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ORIGINAL ARTICLE

Longitudinal associations of nightmare frequency and nightmare distress with suicidal behavior in adolescents: mediating role of depressive symptoms

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Abstract

Study objectives: Nightmares are a significant risk factor of suicidal behavior. This study examined the longitudinal associations of nightmare frequency and distress with suicidal thought (ST), suicide plan (SP), and suicide attempt (SA) and mediating role of depressive symptoms in adolescents.

Methods: A total of 6,923 adolescents who participated in the 1-year follow-up of Shandong Adolescent Behavior & Health Cohort were included for the analysis. Participants completed a self-administered questionnaire to assess nightmares, sleep duration, insomnia, depressive symptoms, substance use, prior suicidal behavior, and family demographics in November–December in 2015. One year later, a follow-up survey was conducted to ask participants to report their depressive symptoms and suicidal behaviors.

Results: Of the sample, 26.2% reported having frequent nightmares (at least twice/month) at baseline, and 10.0%, 3.6%, and 2.7% reported having ST, SP, and SA over 1-year follow-up. The rates of subsequent ST, SP, and SA all significantly increased with baseline nightmare frequency and distress. Path analyses showed that depressive symptoms played a significant mediating role in the associations of frequent nightmares and elevated nightmare distress with ST, SP, and SA before and after adjusting for adolescent and family covariates and prior suicidal behavior.

Conclusions: Suicidal risk increased with nightmare frequency and distress among adolescents. The association between nightmares and suicidal behavior was at least partially mediated by depressive symptoms. Assessing and intervening nightmares and depressive symptoms associated with nightmares may have important implications for preventing adolescent suicidal behavior.

Statement of Significance

It is imperative to identify predictive and modifiable risk factors of suicidal behavior in adolescents to inform prevention strategies. Growing evidence shows that nightmares are associated with suicidal behavior. However, few large studies have specifically examined the prospective associations between nightmares and suicidal behavior and the mediating role of depressive symptoms in adolescents. In the 1-year follow-up study of 6,923 adolescents, the rates of subsequent suicidal behavior significantly increased with baseline nightmare frequency and nightmare distress. The association between nightmares and suicidal behavior was at least partially mediated by depressive symptoms. These findings underscore the importance of assessing and intervening nightmares and depressive symptoms associated with nightmares for preventing adolescent suicidal behavior.

Key words: suicidal behavior; nightmares; depressive symptoms; adolescents

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Introduction

Suicidal behavior is a major public concern in adolescents and young adults all over the world [1–3]. Suicidal behavior is associated with persistent distress, clinical and psychosocial functional impairments, increased demands on health care resources, and elevated risk of repeat self-harm and suicide [3–5]. Although many psychosocial, biological, and clinical factors have been identified, suicidal behavior is difficult to predict in adolescents [3, 6–7]. It is imperative to identify predictive and modifiable risk factors to inform prevention strategies among youth.

Nightmares are prevalent, occurring once or more per week in 2%–10% of the population [8]. Nightmares occur more frequently in pediatric population and psychiatric patients [8–10]. Growing evidence shows that nightmares are associated with increased risk of suicidal behavior or self-harm in clinical and general populations [10–14]. However, epidemiological studies in adolescents or young adults are predominantly cross-sectional or retrospective, their sample sizes are generally small, and their definitions of nightmares and suicidal behavior are inconsistent [12, 15–17]. Only a handful of studies have prospectively examined nightmares and future suicidal behavior in adolescent populations [10, 17, 18]. For example, in a study of 583 undergraduate students, Nadorff *et al.* found that nightmares were related to suicidal ideation after controlling for the symptoms of anxiety and depression [13]. In a study of 50 youths across a 21-day observation period and 3-time points of assessments, the authors reported that actigraphy-defined variability in sleep timing, self-reported insomnia, and nightmares predicted increases in suicidal ideation [19]. In our recent longitudinal study of sleep and self-harm, we found that frequent nightmares were a significant predictor of suicide attempt (SA; OR = 1.96; 95% CI = 1.15–3.33) and non-suicidal self-injury (OR = 1.52, 95% CI = 1.10–2.08) while adjusting for adolescent and family demographic covariates [10].

The psychological and biological process driving the nightmares–suicidality link is not clear [20]. The link between nightmares and suicidal behavior could be explained by sociocognitive factors and emotional dysregulation associated with nightmare distress and/or shared risk factors [14, 20]. Nightmare distress refers to the extent to which nightmares have a negative waking effect [21–22]. Several studies have demonstrated that nightmare distress is highly correlated with psychopathology such as neuroticism, anxiety, and depression [21, 22]. In a study of college students (n = 116), Levin and Fireman concluded that it is nightmare distress but not nightmare frequency that more critically predicts higher psychological disturbance [23].

The most obvious shared risk factor is depression as depression is one of the most important risk factors for suicidal behavior [3] and depression is associated with frequent nightmares [24–25]. In addition, nightmares and depression may share similar biological mechanisms, such as reduced concentrations or activities of serotonin (5-HT), REM sleep disruption, and reduced frontal brain activity [26–30]. These studies suggest that nightmares may increase risk of suicidal behaviors through dysregulated mood or depression. Although some cross-sectional studies with adults have examined the mediation effects of depression in the nightmare frequency–suicidality link [24], to our knowledge, no large-scale prospective studies have specifically examined the predicting role of nightmare distress in suicidal behaviors and the mediating role of depression in the nightmares–suicidality link in adolescents.

Using the longitudinal data from the Shandong Adolescent Behavior & Health Cohort (SABHC), the current analysis was conducted to understand the associations of nightmare frequency and nightmare distress with subsequent suicidal thought (ST), suicide plan (SP), and SA over 1-year follow-up. Specifically, our first aim was to examine the hypothesis that frequent nightmares and nightmare distress increased the risk of suicidal behavior during the subsequent year. Our second aim was to examine the hypothesis that depressive symptoms meditated associations of frequent nightmares with suicidal behavior. Our third aim was to examine the hypothesis that depressive symptoms meditated associations of nightmare distress with suicidal behavior. Figure 1 depicts our hypothesized mediation models.

Methods

Participants and procedure

SABHC is a longitudinal study of adolescent behavior and health in Shandong, China. A total of 11,831 adolescent students participated in the SABHC baseline survey. Detailed sampling and data collection have been described elsewhere [31–33]. In brief, participants were sampled from five middle and three high schools in three counties of Shandong, with consideration of the representativeness of adolescent students in the region, prior study collaboration, convenience, and budget for at least three waves of data collection.

Baseline survey was conducted in 7–11th graders in November–December, 2015 [1, 34–35]. All 7–8th graders and 10th graders at baseline were followed up 1 year later in 2016. A self-administered, structured adolescent health questionnaire (AHQ) was used to assess suicidal behavior, sleep, mental health, and psychosocial factors [36–38]. After getting permission from the target schools, trained public health workers administered the AHQ to participants in their classrooms during regular school hours. Before filling out the questionnaire, participants were asked to read the instructions carefully and informed that the survey was anonymous, and their participation was voluntary. It took about 45 min to fill out the questionnaire.

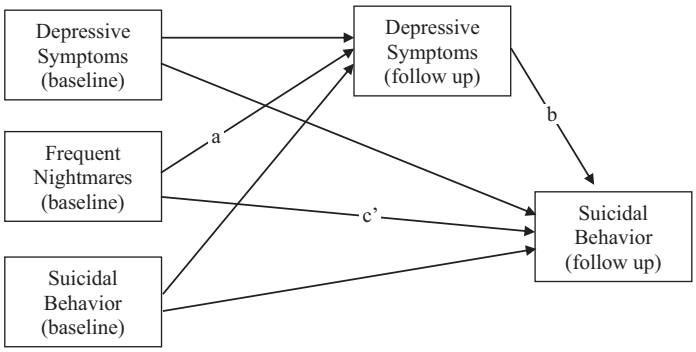
We obtained permission to conduct the study from the principals in the target schools and informed consent from participants before the survey. The study was approved by the research ethics committee of Shandong University School of Public Health and target schools.

Measures

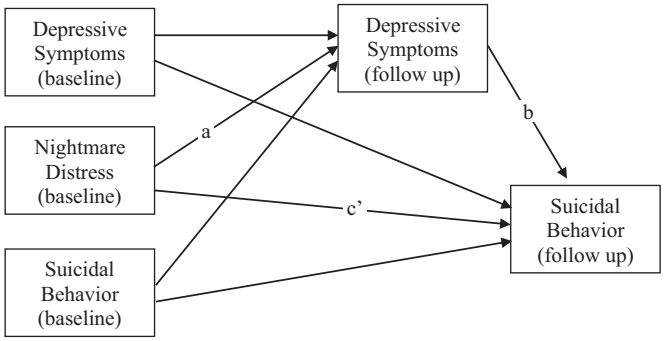
Suicidal behavior

Suicidal behavior includes ST, SP, and SA [39]. ST and SP were defined as a "yes" response to the questions: "Have you ever seriously thought about suicide or killing yourself over the past 12 months?" and "Have you ever had a specific plan for how you would kill yourself over the past 12 months?," respectively. SA was defined as a "yes" response to the question: "Have you ever tried to kill yourself over the past 12 months?" Similar questions were used to ask suicidal behaviors that happened over the past 12 months at 1-year follow-up.

Model A: Depressive symptoms mediating the associations of frequent nightmares with suicidal behavior



Model B: Depressive symptoms mediating the associations of nightmare distress with suicidal behavior



Covariates: Age, sex, smoking, alcohol use, sleep duration, insomnia, family suicide history, familiar economic status, father education, father occupation, interparental relationship, and participating school (7 dummy variables for 8 schools).

Prior suicidal behavior: suicidal thought, suicide plan, and suicide attempt.

Figure 1. Hypothesized mediation models.

Nightmare frequency and distress

Two questions were used to ask about nightmares experienced during the past year and during the past month [10, 23, 40]. "In the past year, how often did you have nightmares (emotionally intense, frightening, and vivid dreams that awoken you from sleep)?" The response was on a 7-point frequency scale (1 = never, 2 = about once a year, 3 = several times a year, 4 = a few times a month, 5 = once a week, 6 = a few times a week, and 7 = almost every night). "During the past month, how many times did you have nightmares?" The participant was asked to enter number of nights with nightmares. The responses to the two questions were significantly and positively correlated ($r = 0.514$, $p < 0.0001$). The nightmare frequency during the past month was used for the current analysis. Frequent nightmares was defined as having nightmares at least twice in the past month [10].

Nightmare distress was assessed by the Nightmare Distress Questionnaire (NDQ) [21]. The NDQ is a 13-item scale used to assess waking distress associated with nightmares. Example questions are whether the individual is frightened of going to sleep, avoids people who have been in their nightmares, or would seek a therapy that will stop the nightmares. The NDQ has adequate internal consistency reliability (Cronbach's alpha = 0.83–0.88) and validity [21, 23]. One item was added to assess the general distress associated with nightmares (i.e. On average, how upset/distressed were you by your nightmares the following day?). Each question was answered on a response scale of 1–5, from never (1) to always (5) [30]. Summing up the scores of the 14 items yields a total nightmare distress score. A higher score indicates a more severe distress due to nightmares. Cronbach's alpha of the current sample was 0.88.

Insomnia symptoms and sleep duration

Insomnia symptoms including difficulty initiating sleep, difficulty maintaining sleep, and early morning awakening were asked with a response of never, <1 time/week, 1–2 times/week, 3–5 times/week, or 6–7 times/week. Clinical insomnia symptoms were defined by presence of any insomnia at least 3 times/week. Sleep duration was asked by "On a typical school day, how many hours of actual sleep did you get at night?"

Depressive symptoms

Depressive symptoms was assessed by the Centre for Epidemiologic Studies Depression Scale (CES-D) [41]. The CES-D is a 20-item self-report questionnaire. Each item is rated on a

Likert scale from 0 to 3 points (0 = ≤1 day/week, 1 = 1–2 days/week, 2 = 3–4 days/week, and 3 = 5–7 days/week). Summing up the scores of the 20 items yields a total CES-D score. The possible range for the total sore is 0–60. Cronbach's alpha of the current sample was 0.86. Depressive symptoms were assessed at baseline and at 1-year follow-up.

Other adolescent and family demographical factors

Adolescent factors as covariates included in the study were age, sex, ever cigarette smoking (yes or no), ever alcohol drinking (yes or no), and the school that participants were attending (seven dummy variables for eight schools). Family covariates were father education and occupation, family history of suicide, self-reported family economic status, and interparental relationship.

Statistical analysis

Chi-square tests for categorical variables and student *t*-tests for continuous variables were used to compare baseline adolescent and family characteristics between participants with and without a history of suicidal behavior (i.e. ST, SP, and SA) at baseline survey. Path analyses with logistic function were performed to examine the direct effects of nightmare frequency and nightmare distress (predictors) on subsequent suicidal behaviors (outcomes) at 1-year follow-up and the mediating role of depressive symptoms (mediator) in the nightmares–suicidal behavior link (see Figure 1 for hypothesized models). Both outcome variables and the mediator were measured at the 1-year follow up, with autoregressive relationships with measures at the baseline. The focal parameters were labeled in Figure 1. Specifically, we were interested in: (1) the path coefficient from nightmare frequency or distress to depressive symptoms at the follow up (coefficient *a*), (2) the path coefficient from depressive symptoms at the follow up to subsequent suicidal behavior (coefficient *b*), and (3) the path coefficient from nightmare frequency or distress to subsequent suicidal behavior after controlling for the mediator (coefficient *c′*). Mediation effect was quantified as *a*b*. If *a*b* was significant but *c′* was not, a full mediation relationship was supported; if both *a*b* and *c′* were significant, a partial mediation relationship was supported. We also computed *a*b*/(*a*b* + *c′*) as an effect size measure for mediation effect if the mediation effect (*a*b*) was significant and if *a*b* and *c′* were in the same direction (i.e. both positive or both negative) [42]. The higher the ratio is, the larger the effect size is. For both Model A and Model B shown in Figure 1, we conducted both unadjusted and adjusted mediation models. Unadjusted mediation model was performed to examine the association between frequent nightmares/nightmare distress and suicidal behavior with depressive symptoms as the mediator. Adjusted mediation model was then performed by controlling for

Table 1. Sample characteristics by history of suicidal behavior at baseline (%)

	Total (*n* = 6,923)	Suicidal (*n* = 839)	Non-suicidal (*n* = 6,084)	χ^2 or *t*-test	*P* value
Female gender	49.9	58.6	48.8	28.85	<0.0001
Age, mean (*SD*)	14.58 (1.45)	15.00 (1.32)	14.52 (1.46)	9.03	<0.0001
Ever smoking	19.0	34.3	16.9	144.78	<0.0001
Ever alcohol use	34.4	54.2	31.7	165.97	<0.0001
Depressive score, Mean (*SD*)	16.79 (9.47)	25.47 (10.83)	15.59 (8.61)	30.12	<0.0001
Sleep duration, mean (*SD*)	7.16 (1.46)	6.68 (1.44)	7.22 (1.45)	10.18	<0.0001
Insomnia symptoms	14.4	24.4	13.0	74.51	<0.0001
Nightmares in the past month				49.39	<0.0001
None	52.9	44.3	54.1		
1 time	20.9	21.9	20.7		
2–3 times	18.1	20.3	17.8		
≥4 times	8.1	13.5	7.3		
Nightmare distress				249.91	<0.0001
Quartile 1	28.6	13.7	30.6		
Quartile 2	21.7	15.9	22.5		
Quartile 3	26.4	27.2	26.2		
Quartile 4	23.4	43.3	20.7		
Mean (*SD*)	22.65(8.57)	27.51(10.58)	21.98(8.02)	17.92	<0.0001
Family suicide history	4.3	6.4	4.0	10.53	0.001
Family economic status				69.96	<0.0001
Excellent or good	20.7	14.5	21.5		
Fair	67.3	65.3	67.6		
Poor or very poor	12.0	20.2	10.9		
Father education				9.39	0.024
Primary school	13.8	15.1	13.7		
Middle school	54.2	49.7	54.8		
High school	18.6	19.3	18.6		
College or above	13.4	15.9	13.0		
Father occupation: nonfarm	61.9	65.2	61.5	4.34	0.037
Interparental relationship				131.98	<0.0001
Excellent	43.0	30.5	44.7		
Good	26.2	23.3	26.6		
Fair	24.7	33.5	23.5		
Poor/separated/divorced	6.1	12.7	5.2		

the effects of adolescent and family covariates in Table 1. Path analyses were performed using *Mplus* 8.4 with robust maximum likelihood estimation method. All other analyses were performed using IBM SPSS Statistics for Windows, Version 23.0.

Results

Sample characteristics

Of 8,629 7th–8th graders and 10th graders at baseline, 7,072 participated in the 1-year follow-up survey, with a follow-up rate of 82.0%. The major reason for loss to follow-up was that some participants went to different classes/schools. A total of 149 participants who did not answer the questions about suicidal behavior at baseline were excluded, leaving a total of 6,923 for the current analysis. Among 6,923 participants, 839 (12.1%) had a history of ST, SP, or SA during the past year at baseline survey. Table 1 presents baseline adolescent and family characteristics according to suicidal history. Mean age of the participants at baseline was 14.6 (*SD* = 1.5) and half were females.

Nightmares, depressive symptoms, and suicidal behavior

Of the sample, 47.1% reported having experienced nightmares at least once, 26.2% twice or more during the past month, and 8.1% at least four times during the past month. Female adolescents reported more frequent nightmares than males ($\chi^2 = 23.71$, $p < 0.0001$).

Participants who reported having a history of suicidal behavior scored significantly higher on CESD depression scale at baseline (25.47 ± 10.83 vs. 15.59 ± 8.61, $t = 30.12$, $p < 0.0001$) and at 1-year follow-up (18.43 ± 10.17 vs. 13.32 ± 7.90, $t = 21.05$, $p < 0.0001$) than those participants without a history of suicidal behavior, respectively.

At baseline, 11.5%, 2.9%, and 1.3% of participants reported having ever ST, SP, and SA over the past 12 months, respectively. At 1-year follow-up, the rates of ST, SP, and SA were 10.0%, 3.6%, and 2.7%, respectively.

As shown in Figure 2, the rates of all subsequent suicidal behaviors at 1-year follow-up significantly increased with nightmare frequency and nightmare distress as demonstrated by Chi-square tests (all *p*s < 0.0001).

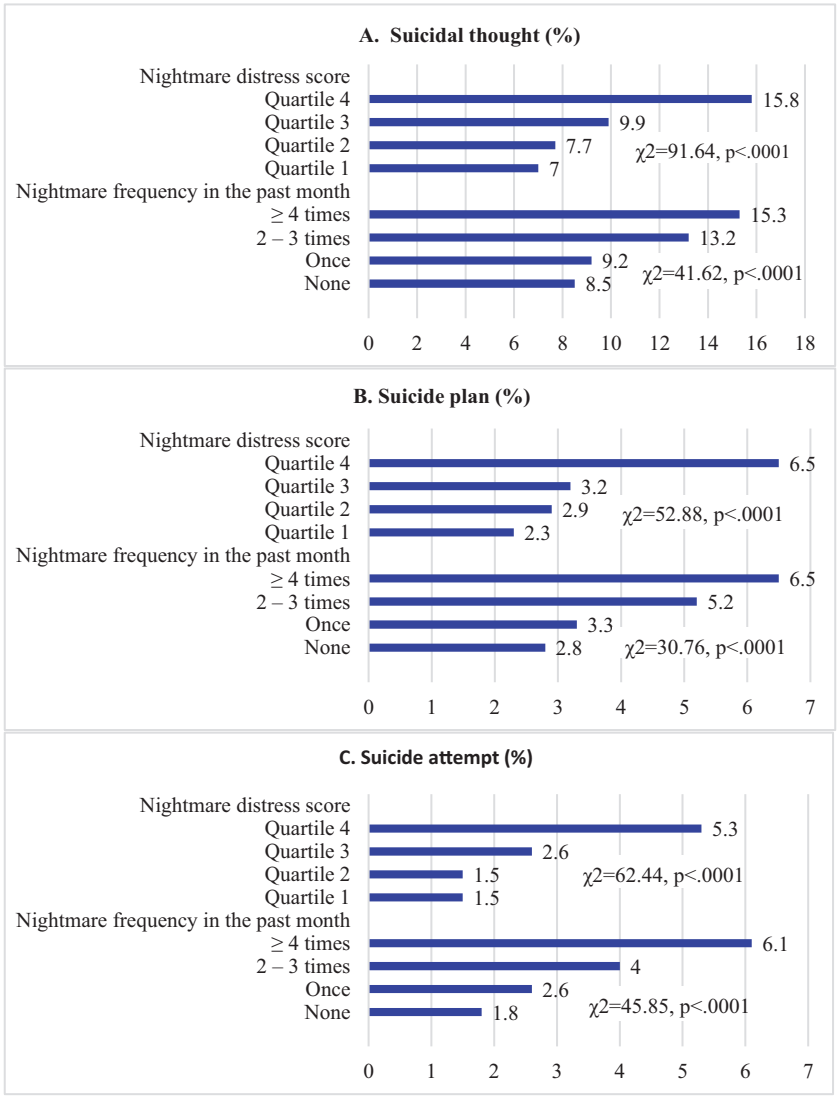


Figure 2. Subsequent suicidal behavior by nightmare frequency and distress.

Table 2. Associations of frequent nightmares and depressive symptoms with subsequent suicidal behaviors

	Unadjusted model			Adjusted model		
Paths	Path coefficients	95% CI	$\frac{a*b}{a*b+c'}$	Path coefficients	95% CI	$\frac{a*b}{a*b+c'}$
	Suicidal thought					
FN→DS (a)	1.259**	0.813 to 1.705		1.223**	0.754 to 1.692	
DS→ST (b)	0.082**	0.072 to 0.092		0.082**	0.071 to 0.092	
FN→ST (c')	0.214*	0.021 to 0.407		0.149	–0.058 to 0.356	
FN→DS→ST (a*b)	0.103**	0.065 to 0.141	0.32	0.100**	0.060 to 0.140	0.40
	Suicide plan					
FN→DS (a)	1.237**	0.789 to 1.686		1.209**	0.737 to 1.681	
DS→SP (b)	0.083**	0.069 to 0.097		0.081**	0.066 to 0.096	
FN→SP (c')	0.367*	0.075 to 0.659		0.324*	0.013 to 0.635	
FN→DS→SP (a*b)	0.102**	0.062 to 0.143	0.22	0.098**	0.056 to 0.139	0.23
	Suicide attempt					
FN→DS (a)	1.255**	0.806 to 1.704		1.228**	0.756 to 1.699	
DS→SA (b)	0.076**	0.060 to 0.092		0.073**	0.055 to 0.091	
FN→SA (c')	0.613**	0.288 to 0.938		0.513**	0.164 to 0.861	
FN→DS→SA (a*b)	0.095**	0.055 to 0.135	0.13	0.090**	0.049 to 0.131	0.15

FN, frequent nightmares; DS, depressive symptoms. $\frac{a*b}{a*b+c'}$, ratio of mediation effect if the mediation effect (a*b) was significant and if a*b and c' were in the same direction (i.e. both positive or both negative)[42]. Unadjusted model, predicting suicidal behavior from nightmare frequency with depressive symptoms at 1-year follow up being the mediator. Adjusted model, nadjusted model + covariates in Table 1 except for depressive symptoms and nightmare distress + history of suicidal behavior at baseline + participating school.

*$p < 0.05$.

**$p < 0.01$.

Path analyses

Tables 2–3 present unstandardized path coefficients (a, b, and c', as well as $a*b$) of subsequent ST, SP, and SA in relation to frequent nightmares and nightmare distress mediated by depressive symptoms. The path coefficients related to binary outcomes are presented in log odds unit. Univariate analyses showed that the log-odds of all the three suicidal behaviors were significantly higher in adolescents who reported having frequent nightmares. Both $a*b$ and c' were positive and significant when predicting from frequent nightmares. A partial mediation relationship was supported for all the three suicidal behaviors, with a ratio of $a*b/(a*b + c')$ ranging from 0.13 to 0.32. The log-odds of suicidal behaviors were also significantly higher in adolescents who scored nightmare distress in the top quartile compared with those adolescents who scored in the lower quartile. When predicting suicidal behavior from nightmare distress, the c' coefficients were all not significant except for the top two quartiles for predicting SA. The $a*b$ coefficients for the top two quartiles were positive and significant ($p < 0.01$) for all the three suicidal behaviors, indicating a full mediation relationship for ST and SP and a partial mediation relationship for SA.

After adjusting for adolescent and family covariates and prior suicidal behavior, majority of direct effects (coefficient c') from predictors to outcomes were reduced and some path coefficients were no longer statistically significant when predicting suicidal behavior from frequent nightmares (Adjusted model in Table 2) and from nightmare distress (Adjusted model in Table 3). Illustratively, the magnitude of direct effects of frequent nightmares on ST, SP, and SA changed from c' = 0.214 (95% CI = 0.021 to 0.407) to 0.149 (95% CI = –0.058 to 0.356), c' = 0.367 (95% CI = 0.075 to 0.659) to 0.324 (95% CI = 0.013 to 0.635), and c' = 0.613 (95% CI = 0.288 to 0.938) to 0.513 (95% CI = 0.164 to 0.861), respectively. The magnitude of direct effects of nightmare distress (the top quantile) to ST, SP, and SA changed from c' = 0.176 (95% CI = –0.077 to 0.430) to 0.152 (95% CI = –0.119 to 0.423), c' = 0.310 (95% CI = –0.089 to 0.709) to 0.349 (95% CI = –0.074 to 0.773), and from c' = 0.835 (95% CI = 0.324 to 1.328) to 0.856 (95% CI = 0.327–1.386), respectively.

The magnitude of mediation effects from frequent nightmares to ST, SP, and SA via depressive symptoms changed from $a*b$ = 0.103 (95% CI = 0.065–0.141) to 0.100 (95% CI = 0.060–0.140), $a*b$ = 0.102 (95% CI = 0.062–0.143) to 0.098 (95% CI = 0.056–0.139), and from $a*b$ = 0.095 (95% CI = 0.055–0.135) to 0.090 (95% CI = 0.049–0.131), respectively. The ratio of $a*b/(a*b + c')$ ranged from 0.15 to 0.40. After controlling for covariates, all mediation effects were still significant ($p < 0.01$) and the mediation relationship remained partial for SP and SA, but the mediation became full for ST. The magnitude of mediation effects from nightmare distress (the top quantile) to ST and SA through depressive symptoms changed from $a*b$ = 0.176 (95% CI = 0.125–0.227) to 0.182 (95% CI = 0.128–0.235) and from $a*b$ = 0.169 (95% CI = 0.113–0.226) to 0.164 (95% CI = 0.106–0.222), respectively. The mediation effect for SP remained the same ($a*b$ = 0.188) although its 95% CI changed slightly. All mediation effects were significant ($p < 0.01$). The ratio of $a*b/(a*b + c')$ ranged from 0.16 to 0.54 for the top quartile. After controlling for covariates, the mediation relationship remained full for ST and SP and partial for SA for the top quartile.

Discussion

To our knowledge, this is one of the largest studies to prospectively examine the associations of nightmare frequency and distress with subsequent suicidal behavior in a sample of Chinese adolescents. Our major findings are (1) both frequent nightmares and nightmare distress at baseline were significantly associated with increased risk of subsequent suicidal behavior and (2) the associations of frequent nightmares and nightmare distress with suicidal behaviors were at least partially mediated by depressive symptoms. These findings and their implications are discussed further.

Table 3. Associations of nightmare distress (NDQS Quartile 1 as reference) and depressive symptoms with subsequent suicidal behaviors

	Unadjusted model			Adjusted model		
Paths	Path coefficients	95% CI	$\frac{a*b}{a*b+c'}$	Path coefficients	95% CI	$\frac{a*b}{a*b+c'}$
	Suicidal thought					
NDQS Q2→DS (a)	0.294	−0.163 to 0.752		0.333	−0.139 to 0.805	
NDQS Q3→DS (a)	0.661**	0.188 to 1.134		0.674**	0.184 to 1.164	
NDQS Q4→DS (a)	2.175**	1.601 to 2.748		2.258**	1.658 to 2.859	
DS→ST (b)	0.081**	0.071 to 0.091		0.080**	0.070 to 0.091	
NDQS Q2→ST (c')	−0.003	−0.274 to 0.268		−0.095	−0.382 to 0.192	
NDQS Q3→ST (c')	0.137	−0.108 to 0.382		0.071	−0.192 to 0.333	
NDQS Q4→ST (c')	0.176	−0.077 to 0.430		0.152	−0.119 to 0.423	
NDQS Q2→DS→ST (a*b)	0.024	−0.013 to 0.061		0.027	−0.011 to 0.065	
NDQS Q3→DS→ST (a*b)	0.054**	0.015 to 0.092	0.28	0.054**	0.014 to 0.094	0.43
NDQS Q4→DS→ST (a*b)	0.176**	0.125 to 0.227	0.50	0.182**	0.128 to 0.235	0.54
	Suicide plan					
NDQS Q2→DS (a)	0.341	−0.120 to 0.801		0.367	−0.108 to 0.843	
NDQS Q3→DS (a)	0.679**	0.203 to 1.154		0.679**	0.186 to 1.172	
NDQS Q4→DS (a)	2.274**	1.696 to 2.852		2.342**	1.737 to 2.947	
DS→SP (b)	0.083**	0.069 to 0.097		0.080**	0.065 to 0.095	
NDQS Q2→SP (c')	0.084	−0.347 to 0.516		−0.008	−0.471 to 0.455	
NDQS Q3→SP (c')	0.119	−0.279 to 0.516		0.027	−0.412 to 0.467	
NDQS Q4→SP (c')	0.310	−0.089 to 0.709		0.349	−0.074 to 0.773	
NDQS Q2→DS→SP (a*b)	0.028	−0.010 to 0.067		0.029	−0.009 to 0.068	
NDQS Q3→DS→SP (a*b)	0.056**	0.016 to 0.097	0.32	0.055**	0.014 to 0.095	0.67
NDQS Q4→DS→SP (a*b)	0.188**	0.132 to 0.245	0.38	0.188**	0.129 to 0.247	0.35
	Suicide attempt					
NDQS Q2→DS (a)	0.354	−0.106 to 0.815		0.378	−0.097 to 0.854	
NDQS Q3→DS (a)	0.700**	0.224 to 1.175		0.696**	0.203 to 1.189	
NDQS Q4→DS (a)	2.296**	1.719 to 2.873		2.349**	1.744 to 2.954	
DS→SA (b)	0.074**	0.057 to 0.090		0.070**	0.052 to 0.088	
NDQS Q2→SA (c')	−0.153	−0.744 to 0.439		−0.377	−1.043 to 0.289	
NDQS Q3→SA (c')	0.569*	0.094 to 1.044		0.483	−0.033 to 0.999	
NDQS Q4→SA (c')	0.835**	0.342 to 1.328		0.856**	0.327 to 1.386	
NDQS Q2→DS→SA (a*b)	0.026	−0.009 to 0.061		0.026	−0.008 to 0.060	
NDQS Q3→DS→SA (a*b)	0.052**	0.014 to 0.089	0.08	0.048**	0.012 to 0.085	0.09
NDQS Q4→DS→SA (a*b)	0.169**	0.113 to 0.226	0.17	0.164**	0.106 to 0.222	0.16

DS, depressive symptoms; NDQS, nightmare distress questionnaire score; Q2–Q4, Quartile 2–Quartile 4. $\frac{a*b}{a*b+c'}$, ratio of mediation effect if the mediation effect (a*b) was significant and if a*b and c' were in the same direction (i.e. both positive or both negative)[42]. Unadjusted model, predicting suicidal behavior from nightmare distress with depressive symptoms at 1-year follow up being the mediator. Adjusted model, unadjusted model + covariates in Table 1 except for depressive symptoms and nightmare frequency + history of suicidal behavior at baseline + participating school.

*$p < 0.05$.

**$p < 0.01$.

The association between frequent nightmares and suicidal behavior has been demonstrated by a number of cross-sectional studies and a handful of longitudinal studies in clinical and general populations [12–13, 16, 43]. For example, in a cross-sectional study of 1,362 Chinese adolescents, Liu *et al.* found that frequent nightmares were significantly associated with increased risk for SA (OR = 2.43, 95% CI = 1.76–3.35) and suicidal ideation (OR = 1.69, 95% CI = 1.20–2.38) after adjustment for age, sex, father's occupation, and depressive symptoms [16]. In a clinical prospective study of 165 suicide attempters, the authors reported that frequent nightmares was associated with repeat SA after adjusting for axis-I DSM-IV diagnoses and depressive and anxious symptoms [44].

The rates of subsequent suicidal behaviors over 1-year follow-up increased with nightmare distress severity. To our knowledge, there are no prospective studies that have specifically examined the association between nightmare distress and suicidal behavior in the general population of adolescents. Nightmare distress has been considered as a trait factor that may reflect the severity of waking distress and mood dysregulation associated with nightmares, such as depression and anxiety [21, 23, 30], which in return can lead to suicidal behavior. Our finding highlights the clinical importance to assess and intervene both nightmare frequency and nightmare distress.

Our mediation analysis shows that the associations between nightmares (frequency and distress) and suicidal behavior were mediated by depressive symptoms at least in part. There is growing evidence that nightmares can affect daytime functioning and mood dysregulation and that negative affect may play a pivotal role in the association between nightmares and suicidal behaviors [8, 23, 30]. For example, Köthe and Pietrowsky [45] prospectively investigated the effects of nightmares on self-reported emotions and reported that participants felt more agitated, physically aroused, anxious and sad, less able to concentrate, less cheerful, and less self-confident on days after nightmares. In a recent online cross-sectional survey, Ward-Ciesielski *et al.* [46] reported that emotion regulation mediated the direct effect of nightmares on suicidal risk and SA. Neurobiologically, nightmares, depression, and suicidal behavior have all been related to reduced concentrations or activities of

serotonin, REM sleep disruption, and/or reduced frontal brain activity [26–30]. For example, a recent study of 19 nightmare-prone individuals, Marquis *et al.* [30] found that greater nightmare severity was related to reduced activity in a limbic prefrontal emotion regulation network comprising primarily medial prefrontal cortex, anterior cingulate cortex, hippocampus, and amygdala. Further neurobiological and psychological behavioral research is needed to better understand the underlying mechanisms between nightmares, depressive symptoms, and suicidal behavior in adolescents.

The current study has several strengths. The first strength is the longitudinal design that allows us to look at the association of nightmare frequency and distress with suicidal behaviors over time. The second strength is that the study was conducted in a large sample of adolescents in the community ($N = 6{,}923$). The third strength is that multiple potential adolescent and family confounders such as substance use (smoking and alcohol), insomnia, family history of suicide, family environmental factors, and prior suicidal behavior were statistically controlled when examining the nightmares–suicidal behavior association.

These findings need to be interpreted with the following limitations. First, all data were assessed by self-report, which may have led to biased reporting of suicidal behavior and nightmares. Second, nightmare frequency was retrospectively reported, in which nightmare occurrence might be underestimated [23]. Third, nightmares were defined in the current study as intense, frightening, and vivid dreams that awake respondents. It is unknown to what extent nightmares reported here in the questionnaire survey are clinically meaningful and are consistent with DSM-V nightmare disorder diagnostic criteria [47]. Fourth, these associations between nightmare frequency, nightmare distress, and suicidal behaviors were observed in a sample of Chinese school adolescents. It is difficult to know how well the findings generalize to other ethnic school adolescents and clinical samples. Further research is needed with diverse samples, technologically enhanced methods/instruments, and clinical assessments to replicate these findings.

Despite these limitations, our study of a large community sample of adolescents provides evidence that nightmare frequency and distress are associated with increased rates of subsequent suicidal behaviors over 1-year follow-up. Furthermore, the effect of nightmares on suicidal behavior is at least partially mediated through dysregulated mood (i.e. depression). These findings may have several important clinical and public health implications because nightmares are more common than usually thought [23], underreported, undetected, and untreated [48] and because nightmares are modifiable by psychological and pharmacological treatments [49–50]. First, the findings underscore the importance of screening adolescents at risk of suicidal behavior by assessing nightmare frequency and associated distress. Second, the findings underline the need for clinicians to be alert to suicidal behavior in adolescents who report frequent nightmares. Third, clinicians should help these adolescents get appropriate treatment for their nightmares and distress and depressive symptoms associated with nightmares. Furthermore, more research needs to examine the neurobiological mechanisms of the nightmares–suicidality link and the effects of intervention programs targeting at reducing nightmare frequency and coping with distress/dysregulated mood due to nightmares in adolescents.

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