depression. However, the DSRS measures nightmares but not suicide. Two DSRS sleep-related items (nightmares and sleep quality) were omitted as was for the PTSD-SS; thus, the DSRS severity score was based on the remaining 16 items. The total score ranged from 0 to 32. A cutoff score of 14 was used to classify whether an adolescent had clinically significant depressive symptoms or not. Also, the full version of DSRS was also analyzed to examine the inflation effect. Cronbach's alpha of the DSRS ranged from .798 to .812 in the present study.

Statistical analyses

Analyses were conducted using SAS version 9.4 for Windows (SAS Inst., Cary, NC). Chi-square tests were conducted to identify possible characteristics of participants who had not completed all the three surveys. Generalized estimating equation (GEE) models with the unstructured correlation structure were used to test the cross-sectional and longitudinal associations between insomnia, PTSD, and depression. GEE is a type of regression analysis that accounts for within-subject correlation across repeated measurements and is appropriate to estimate population-averaged effects over time [35]. In addition, GEE is suitable for both dichotomous and continuous outcome variables; specifically, for dichotomous outcome variables, the GEE models worked out odds ratios (ORs) and 95% confidence intervals (CIs).

For cross-sectional analyses in this study, insomnia was the dependent variable, while PTSD and depression were entered simultaneously into the equation as time-varying independent variables. For longitudinal analyses, two sets of lagged GEE models were analyzed: the first set of analysis was conducted to examine the prediction from PTSD and depression to

insomnia, in which insomnia at time $t + 1$ (i.e. T2 and T3) was the dependent variable, while PTSD and depression at time t (T1 and T2) were modeled as the predictors with baseline (T1) insomnia being controlled; the second set was conducted to examine the prediction from insomnia to PTSD or depression, in which PTSD and depression at time $t + 1$ (T2 and T3) were set as the dependent variable separately, while insomnia at time t (T1 and T2) was modeled as the predictor with baseline (T1) PTSD or depression being controlled. The visualized analyzing methods are displayed in Figure 1.

In order to examine the unique effect of each independent variable, simple (model 1 and model 2) and multiple (model 3) analyses were conducted. All GEE analyses in this study were performed under adjustments for demographics (sex, grade, number of children in the family, and residence) and earthquake exposure variables (death, disappearance, and/or injury of family members, house damage, property loss other than house damage, and witness or hearing of tragic scenes). In addition, multiple linear regressions with PTSD and depression as continuous variables were conducted to evaluate the stability of the results. The main findings were similar to logistic regressions. To examine the inflation effects of repeated items, both data from full version scales and after deletion of sleep items were analyzed. The two methods showed no difference. Finally, Sobel test was used to examine possible mediation [36]. All p values were two sided and statistical significance was determined at $p < .05$.

Among the 1,573 target participants, 1,492 adolescents who had completed at least one time point constituted the sample of this study. Missing data were replaced with estimates derived by single imputation, which was performed using an expectation maximization algorithm with all T1 variables as predictors. In order to investigate possible bias, we reran all analyses using only participants who had no missing data, and the results of the two methods were similar. Thus, only the results of single imputation are presented.

Results

In the current sample, the prevalence rates of probable PTSD were 22.5%, 12.7%, and 13.8% at T1, T2, and T3, respectively; the prevalence rates of depressive symptoms were 38.0%, 28.8%, and 36.7% at T1, T2, and T3, respectively; and the prevalence rates

of insomnia symptoms were 29.4%, 23.5%, and 23.5% at T1, T2, and T3, respectively. Figure 2 displays proportions of depression and insomnia by PTSD status. Overall, among participants with probable PTSD, approximately 70% had comorbid depressive symptoms (73.2%, T1; 68.2%, T2; 70.9%, T3) and approximately 47% complained of insomnia (48.5%, T1; 48.1%, T2; 44.2%, T3).

The cross-sectional associations between insomnia, PTSD, and depressive symptoms are presented in Table 2. Insomnia was significantly associated with PTSD symptoms ($OR = 2.04, p < .001$), after adjustment of demographics, earthquake exposure variables, and depression. When demographics, earthquake exposure variables, and PTSD were controlled, insomnia was also significantly associated with depressive symptoms ($OR = 2.10, p < .001$).

The longitudinal associations from PTSD and depressive symptoms to insomnia are demonstrated in Table 3. After adjustment of demographics, earthquake exposure variables, and baseline insomnia, both PTSD (model 1, $OR = 1.69, p < .001$) and depressive symptoms (model 2, $OR = 1.56, p < .001$) significantly predicted insomnia independently. When PTSD and depression were simultaneously added into the regression equation, the associations were weakened but still significant (model 3, $OR = 1.50, p < .001$ for PTSD; $OR = 1.42, p < .001$ for depression).

In the opposite direction, when demographics, earthquake exposure variables, and baseline PTSD were controlled, both insomnia (model 1, $OR = 1.30, p < .05$) and depression (model 2, $OR = 3.28, p < .001$) longitudinally predicted PTSD symptoms (Table 4). However, when insomnia and depression were simultaneously added in the regression, only depression (model 3, $OR = 3.25, p < .001$) remained predictable to PTSD symptoms, while the longitudinal association from insomnia to PTSD was no longer significant (model 3, $OR = 1.11, p = .445$). According to Baron and Kenny [37], results of these three models for PTSD here showed a mediation effect of depressive symptoms between insomnia and PTSD. To directly test the indirect effect of insomnia on PTSD symptoms through depression, we performed the Sobel test using SAS macro with 10,000 bootstrap [36]. The results indicated that the indirect effect was 0.047 ($p < .001$; 95% CI: 0.038–0.058).

As for the prediction model for depressive symptoms, both insomnia and PTSD significantly predicted the development of depression no matter whether they were included in the equation separately (model 1, $OR = 1.69, p < .001$ for insomnia; model 2, $OR = 3.19, p < .001$ for PTSD) or jointly (model 3, $OR = 3.11, p < .001$ for PTSD; $OR = 1.65, p < .001$ for insomnia).

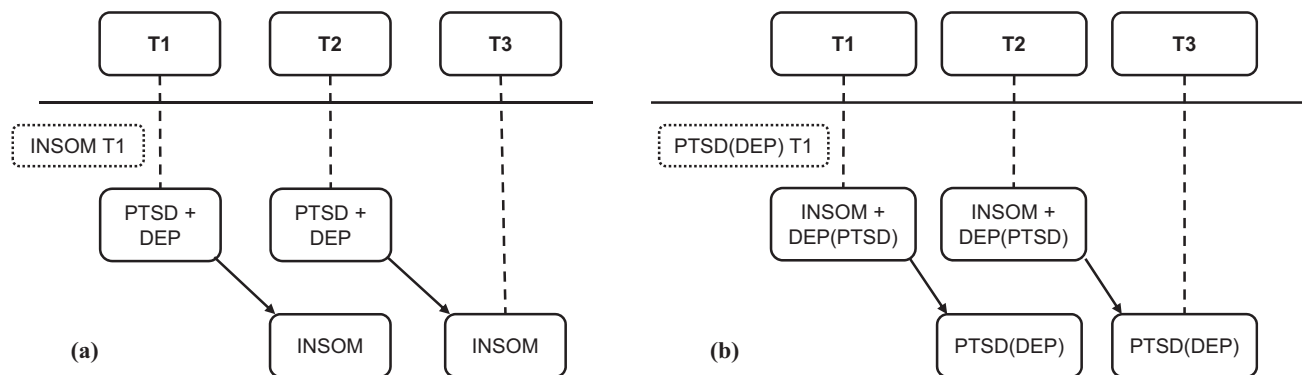


Figure 1. Visualization of the longitudinal lagged GEE models to predict (a) insomnia and (b) PTSD and depression, with demographics and earthquake exposure being controlled. Abbreviations: INSOM: insomnia; DEP: depression; PTSD: posttraumatic stress disorder.

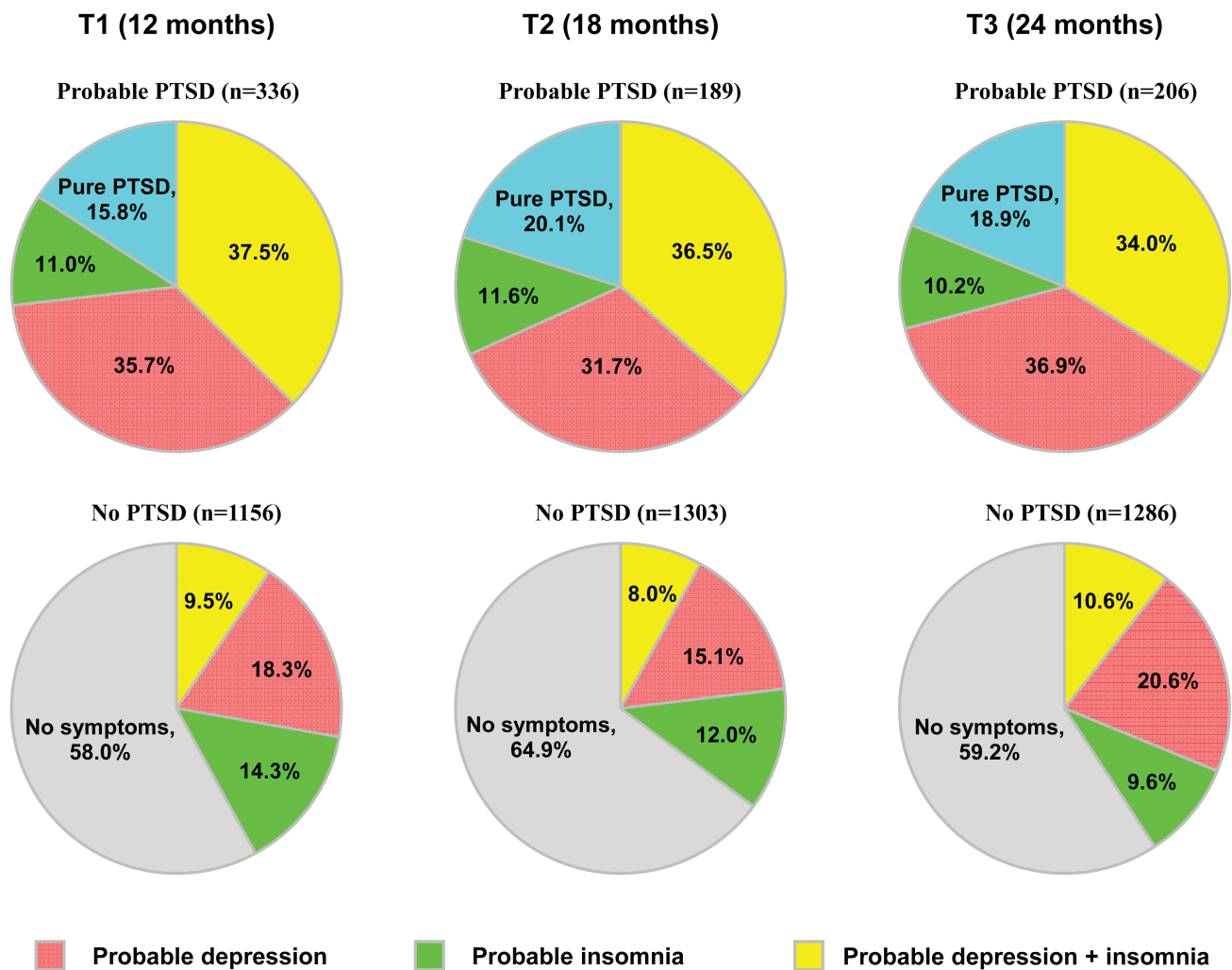


Figure 2. Proportions of probable depression and insomnia by probable PTSD status.

Table 2. Cross-sectional GEE model to predict insomnia

Variable	Insomnia OR [95% CI]
Sex, ref = male	0.97 [0.81, 1.16]
Grade at baseline, ref = seventh	1.73 [1.28, 2.33]***
No. of children in the family, ref = 1	1.05 [0.83, 1.33]
Location, ref = urban	1.24 [1.03, 1.49]*
Death, disappearance, and/or injury of family members, ref = no	
Injury	0.93 [0.71, 1.22]
Death/disappearance	0.94 [0.72, 1.24]
House damage, ref = no	
Moderate	0.92 [0.72, 1.17]
Severe	0.95 [0.75, 1.21]
Property loss, ref = no	
Moderate	0.87 [0.70, 1.09]
Severe	1.09 [0.83, 1.43]
Direct witness of tragic scenes, ref = no	1.21 [1.00, 1.46]*
PTSD ^a , ref = no	2.04 [1.67, 2.49]***
Depression ^a , ref = no	2.10 [1.78, 2.47]***

^aTime-varying covariates.

* $p < .05$; ** $p < .01$; *** $p < .001$.

Discussion

To our best knowledge, this is the first longitudinal study to examine the bidirectional associations of insomnia with PTSD and depressive symptoms among trauma-exposed adolescents. In the current sample, insomnia complaints were common in adolescents with probable PTSD. Our findings demonstrated that insomnia symptoms were significantly associated with PTSD and depressive symptoms cross-sectionally. Furthermore, insomnia could predict and was predicted by PTSD and depressive symptoms longitudinally. Depressive symptoms played an important mediation role between insomnia and PTSD symptoms.

During the second year after the deadly earthquake, nearly half of the adolescents with probable PTSD reported difficulty initiating or maintaining sleep, which was similar to that for adult PTSD [4, 5]. In addition, consistent with previous numerous cross-sectional studies [4, 5], our findings showed that insomnia was significantly associated with PTSD and depressive symptoms among adolescent survivors. The consistency among various studies highlights that insomnia is highly comorbid with PTSD for both adolescents and adults.

Table 3. Longitudinal lagged GEE models to predict insomnia^a

	Insomnia		
	Model 1	Model 2	Model 3
	OR [95% CI]	OR [95% CI]	OR [95% CI]
Insomnia at baseline	4.67 [3.75, 5.76]***	4.64 [3.75, 5.75]***	4.49 [3.62, 5.56]***
PTSD ^b	1.69 [1.34, 2.13]***		1.50 [1.18, 1.92]***
Depression ^b		1.56 [1.28, 1.90]***	1.42 [1.16, 1.75]***

^aDemographics, earthquake exposure variables, and time were controlled in all these models.^bTime-varying covariates.**p* < .05; ***p* < .01; ****p* < .001.**Table 4.** Longitudinal lagged GEE models to predict PTSD and depression^a

Variable	PTSD		
	Model 1	Model 2	Model 3
	OR [95% CI]	OR [95% CI]	OR [95% CI]
PTSD at baseline	15.75 [11.57, 21.46]***	12.93 [9.50, 17.60]***	12.63 [9.22, 17.30]***
Depression ^b		3.28 [2.47, 4.34]***	3.25 [2.44, 4.32]***
Insomnia ^b	1.30 [1.00, 1.70]*		1.11 [0.84, 1.46]
Variable	Depression		
	Model 1	Model 2	Model 3
	OR [95% CI]	OR [95% CI]	OR [95% CI]
Depression at baseline	8.34 [6.77, 10.28]***	7.65 [6.20, 9.44]***	7.25 [5.87, 8.96]***
PTSD ^b		3.19 [2.39, 4.27]***	3.11 [2.31, 4.18]***
Insomnia ^b	1.69 [1.39, 2.05]***		1.65 [1.35, 2.01]***

^aDemographics, earthquake exposure variables, and time were controlled in all these models.^bTime-varying covariates.**p* < .05; ***p* < .01; ****p* < .001.

Previous longitudinal studies have indicated that pretrauma and peri-trauma insomnia condition predicts the development and maintenance of PTSD [12, 14–16]. Our findings suggested that insomnia was still longitudinally associated with PTSD symptoms even after a long period from the traumatic event. Taken together, these studies imply that insomnia has an important contribution to PTSD among both adults and children. Multiple plausible mechanistic processes may explain the role of insomnia in the developmental pathology of PTSD, such as underlying neurobiological alterations [38], disruption of sleep-dependent emotional processing [39], and compromised generalization of fear extinction [40]. It is possible that the role of sleep is distinct in different stages of trauma. Future studies can explore specific mechanisms according to specific time frame of trauma. In addition, mediators and moderators between insomnia and PTSD should be further examined. As we will discuss below, depressive symptoms, for example, contribute to the link from insomnia to PTSD.

There has previously been only one study which examined the longitudinal prediction from PTSD to insomnia. It was reported that depression and PTSD symptoms at 4 months postdeployment failed to significantly predict changes in insomnia at 12 months postdeployment in a sample of Iraq combat veterans [18]. Contrary to that study, our findings supported that PTSD could increase the risk of insomnia over time. The conflicting findings between the two studies may be due to differences in samples (adolescents vs. young adults), study instruments, and particular stages after the trauma. It should also be noted that sleep-related items

were removed from the estimation of PTSD symptoms in our study, so the replicate prediction effect of those sleep-related items was excluded. Recently, an ecological momentary assessment study indicated that both sleep- and PTSD-related factors played a role in maintaining insomnia among subjects with PTSD [41].

Extending previous studies in general population [22], our findings demonstrated a reciprocal relationship between insomnia and depression in adolescent earthquake survivors. The results also suggested that depression played an important mediating role between insomnia and PTSD. Several postdisaster studies have documented depression to be intractable over time among adolescents [42, 43]. These highlight the importance of treatment of depression for the prevention and treatment of other postdisaster psychopathology. Moreover, for the first time, our findings showed that there was a vicious circle among insomnia, PTSD, and depression in trauma-exposed adolescents. The interplay of insomnia, PTSD, and depression has important clinical implications. Randomized controlled trials have provided initial support for the use of cognitive behavioral therapy for insomnia or trauma-focused therapy to address sleep disturbances and PTSD symptoms in PTSD patients [44–46], but insomnia still remains residual for nearly half of the patients after therapy. It is likely that intractable depression obstructs the recovery of insomnia and PTSD symptoms. Future behavioral and pharmacological treatment for posttraumatic insomnia should integrate depression or traumatic grief treatment module into existing frameworks.

Strengths and limitations

Strengths of this study include a large sample size, multiple waves of longitudinal data collection, and standardized measures used to assess PTSD, depression, and insomnia. However, there are several limitations that need to be noted. First, PTSD, depression, and insomnia were measured with self-reported questionnaires, so there might be report bias. Previous studies have observed inconsistencies between subjective and objective sleep outcomes in PTSD patients [3]. Multiple methods to assess sleep such as actigraphy and PSG are needed in future studies. Second, most participants were high school students. We should be cautious not to generalize the findings to other population or other types of traumatic disaster. Third, males and individuals who had witnessed tragic scenes were more likely to drop out in follow-up. Although expectation maximization algorithm was used to impute the missing data, the SE may be underestimated, which could lead to increased risk of false positive rate. Fourth, there were some potential covariates that we had not assessed, such as exposure to new traumatic events, treatment status, and mental conditions before the earthquake. Finally, this is an observational study. Future studies can use intervention methods to further determine the causal relationships among insomnia, PTSD, and depression.

Conclusions

Insomnia symptoms were common in adolescents with PTSD. Insomnia, PTSD, and depression could prospectively predict each other among adolescents. These findings may provide important clinical implications for the management of sleep disturbances while treating PTSD and depression in adolescent survivors after a traumatic disaster. Further studies are needed to examine the potential mediators and moderators among relationships of insomnia, PTSD, and depression.

Funding

The present study was funded by the National Natural Science Foundation of China (grant numbers: 31271096, 31671165, and 31700987); Research on the Processes and Repair of Psychological Trauma in Youth, Project of Key Institute of Humanities and Social Sciences, MOE (grant number: 16JJD190001); Guangdong Province Universities and Colleges Pearl River Scholar Funded Scheme (GDUPS 2016).

Conflict of interest statement. None declared.

References

1. Pigeon WR, et al. Insomnia as a precipitating factor in new onset mental illness: a systematic review of recent findings. *Curr Psychiatry Rep.* 2017;19(8):44.
2. Miller KE, et al. Sleep and dreaming in posttraumatic stress disorder. *Curr Psychiatry Rep.* 2017;19(10):71.
3. Spoormaker VI, et al. Disturbed sleep in post-traumatic stress disorder: secondary symptom or core feature? *Sleep Med Rev.* 2008;12(3):169–184.
4. Neylan TC, et al. Sleep disturbances in the Vietnam generation: findings from a nationally representative sample of male Vietnam veterans. *Am J Psychiatry.* 1998;155(7):929–933.
5. Ohayon MM, et al. Sleep disturbances and psychiatric disorders associated with posttraumatic stress disorder in the general population. *Compr Psychiatry.* 2000;41(6):469–478.
6. Short NA, et al. The mediating role of sleep disturbances in the relationship between posttraumatic stress disorder and self-injurious behavior. *J Anxiety Disord.* 2015;35:68–74.
7. Belleville G, et al. Impact of sleep disturbances on PTSD symptoms and perceived health. *J Nerv Ment Dis.* 2009;197(2):126–132.
8. Brownlow JA, et al. Influence of sleep disturbance on global functioning after posttraumatic stress disorder treatment. *J Trauma Stress.* 2016;29(6):515–521.
9. Zayfert C, et al. Residual insomnia following cognitive behavioral therapy for PTSD. *J Trauma Stress.* 2004;17(1):69–73.
10. Nappi CM, et al. Treating nightmares and insomnia in posttraumatic stress disorder: a review of current evidence. *Neuropharmacology.* 2012;62(2):576–585.
11. Brownlow JA, et al. Treatment of sleep disturbances in post-traumatic stress disorder: a review of the literature. *Curr Psychiatry Rep.* 2015;17(6):41.
12. Gehrman P, et al. Predeployment sleep duration and insomnia symptoms as risk factors for new-onset mental health disorders following military deployment. *Sleep.* 2013;36(7):1009–1018. doi:10.5665/sleep.2798.
13. van Lier S, et al. Impact of impaired sleep on the development of PTSD symptoms in combat veterans: a prospective longitudinal cohort study. *Depress Anxiety.* 2013;30(5):469–474.
14. Bryant RA, et al. Sleep disturbance immediately prior to trauma predicts subsequent psychiatric disorder. *Sleep.* 2010;33(1):69–74. doi:10.1093/sleep/33.1.69.
15. Koren D, et al. Sleep complaints as early predictors of posttraumatic stress disorder: a 1-year prospective study of injured survivors of motor vehicle accidents. *Am J Psychiatry.* 2002;159(5):855–857.
16. Garthus-Niegel S, et al. Maintaining factors of posttraumatic stress symptoms following childbirth: a population-based, two-year follow-up study. *J Affect Disord.* 2015;172:146–152.
17. Geng F, et al. Sleep problems among adolescent survivors following the 2008 Wenchuan earthquake in China: a cohort study. *J Clin Psychiatry.* 2013;74(1):67–74.
18. Wright KM, et al. Insomnia as predictor versus outcome of PTSD and depression among Iraq combat veterans. *J Clin Psychol.* 2011;67(12):1240–1258.
19. Brady KT, et al. Comorbidity of psychiatric disorders and posttraumatic stress disorder. *J Clin Psychiatry.* 2000;61(Suppl 7):22–32.
20. Horesh D, et al. An in-depth look into PTSD-depression comorbidity: a longitudinal study of chronically-exposed Detroit residents. *J Affect Disord.* 2017;208:653–661.
21. Geng F, et al. Posttraumatic stress disorder and psychiatric comorbidity among adolescent earthquake survivors: a longitudinal cohort study. *J Abnorm Child Psychol.* 2019;47(4):671–681.
22. Alvaro PK, et al. A systematic review assessing bidirectionality between sleep disturbances, anxiety, and depression. *Sleep.* 2013;36(7):1059–1068. doi:10.5665/sleep.2810.
23. Breslau N, et al. Sleep disturbance and psychiatric disorders: a longitudinal epidemiological study of young adults. *Biol Psychiatry.* 1996;39(6):411–418.
24. Fan F, et al. Sleep disturbance predicts posttraumatic stress disorder and depressive symptoms: a cohort study of Chinese adolescents. *J Clin Psychiatry.* 2017;78(7):882–888.

25. Fan F, et al.; WEAHC Study Group. Cohort profile: the Wenchuan earthquake adolescent health cohort study. *Int J Epidemiol.* 2017;**46**(1):27–28.
26. Geng F, et al. Prospective associations between sleep problems and subtypes of anxiety symptoms among disaster-exposed adolescents. *Sleep Med.* 2018;**50**:7–13.
27. Fan F, et al. Longitudinal trajectories of post-traumatic stress disorder symptoms among adolescents after the Wenchuan earthquake in China. *Psychol Med.* 2015;**45**(13):2885–2896.
28. Buysse DJ, et al. The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. *Psychiatry Res.* 1989;**28**(2):193–213.
29. Liu X, et al. Insomnia and hypersomnia associated with depressive phenomenology and comorbidity in childhood depression. *Sleep.* 2007;**30**(1):83–90. doi:10.1093/sleep/30.1.83.
30. Liu X, et al. Sleep patterns and problems among Chinese adolescents. *Pediatrics.* 2008;**121**(6):1165–1173.
31. Liu XC, et al. Development of the post-traumatic stress disorder self-rating scale and its reliability and validity. *Chin J Behav Med Sci.* 1998;**7**:93–96.
32. Fan F, et al. Symptoms of posttraumatic stress disorder, depression, and anxiety among adolescents following the 2008 Wenchuan earthquake in China. *J Trauma Stress.* 2011;**24**(1):44–53.
33. Birmaher B. The validity of depressive disorder in childhood and the development of a self-rating scale: a research report. *J Child Psychol Psychiatry.* 1981;**22**(1):73–88.
34. Su LY, et al. Norm of the depression self-rating scale for children in Chinese urban children. *Chin Ment Health J.* 2003;**17**(8):547–549.
35. Zeger SL, et al. Longitudinal data analysis for discrete and continuous outcomes. *Biometrics.* 1986;**42**(1):121–130.
36. Preacher KJ, et al. SPSS and SAS procedures for estimating indirect effects in simple mediation models. *Behav Res Methods Instrum Comput.* 2004;**36**(4):717–731.
37. Baron RM, et al. The moderator-mediator variable distinction in social psychological research: conceptual, strategic, and statistical considerations. *J Pers Soc Psychol.* 1986;**51**(6):1173–1182.
38. Germain A, et al. Sleep-specific mechanisms underlying posttraumatic stress disorder: integrative review and neurobiological hypotheses. *Sleep Med Rev.* 2008;**12**(3):185–195.
39. Walker MP, et al. Overnight therapy? The role of sleep in emotional brain processing. *Psychol Bull.* 2009;**135**(5):731–748.
40. Pace-Schott EF, et al. Effects of sleep on memory for conditioned fear and fear extinction. *Psychol Bull.* 2015;**141**(4):835–857.
41. Short NA, et al. Predictors of insomnia symptoms and nightmares among individuals with post-traumatic stress disorder: an ecological momentary assessment study. *J Sleep Res.* 2018;**27**(1):64–72.
42. Geng F, et al. A prospective study of psychiatric symptoms among adolescents after the Wenchuan earthquake. *J Trauma Stress.* 2018;**31**(4):499–508.
43. Goenjian AK, et al. A prospective study of posttraumatic stress and depressive reactions among treated and untreated adolescents 5 years after a catastrophic disaster. *Am J Psychiatry.* 2005;**162**(12):2302–2308.
44. Woodward E, et al. Effects of psychotherapies for posttraumatic stress disorder on sleep disturbances: results from a randomized clinical trial. *Behav Res Ther.* 2017;**97**:75–85.
45. Talbot LS, et al. Cognitive behavioral therapy for insomnia in posttraumatic stress disorder: a randomized controlled trial. *Sleep.* 2014;**37**(2):327–341. doi:10.5665/sleep.3408.
46. Ho FY, et al. Cognitive-behavioral therapy for sleep disturbances in treating posttraumatic stress disorder symptoms: a meta-analysis of randomized controlled trials. *Clin Psychol Rev.* 2016;**43**:90–102.