



# Interactive effects of delayed bedtime and family-associated factors on depression in elementary school children

Jin-Ding Lin<sup>a</sup>, Ho-Jui Tung<sup>b</sup>, Yu-Hsin Hsieh<sup>a</sup>, Fu-Gong Lin<sup>a,\*</sup>

<sup>a</sup>School of Public Health, National Defense Medical Center, Taipei, Taiwan

<sup>b</sup>Department of Healthcare Administration, Asia University, Taichung, Taiwan

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## ABSTRACT

Shorter sleep time was reported to be associated with psychological functioning in children. We intended to examine the relationship between nocturnal sleep duration and depression status by investigating if delayed bedtime could be one of the enhancement factors for depression in children. A cross-sectional study was performed to investigate the depression status in elementary school children in middle Taiwan. Total 676 participants from 29 schools, in grades 3–6 were recruited to participate in the study. A modified depression scale for domestic school children was used to determine the depression status. Data of depression-related demographic characteristics, family, school variables and bedtime data were collected with a structured questionnaire. The results showed that almost one in five children (18%) had depression status. Delayed bedtime, child–parent relationship, family climate, and peer relationship were found to be the main predictors of childhood depression. Further stratification analysis showed that delayed bedtime significantly interacted with family climate and peer relationship on childhood depression. The risk of depression for children with a delayed bedtime of 10 PM and either in a non-harmonious family life or without a close parent–child relationship was 4.35 and 4.73 times greater than the reference group respectively. This study provides evidence for interactive effects between delayed bedtime and family concern factors which synergistically elevated the risk of childhood depression. This information may serve as a practical guide for parents and school teachers by recognizing that an adequate bedtime schedule could serve as a preventive measure against depression in children.

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## 1. Introduction

Sleep is one of the critical factors to school children for their physiological well-being and quality of life. Lack of sleep may impact their daytime activities and academic performance in school (Dewald, Meijer, Oort, Kerkhof, & Bogels, 2010; Hudson, Gradisar, Gamble, Schniering, & Rebelo, 2009). The average daily sleep duration of elementary school-aged children has been found to range from 9.3 to 10.6 h (Iglowstein, Jenni, Molinari, & Largo, 2003). Insufficient sleep has been found to be common for children and adolescents in both Asian and Western countries (Lue, Wu, & Yen, 2010; Moore et al., 2009). Sleep problems in children may lead to anxiety and depression (Hudson et al., 2009; Moore et al., 2009).

\* Corresponding author at: School of Public Health, National Defence Medical Center, No. 161, Min-Chun E. Rd., Sec. 6, Taipei, Taiwan. Tel.: +886 2 8792 3100x18470; fax: +886 2 87923147.

E-mail addresses: fugong@ndmctsg.edu.tw, fugong@mail.ndmctsg.edu.tw (F.-G. Lin).

Depression in adults may originate from factors stemming from their childhood and family environment, especially for those who come from families with low socioeconomic status, family disruption, parental divorce or a history of mental illness. Such children may suffer from a higher risk of depression in adult life (Gilman, Kawachi, Fitzmaurice, & Buka, 2002; Melchior, Moffitt, Milne, Poulton, & Caspi, 2007; Tracy, Zimmerman, Galea, Mccauley, & Stoep, 2008). Current studies suggest that depressive syndromes in children may have a negative impact on their development, school performance and family relationships and may be an important precursor to psychopathology in adulthood (Bhatia & Bhatia, 2007; Chang, Zauszniewski, Heinzer, Musil, & Tsai, 2007).

Depression is found to be associated with other mental disorders such as anxiety disorder, oppositional disorder, substance use disorder and conduct disorder (Fergusson, Boden, & Horwood, 2010). The Taiwanese National survey data in 1999 indicated that 30.5% of adolescents between the ages of 12 and 18 experienced depressive symptoms (Lue et al., 2010). Research on measuring depressive symptoms conducted in 2007 revealed that almost a quarter of the children (24%) were found having depressive symptoms, and 4.2% of the children were reported with major depressive disorders (Chang, Chen, & Lien, 2007).

Risk factors for adolescents and childhood depression were documented in various studies revolving around multiple and complex issues of personal characteristics, family and school environments (Wu, Kao, Yen, & Lee, 2007). Referring to personal characters, age, sex, body weight and sleep behavior were all accounted for (Erickson, Robinson, Haydel, & Killen, 2000); while the familial components of social economic status, family climate (Gilman et al., 2002), parenting styles and the depression history of the parents (Freres, Gillham, Reivich, & Shatte, 2002) were also mentioned in childhood depression research. The factors concerning school environment, peer relationships, support and academic performance were related to child mental health and the occurrence of depression (Lin et al., 2008). Children who had relatively few friends tended to experience depressive symptoms (Schwartz, Gorman, Duong, & Nakamoto, 2008).

Current studies on the relationships between shorter sleep duration and depression were mostly carried out on adolescents who appeared to be more sophisticated in articulating viewpoints and expressing their emotions when being measured by the scales compared to pre-adolescents (Dewald et al., 2010; Gangwisch et al., 2010; Moore et al., 2009). Nevertheless, Hudson had reported that elementary school-aged children with clinically anxious symptoms had significantly shorter sleep duration than a control group. However, few papers have their focus centered on pre-adolescent children. In this work, the variables associated with the factors of personal characteristics, family and school were measured. The goal was to evaluate the effects of how insufficient sleep interacts with these factors with regards to depression.

## 2. Methods

### 2.1. Participants

In 2009 a total of 36 elementary schools in Miaoli County who ran governmental-assisted after school programs were contacted. A total of 29 schools agreed to join the study comprising of 1643 students in grades 3 through 6 who attended after-school classes. The 29 schools located evenly at the west side of 10 more populous towns in the County, whereas the residual 8 towns were primarily located on the less populous mountain areas of the east side of the County. This study was approved by the Institute Review Board of the Tri-Service General Hospital, National Defense Medical Center (Approval number: 98-05-239). Parents were informed of the content of the study and given the opportunity to consent or refuse the participation of their children while children were also allowed to refuse their participation at any time. Surveys and physical measurement of height and weight were taken during after-school class hours by scale and height machine with trained assistants. Finally 676 questionnaires were completed and analyzed.

### 2.2. Measurement of depressive symptoms

The “Depression Screening Scale for Children and Adolescents” developed by Chang, Chen, et al. (2007) for Taiwanese children and adolescents, was used to measure the depression status. The scale was a combined and modified version of various other measurement methods, similar to those found in the *Diagnostic and statistical manual of mental disorder*, 3rd and 4th edition published by the American Psychiatric Association, *Reynolds Child Depression Scale* (RCDS), *Children’s Depression Inventory* by Kovacs (CDI) and *Beck Depression Inventory* (BDI). There were 34 items in Chang’s scale covering five factors, they are: (1) depression-dysphoric mood; (2) hopelessness; (3) low-self esteem; (4) somatic complaints and psychomotor and (5) social-conduct- problems. Each item was scored 0–4 and subjects were asked to indicate how frequently they had experienced a described situation during the last 2 weeks. Substantial internal consistency of the scale was indicated by a Cronbach’s alpha of 0.94. Scores summated greater than 33 were classified as possible depression disorders. In Chang’s study, the very same scale was used to test hospital outpatient samples and 95% of the clinically diagnosed patients were correctly classified by this screening scale.

### 2.3. Measurements of bedtime and getup time

Children were asked about their usual bedtime and wake-up time during weekdays. Nighttime sleep duration was calculated from the two time points of bedtime and wake-up time. Sleep duration reported in the studies was generally interpreted as time spent in bed. Bedtime was further categorized into four time groups to calculate and compare the risk of

different bedtime periods for depression: before 9 PM, between 9 PM and 10 PM, between 10 PM and 11 PM, and after 11 PM. Getup time was also grouped as before 5 AM, between 5 AM to 6 AM, between 6 AM to 7 AM, and after 7AM.

#### 2.4. Measurements of independent variables

There were 39 questions in the questionnaire designed to uncover variables involving personal characteristics, family concern and school concern. Personal demographic characteristics consisted of age, gender and body mass index (BMI) which was calculated as  $\text{weight}/\text{height}^2$  in  $\text{kg}/\text{m}^2$  units. Children's BMI were categorized as normal, underweight and overweight based on the criteria of the Department of Health, Taiwan. Normal weight was defined as having a BMI lying between 5 and 84th percentile for age and sex; overweight was having a BMI  $\geq$  85th percentile, and underweight was defined as having a BMI  $<$  5th percentile.

Family concern variables were measured with self-stated items to define the household: living with both parents or single-parent. As previously reported (Beesdo, Pine, Lieb, & Wittchen, 2010; Rhee, Lumeng, Appugliese, Kaciroti, & Bradley, 2006), the measurement scales for children's perception of parenting styles and family climate were primarily designed for use in assessing adolescents, and not designed as such for use with young children. Hence respondents normally required a longer time to complete the questionnaire and parental assistance was often required during the process. In our study, the subjects were elementary school children and may have had difficulties completing a time-consuming questionnaire or fail to fully comprehend the questions asked. We therefore adopted a more simplified scale designed by Chang, Chen, et al. (2007) where children were asked about their perception of the parenting style they experienced at home: (1) authoritative, annotated as respectful of child's opinions with clear boundaries, (2) authoritarian, annotated as strict disciplinarian (3) permissive, annotated as indulgent without discipline or (4) neglectful, annotated as emotionally uninvolved; while family climate was categorized as (1) harmonious or (2) not harmonious. In Chang's own study, the simplified scales played a vital role in recognizing depression in elementary school children. The depression scores for children perceived to experience an authoritative parenting style was significantly lower than the other groups. Meanwhile, children reporting to have a harmonious family climate at home scored lower in the scale. Measurements for the child–parent relationship were simplified with the two options of being “close” or “not close”. School concern variables were measured with subject academic performance divided into three categories, the first, middle and lower third, by the teachers' assessments. Peer relationships were measured by self-report as being “close” or “not close”.

#### 2.5. Statistical analysis

Data analysis was conducted using PASW Statistics 18.0 software. The Chi-square test was used for evaluating the association between categorical variables and depression status and *t*-test and ANOVA test were employed for comparison of continuous variables such as age and sleeping duration in grouped data.

In the analysis for depressive symptoms, the result was exhibited in two main groups employing the summated scores of 33 as a cut-off point: 'at risk' ( $>33$ ) of depression and 'not at risk' ( $\leq 33$ ). Dichotomized depression scores of single binary (0,1) outcome was used to fit the logistic regression model *p* value  $<0.05$  was considered statistically significant in all tests that were conducted. Multivariate analysis was carried out to evaluate the odds ratio for associations between the presence of a potential risk or a protective factor for depression with a 95% confidence interval.

Covariates included in the adjusted multivariate model were personal characteristics of age, sex, BMI, sleep duration and the family's receipt of governmental assistance; followed by family associated variables of parent marital status, family climate, child–parent relationship and family parenting style; and finally with the school concern variables of peer relationship and academic performance assessment by teachers.

Odds ratio of measured variables for depression were computed by Chi-square in the unadjusted univariate model; whereas in multi-variate analysis, odds ratios were computed with logistic regression model.

In order to examine the combined effects on the risk of depression attributable to the presence of both later bedtimes and either poor child–parent relationships, family climate, or peer relationships, the related family/school significant variables for depression were stratified on a delayed bedtime (10 PM as the cut point) basis by using logistic regression to identify and compare the individual and combined odds ratio on the risk of depression. Expected combined effects for the two indicators from an additive model are calculated as  $(OR_{\text{variable 1}} + OR_{\text{variable 2}} - 1)$ , and from the multiplicative model calculated as  $(OR_{\text{variable 1}} \times OR_{\text{variable 2}})$  as previous described (Andersson, Alfredsson, Kallberg, Zdravkovic, & Ahlbom, 2005). Expected OR and observed OR ( $OR_{\text{variable 1}}$  and  $OR_{\text{variable 2}}$ ) of two indicators on depression risk were then compared and examined the existence of interaction effect. In all of the tests carried out in this study, a *p*-value of  $<0.05$  was considered to be statistically significant.

### 3. Results

#### 3.1. Description of the sample

This study included a sample of 676 children with a sex ratio of 48% boys and 52% girls who attended after-school classes. The mean age was at 9.68 years ranging from 7 to 12 years (see Table 1). Among them, one in three children (32.1%) received

**Table 1**  
Demographic characteristics of children in the study.

Variable	N = 676	%	Mean $\pm$ SD <sup>a</sup> (range)
<b>Depression score</b>			18.40 $\pm$ 16.60 (0–102)
$\leq 33$	555	82.1	
$> 33$	121	17.9	
<b>Children variables</b>			
Age (years)	676		9.68 $\pm$ 1.16 (7–12)
Nocturnal sleep duration (h)	676		8.60 $\pm$ 1.01 (5–13)
Bedtime			
$\leq 9$ PM	193	28.6	
9–10 PM	325	48.1	
10–11 PM	114	16.9	
$> 11$ PM	44	6.5	
Getup time			
$\leq 5$ AM	14	2.1	
5–6 AM	190	28.1	
6–7 AM	467	69.1	
$> 7$ AM	5	0.7	
Gender			
Female	353	52.2	
Male	323	47.8	
BMI			
Normal	397	58.7	
Under/overweight	279	41.3	
Government assistance			
No	459	67.9	
Yes	217	32.1	
<b>Family variables</b>			
Mother ethnicity			
Taiwanese	519	76.8	
Foreign	157	23.2	
Household type			
Both parents	572	84.6	
Single parent	104	15.4	
Child–parent relationship			
Close	505	74.7	
Not close	171	25.3	
Parenting style			
Authoritative	616	91.1	
Not authoritative <sup>b</sup>	60	8.9	
Family climate			
Harmonious	229	33.9	
Not harmonious	447	66.1	
<b>School variables</b>			
Peer relationship			
Close	351	51.9	
Not close	325	48.1	
Academic performance			
First two thirds	465	68.8	
Last third	211	31.2	

Nocturnal sleep duration was calculated from bedtime and wake-up time, BMI: body mass index grouped according to Department of Health, Taiwan, R.O.C.

<sup>a</sup> SD: standard deviation.

<sup>b</sup> Not authoritative category included three combined data of authoritarian, permissive, neglectful groups.

government financial support while two out of five children (41.3%) were considered having an abnormal BMI, either under or overweight. We found that the average mean depression score was 18.40 (SD = 16.60) and 18% of children were categorized as ‘at risk of depression’.

### 3.2. Bedtime and wake-up time periods

In our study, average nocturnal sleep duration during weekdays was just below 9 h (8.6 h). As shown in Table 1, about 28.6% of students went to bed before 9 PM, most of them (48.1%) were set bedtime between 9 PM and 10 PM, and less than one in four children (23.3%) went to bed after 10 PM. On the getup time, about 30% cases getup before 6 PM, and more than two-thirds (69%) of children got up between 6 AM and 7 AM.

### 3.3. Variables associated with depression

Based on the analysis of measured variables exhibited in Table 2, the personal characteristics of age, gender, BMI and government assistance did not appear to have significant relations with the subject's depression status. Table 2 exhibits the odds ratios or measured variables for depression. In the model 1, results from unadjusted univariate analysis showed that children with bedtimes of 10–11 PM, after 11 PM were more likely to be depressive than that with bedtime before 9 PM. For family variables, children with “not close” child–parent relationship were found to have a 2.11-fold greater risk of depression, meanwhile children who experienced a “harmonious” family climate were almost twice as likely (1.89 fold) to be protected from depressive symptoms as opposed to those who did not have a “harmonious” family climate. Concerning the school variables, the risk for depression was nearly doubled (1.99-fold) for the reference group compared with children that consider themselves to have a “close” peer-relationship. In the model 2, considering the covariates in the logistic regression analysis, a vital link was established between nocturnal sleep duration and depression showed that those with

**Table 2**  
Relation of the child characteristics associated with depression in univariate and multivariate analysis (N = 676).

Characteristics	Model 1 <sup>a</sup>	Model 2 <sup>b</sup>	Model 3 <sup>c</sup>
	Univariate OR (95% CI)	Multivariate OR (95% CI)	Multivariate OR (95% CI)
<b>Demographic variables</b>			
Age	–	1.07 (0.89–1.28)	1.06 (0.88–1.27)
Nocturnal sleep duration	–	0.74 (0.61–0.89)**	–
Bedtime			
≤9 PM	1	–	1
9–10 PM	1.17 (0.70–1.95)	–	1.15 (0.67–1.97)
10–11 PM	1.90 (1.04–3.46)*	–	1.89 (1.00–3.60)*
>11 PM	4.48 (2.36–10.08)**	–	4.66 (2.14–10.15)**
Getup time			
≤6 AM	1	–	1
>6 AM	0.93 (0.60–1.43)	–	0.94 (0.59–1.49)
Gender			
Female	1	1	1
Male	1.05 (0.71–1.56)	1.07 (0.70–1.64)	1.09 (0.71–1.67)
BMI			
Normal	1	1	1
Under/overweight	0.88 (0.59–1.32)	0.91 (0.60–1.39)	0.94 (0.61–1.43)
Government assistance			
No	1	1	1
Yes	1.26 (0.84–1.90)	1.08 (0.68–1.72)	1.11 (0.70–1.78)
<b>Family variables</b>			
Mother ethnicity			
Taiwanese	1	1	1
Foreign	1.24 (0.79–1.94)	1.26 (0.77–2.04)	1.31 (0.81–2.13)
Household type			
Both parents	1	1	1
Single parent	1.37 (0.82–2.30)	1.31 (0.75–2.30)	1.44 (0.81–2.54)
Child–parent relationship			
Close	1	1	1
Not close	2.11 (1.39–3.20)**	1.78(1.13–2.79)*	1.83 (1.16–2.89)**
Parenting style			
Authoritative	1	1	1
Not authoritative	1.03 (0.52–2.05)	0.75(0.35–1.57)	0.73 (0.34–1.55)
Family climate			
Harmonious	1	1	1
Not harmonious	1.89 (1.20–2.98)**	1.86 (1.16–2.98)*	1.90 (1.18–3.07)**
<b>School variables</b>			
Peer relationship			
Close	1	1	1
Not close	1.99 (1.33–2.98)**	1.97 (1.29–3.03)**	1.95 (1.27–3.01)**
Academic performance			
First two thirds	1	1	1
Last third	1.33 (0.88–2.00)	1.17 (0.75–1.83)	1.16 (0.59–1.49)

<sup>a</sup> Model 1 – unadjusted.

<sup>b</sup> Model 2 – includes time in bed for sleep habit with demographic, family and school related variables adjusted in equation.

<sup>c</sup> Model 3 – includes bedtime, getup time periods for sleep habits with demographic, family and school related variables adjusted in equation; CI, confidence interval; OR, odds ratio.

\*  $p < 0.05$ .

\*\*  $p < 0.01$ .

longer nighttime sleep duration (time spent in bed) were 0.74-fold less likely to be at risk of depression. And the other three significant variables in model 1 of child–parent relationship, family climate and peer-relationship were also found significant in model 2, with demographic, family and school related variables adjusted in equation, which the result was compatible with model 1. In the model 3, adjusted odds ratio of delayed bedtimes 10–11 PM, after 11 PM for depression were 1.89, 4.66 folds respectively than whose bedtime before 9 PM. Conversely a vital link was established between nocturnal sleep duration and depression showed that those with longer sleep duration were 0.74-fold less likely to be at risk of depression. For family variables, children with “not close” child–parent relationship were found to have a 1.78-fold greater risk of depression, meanwhile children who experienced a “harmonious” family climate were almost twice as likely (1.86-fold) to be protected from depressive symptoms as opposed to those who did not have a “harmonious” family climate. Concerning the school variables, the risk for depression was nearly doubled (1.97-fold) for the reference group compared with children that consider themselves to have a “close” peer-relationship. The analysis on the relation with bedtime-getup time and depression status indicated that a bedtime of after 10 PM or later was a deciding factor for depression as the risk level was 2.28-fold higher than those whose bedtimes were before 10 PM. By contrast getup time did not seem to form a crucial link with depression.

### 3.4. Synergistic effects of variables on depression

Four factors were found to be significantly associated with depressive status and they were presented by independently adjusted effects using a multivariable logistic model (see Table 2). To further assess if children’s delayed bedtime interacted with the other three significant risk factors, variables were dichotomously stratified to examine the individual effects and joint effects under the condition of bedtime after 10 PM on child depression. Individual effect of each variable with bedtime and comparison between expected joint effects and observed joint effects of stratified variables on depression were then performed with logistic regression methods. As shown in Table 3, the individual effect of bedtime and family climate showed a moderate association of 1.77 and 1.83 risk odds compared to the reference group. The expected joint effects of the two variables were 2.60-fold ( $1.77 + 1.83 - 1$ ) under the additive model and were 3.24-fold ( $1.77 \times 1.83$ ) under multiplicative model calculated as previously stated (Andersson et al., 2005; Botto & Khoury, 2001). Whereas the observed joint effects of the two variables were 4.35-fold showing a higher strength of association with depression than the expected joint effects in both additive and multiplicative model. The combined factors of bedtime after 10 PM and children who did not perceive a harmonious family climate demonstrated a synergistic effect.

Equally, the interaction effect between children’s bedtime and child–parent relationship on depression was analyzed. The individual risk odds of the two variables on depression were 1.67 and 2.04 respectively which were comparatively greater than the reference group. After adjusting the other variables, the odds ratios of expected joint effects of the two variables was 2.71 ( $1.67 + 2.04 - 1$ ) under the additive model and was 3.41 ( $1.67 \times 2.04$ ) in the multiplicative model. The observed joint effects of the two variables on the depression risk increased to 4.73-fold implying that a synergistic effect was also present in the situation of the children with delayed bedtime of after 10 PM and did not have a close child–parent relationship. Additionally, to examine the interaction effect between bedtime, and peer relationship, the individual odds of two variables on depression risk were 2.36 and 3.36, respectively. The risk odds on depression of expected joint effects of the two variables were 4.72 ( $2.36 + 3.36 - 1$ ) with the observed joint effects being 4.01 hence the synergistic effect was not obvious.

**Table 3**  
Interactive effects of children bedtime and relevant significant variables on depression.

Variable 1	Variable 2	Crude OR (95% CI)	AOR <sup>a</sup> 95% CI)
<b>Harmonious family climate</b>	<b>Delayed bedtime after 10 PM</b>		
Yes	No	1	1
Yes	Yes	2.10 (0.88–5.01)	1.83 (0.74–4.50)
No	No	1.76 (1.01–3.07) <sup>*</sup>	1.77 (1.00–3.11) <sup>*</sup>
No	Yes	4.14 (2.23–7.70) <sup>**</sup>	4.35 (2.30–8.24) <sup>**</sup>
<b>Close children–parent relationship</b>	<b>Delayed bedtime after 10 PM</b>		
Yes	No	1	1
Yes	Yes	2.06 (1.21–3.52) <sup>**</sup>	2.04 (1.18–3.53) <sup>*</sup>
No	No	1.85 (1.10–3.14) <sup>*</sup>	1.67 (0.96–2.88)
No	Yes	4.94 (2.60–9.43) <sup>**</sup>	4.73 (2.38–9.39) <sup>**</sup>
<b>Close peer relationship</b>	<b>Delayed bedtime after 10 PM</b>		
Yes	No	1	1
Yes	Yes	3.58 (1.87–6.83) <sup>**</sup>	3.36 (1.73–6.53) <sup>**</sup>
No	No	2.57 (1.87–6.83) <sup>**</sup>	2.36 (1.37–4.00) <sup>**</sup>
No	Yes	4.39 (2.33–8.27) <sup>**</sup>	4.01 (2.09–7.70) <sup>**</sup>

<sup>a</sup> Adjusted for children, family and school associated variables as shown in Table 1.

<sup>\*</sup>  $p < 0.05$ .

<sup>\*\*</sup>  $p < 0.01$ .

#### 4. Discussions

In this study, with multivariate and stratified analysis strategies, we were able to assess the independent and the joint modification effects of sleep habits with family and school factors on depression status. The close relationship between later bedtime and depression in children showed in our results was compatible with previous studies (Gangwisch et al., 2010), and furthermore children with a delayed bedtime after 10 PM were not only found to be associated with depression independently but also one enhanced factor on depression risk in considering together with the family concern variables. Most previous studies presented the risks of depression associated with family and school factors for adolescents and children as independent variables, thus may have underestimated the joints effect of these variables. With the analysis, the joint effects of the delayed bedtime and non-harmonious family climate showed multiplicative interaction on the risk ratio of depression up to 4.35-fold greater than the reference group; while the joint effects of the delayed bedtime and not close child–parent relationship also showed multiplicative interaction of 4.73-fold greater. The interacted results of family factors and bedtime on depression might indicate that sleep habits of elementary school children were still dependent on parents set bedtime. Children's emotion might be influenced by child–parent interrelationship and family climate and led to late bedtime. This would be supported by the data that depressed children reported to have higher proportion non-harmonious family climate and not-close child–parent relationship than the non-depressed. This also reveals that family factors of family climate and child–parent relationship played important roles in child mental health, especially in those who with the sleep habit of late bedtime.

In our cases, children at 4–6 grades, with the requirement to attend school at regular scheduled time around 7:30 AM and the normal class ended at 4:00 PM, with attending the after class extending to 6 PM, they spend day time almost in the school. The night sleep is the only time for them to rest and surely an important period for their physical and psychology development. However, the mean time spent in bed of children in the investigation was 8.6 h and was obviously shorter than 9.8 h for children aged between 8–12 as previously reported by Iglowstein et al. (2003) and the average sleep duration of 10.2 h for 10-year-old children reported by Szymczak, Jasinska, Pawlak, and Zwierzykowska (1993). On time to school might be one stressor for children, especially for the children with late bedtime. Iglowstein et al.'s (2003) study reported that sleep duration had decreased for children born between 1974 and 1993 with progressively later bedtime but unchanged getup time across decades. Our data showed that children who went to bed after 10 PM had significantly higher depression risk than those before 10 PM regardless of the getup time in the adjusted logistic regression model. Therefore, it implied that the delayed bedtime mediated the sleep length of school children and subsequently influenced the depression status. Studies showed that children and adolescents set bedtime were highly correlated with depression syndrome (Gangwisch et al., 2010). The Taiwanese parent-set bedtime may be considered too late for children and it is certainly worth taking into account the possible psychological impact when it comes to setting an adequate bedtime.

Analysis of the demographic factors revealed that children's age, gender and family factors such as family climate and child–parent relationship were significantly related to their nocturnal sleep time. Boys spent a shorter time in bed of 8.48 h compared to girls of 8.71 h ( $p < 0.01$ ) and the duration were shorter with older children. Children aged 12 had the shortest nighttime in bed of 8.11 h compared with others ( $p < 0.01$ ) as shown in Fig. 1. Both age and gender were significantly correlated with nighttime sleep duration which in turn implied that age and gender might be the intermediate risk factors for depression.

Previous studies provided evidence in associating sleep disorder with children's school performance (Gozal, 1998) and longer sleep duration was also linked with better school performance (Dewald et al., 2010). Researches on sleep physiology showed that truncated sleep brought on by delayed bedtime was associated with a delayed endogenous melatonin onset and delayed daytime phase circadian rhythm (Burgess & Eastman, 2004; Yang et al., 2001). Delayed bedtime resulted in both a decrease in self-rated alertness during the daytime and a decrease in students' academic performance (Chung & Cheung, 2008; Clodoré et al., 1987). Regular circadian rhythms of sleep pattern and an increase in total sleep time will result in

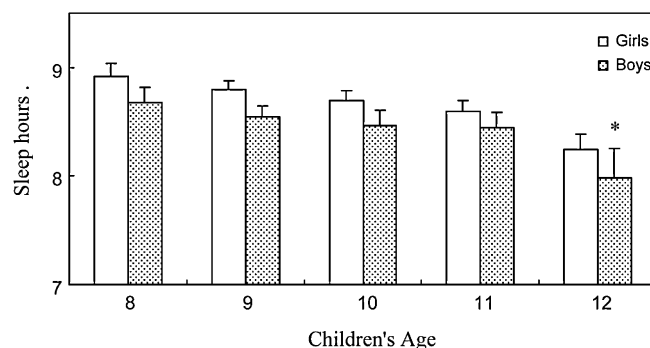


Fig. 1. Relation of age by sex with sleep hours in children.

improved daytime functioning (Chung & Cheung, 2008; Monk, Petrie, Hayes, & Kupfer, 1994). Thirty-six percent of children had a delayed bedtime later than 10 PM. They showed poorer academic performance than children who went to bed before 10 PM where only 29.6% underperform academically. Delayed bedtime for children was associated with depression and might also influence their academic performance via disturbance of circadian rhythm.

The sample in this study was taken from after-school class students in rural areas of MiaoLi County. Some other confounding variables were therefore not evaluated for, including urbanization. Since the study is cross sectional, causality or any direction of causality cannot be determined, but there are many interesting possibilities that could be explored such as: is later bedtime and resultant shorter sleep duration reflective of insomnia, a symptom of depression, and therefore reflects the severity of depression? And does lack of sleep lead to depressed mood and irritability which functions to negatively impact the children's interpersonal relationships with parents or classmates? There exist some potential bidirectional relationships among delayed bedtime, family factors and depression status in children which may need further follow-up. In order to reduce the risk of depression in children, we suggest that more concern should be placed on the child having regular and sufficient sleep duration as well as improvements in the family environment, especially the relationship between the parents and the child. These two factors should have the maximum impact on the risk reduction.

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